TRANSHUMAN SPACE™

UNDER PRESSURE™

POWERED BY GURPS®

WRITTEN BY DAVID MORGAN-MAR, KENNETH PETERS, AND CONSTANTINE THOMAS

STEVE JACKSON GAMES

UNDER PRESSURE™

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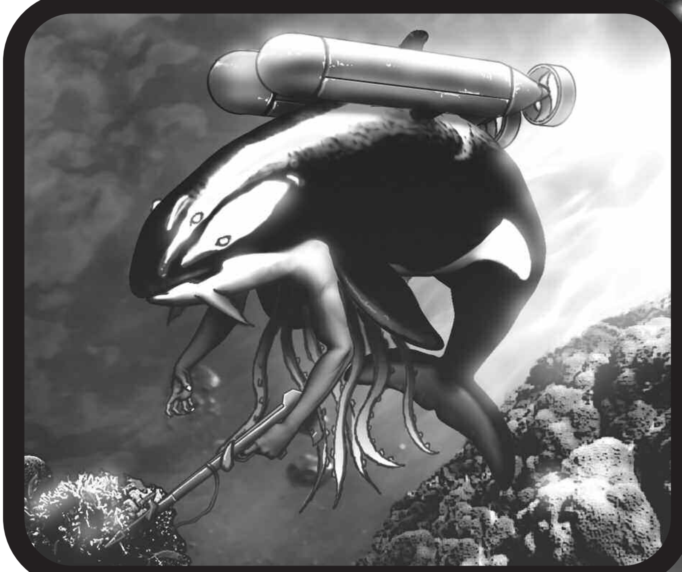

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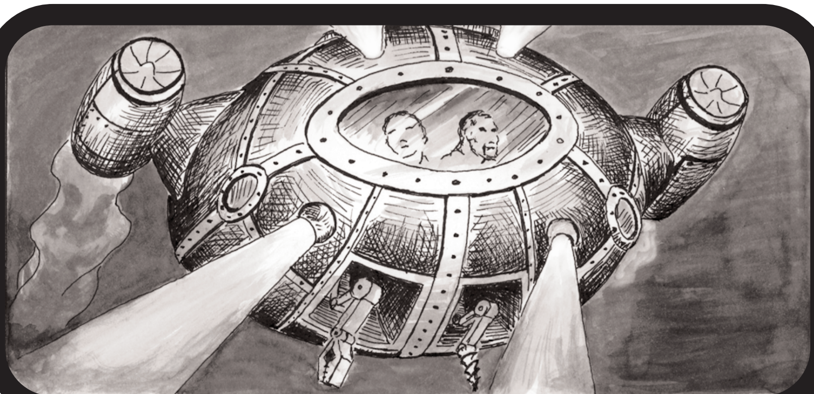
CONTENTS



INTRODUCTION

Space may be a frontier, but it's not the only one. There is an environment just as hostile, just as dangerous, just as unknown – and all it takes to get there is a trip to the beach. The oceans of Earth represent a bonanza of living space and resources, waiting to be claimed by whomever can overcome its unique difficulties. The transhuman synthesis of mechanical and biological technology allows people to live, work, and come into conflict in this shadowy world beneath the waves.

As humanity spreads to the planets, more liquid environments are found – or created. The technologies spawned on Earth also find applications in the seas of Mars, the high-pressure ocean of Europa, and the hydrocarbon lakes of Titan.

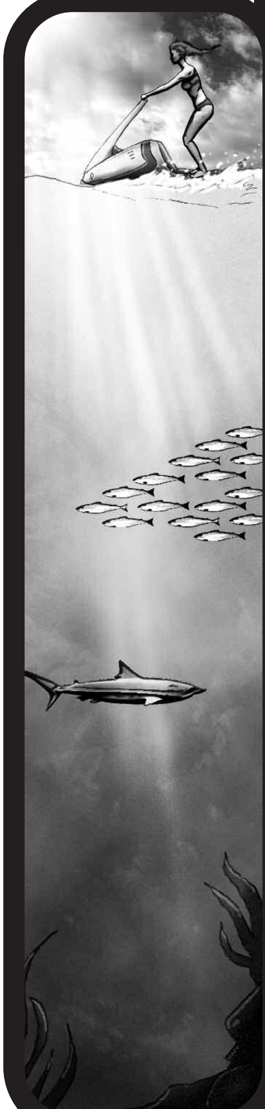
Transhuman Space: Under Pressure examines the oceanic environments of 2100, from the teeming seas of Earth that millions of transhumans call home, to the exotic oceans of liquid ethane and other chemicals on moons of the Deep Beyond.

Space is the easy frontier. Now try the hard one.

ABOUT TRANSHUMAN SPACE

The ***Transhuman Space*** series presents a unique hard-science and high-biotech universe for roleplaying. Set in the Solar System in the year 2100, it is a setting rich in adventure, mystery, and ideological conflict. The core book is ***Transhuman Space***, which presents an overview of the setting. Other books available include ***Fifth Wave*** (focusing on Earth), ***In the Well*** (Mars and the inner system), and ***Deep Beyond*** (the outer system).

ABOUT THE AUTHORS



David Morgan-Mar lives in Sydney, Australia. While studying for his doctorate in astrophysics, he goofed off creating web pages, watching cricket, and playing games. Since graduating, his jobs have been creating web pages, reporting on cricket matches, and writing gaming material. He has contributed to several ***GURPS*** books, including ***Monsters*** and ***Steam-Tech***. Now he grows bonsai, plays with Lego toys, and wonders when those pursuits will start to pay off.

Kenneth Peters lives in Post Falls, Idaho. He is an anthropology major and sergeant in the USMCR. He spends his free time playing with ***GURPS Vehicles,*** *Second Edition* and learning 3D animation software. He wrote ***Spacecraft of the Solar System*** and sections of several ***Shadowrun*** books, but still wonders when he will be issued a posse of fanboys and a Ferrari.

Constantine Thomas is a Brit, living on Vancouver Island, British Columbia. He works at the Institute of Ocean Sciences, advancing the new field of planetary oceanography. He has been a ***GURPS*** fan for 15 years and has contributed to ***Transhuman Space*** since it was announced. He collects CDs and roleplaying games, hopes to visit a hydrothermal vent some day (since it's unlikely he'll walk on another world), and wonders when he will be able to convert this book into a research paper.

ABOUT GURPS

Steve Jackson Games is committed to full support of the ***GURPS*** system. Our address is SJ Games, Box 18957, Austin, TX 78760. Please include a self-addressed, stamped envelope (SASE) any time you write us! Resources include:

Pyramid (**www.sjgames.com/pyramid/**). Our online magazine includes new ***GURPS*** rules and articles. It also covers ***Dungeons and Dragons, Traveller, World of Darkness, Call of Cthulhu,*** and many more top games – and other Steve Jackson Games releases like ***In Nomine, Illuminati, Car Wars, Toon, Ogre Miniatures,*** and more. *Pyramid* subscribers also have access to playtest files online!

New supplements and adventures. ***GURPS*** continues to grow, and we'll be happy to let you know what's new. For a current catalog, send us a legal-sized or 9"×12" SASE – please use two stamps! – or just visit **www.warehouse23.com**.

Errata. Everyone makes mistakes, including us – but we do our best to fix our errors. Up-to-date errata sheets for all ***GURPS*** releases, including this book, are available on our website – see below.

Gamer input. We value your comments, for new products as well as updated printings of existing titles!

Internet. Visit us on the World Wide Web at **www.sjgames.com** for errata, updates, Q&A, and much more. ***GURPS*** has its own Usenet group, too: rec.games.frp.gurps.

GURPSnet. This e-mail list hosts much of the online discussion of ***GURPS.*** To join, point your web browser to **www.sjgames.com/mailman/listinfo/gurpsnet-l/**.

The ***Transhuman Space: Under Pressure*** web page can be found at **www.sjgames.com/transhuman/underpressure/**.

Page References

Rules and statistics in this book are specifically for the ***GURPS Basic Set,*** *Third Edition.* Any page reference that begins with a B refers to the ***GURPS Basic Set*** – e.g., p. B102 means p. 102 of the ***GURPS Basic Set,*** *Third Edition.* Page references that begin with CI indicate ***GURPS Compendium I.*** Other references are DB to ***Deep Beyond***, FW to ***Fifth Wave***, ITW to ***In the Well***, SSS to ***Spacecraft of the Solar System***, and TS to ***Transhuman Space***. The abbreviation for *this* book is UP. For a full list of abbreviations, see p. CI181 or the updated web list at **www.sjgames.com/gurps/abbrevs.html**.

1 THE OTHER FRONTIER

Typhoon winds lashed the deck of the Palayancillo arcology as it rode in the heavy swell of the South China Sea. Renan Lumahan took a last look at home before winching himself aboard the evacuation sub. It was just a precaution, he told himself. The tether cables that groaned against the currents and the storm waves could hold the city safely in winds twice this speed. Or so the engineers said.

Renan wasn't looking forward to spending the next few days in Manila. He could feel the dirt beneath his feet there, even through his shoes. Solid ground. Its stability unsettled him. Last time he visited, he'd booked a room in the Ayala Hotel overlooking Manila Bay. From there he could see the sunset over the water, but the distant peak of Mount Bataan on the peninsula spoiled the illusion.

The terranos could never understand. What it meant to live on the open sea, free of the sordid history of land, free of the politics, the treachery, the greed that went with limited space and limited resources. Out here there was all the space you could ask for, and a few hundred feet down were riches beyond counting.

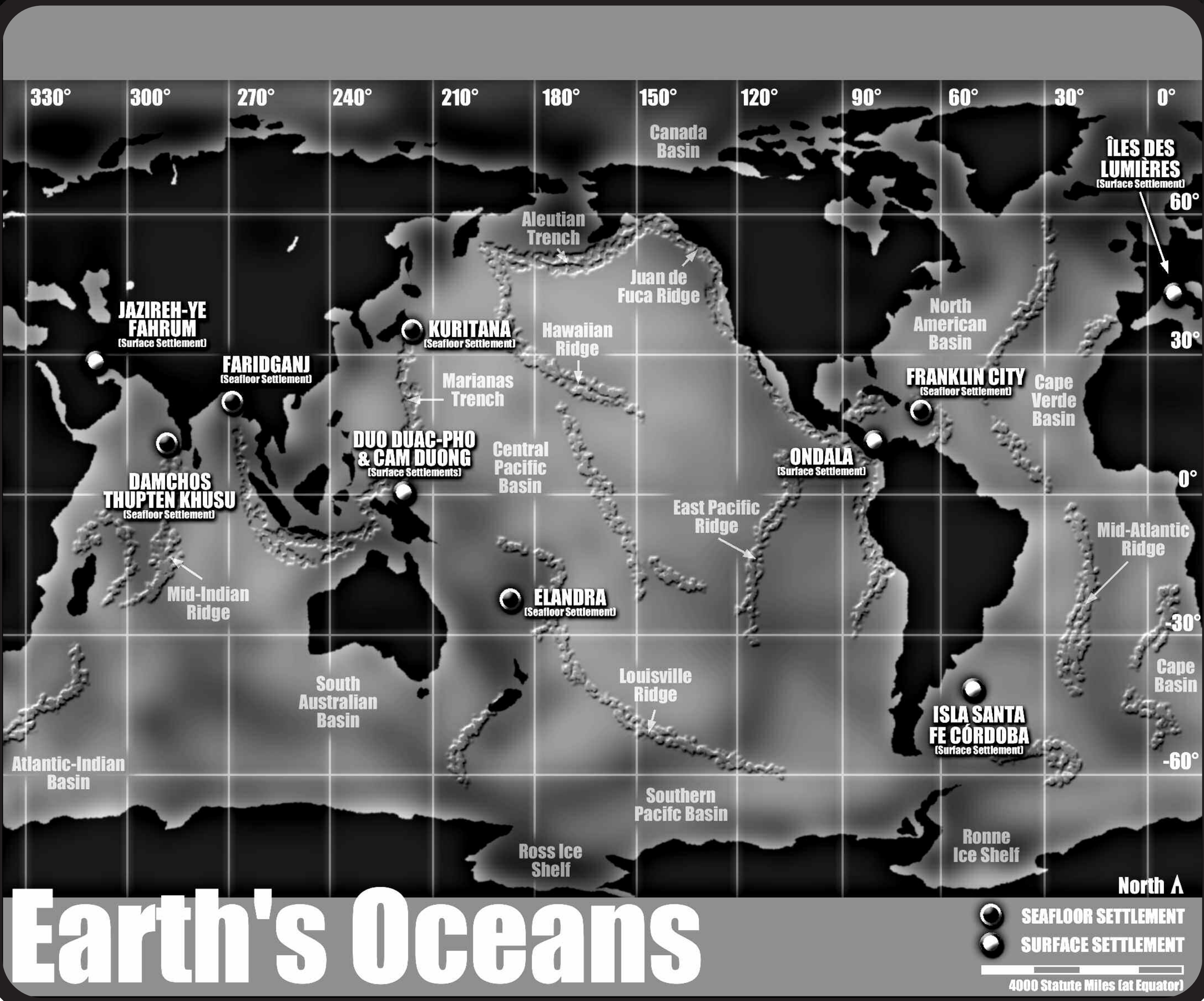
It wasn't easy living in the best place on Earth. Last year's storm season had been bad, but this one was predicted to be worse. But then nothing worth doing was easy. Renan inhaled the foam-whipped air, and then shut the hatch behind him. He knew he'd return as soon as this storm blew over.

In 2100 the oceans are the newest frontier on Earth. Regions formerly beyond the control of any nation are being exploited for the mineral and biological wealth they possess. With formal treaties rare, territorial claims must be defended with might. Nations cobble together aquatic colonies as rapidly as they can in order to legitimize "ownership" of the oceans, while corporations simply construct new land in convenient and government-free locations.

High-tech surface and submarine navies patrol the waters, frequently clashing with commercial fishing or mining ventures that operate outside a protective jurisdiction. The forces of terrorism are also well-equipped, with the ability to take out unprotected ships or commercial operations platforms. Activist groups target the many companies engaged in modifying (or defiling) the ocean environment – creating genemod species that outcompete natural species, strip-mining the sea floor, uplifting sea creatures to sapience and enslaving them, or producing parahumans and bioroids adapted for living underwater. Such companies and the nations that sponsor them must defend themselves.

But the oceans are immense and no power can patrol everywhere. Filling the gaps are free settlements and homesteads, inhabited by people seeking respite from the politics of the modern world. Never before has it been so easy to renounce all national ties and live free of government. And never before has it been so easy to set up criminal operations far away from the scrutiny of the law.

Humanity had mapped the moon and Mars by the late 20th century. At the dawn of the 22nd century, the oceans of Earth still hold secrets and present a troubled frontier for transhuman society.



Timeline

2009: Deadline for the lodgement of national claims to sea-floor territory beyond 200 nautical miles from land under article 76 of the United Nations Convention on the Law of the Sea; several nations make a flurry of last-minute claims.

2011: Atlantic bluefin tuna stocks collapse under pressure of overfishing and taking of juveniles – the species all but vanishes from the Atlantic Ocean.

2013: First International Conference on Fish Stocks meets in Trieste, but fails to resolve anything after much heated debate.

2018: Pacific bluefin tuna stocks collapse. Single tuna prices at Tokyo's Tsukiji fish market surpass $1 million.

2021: Armenian forces strike Azerbaijani oil wells, causing catastrophic oil spill in the Caspian Sea.

2022: Turkish millionaire Melik Evrim buys an aging Iraqi oil tanker and secretly converts it into a genetic engineering laboratory. Operating offshore to avoid regulation, this successful endeavor becomes the transnational Biotech Euphrates.

2024: Northern right whales become extinct; the last known individual is killed by a ship strike.

2027: U.S. company Blake Energy begins first large scale sea-floor mining operation on Blake Ridge between Florida and Bermuda, causing international outcry.

2030: Argentine oil drilling near Antarctica sparks new conflict with United Kingdom.

2031: A group of Australian gengineers and marine biologists form GenTech Pacifica, a company dedicated to improving fish and mollusk yields in aquaculture farms. Canadian navy fires on Spanish and Portuguese fishing vessels in Grand Banks area.

2033: Antarctic War breaks out when Argentina begins drilling for oil on the Antarctic Peninsula, in violation of the Antarctic Treaty. Venice temporarily evacuated because of rising sea levels.

2034: Environmentalists uncover evidence that Indonesian company Nusantara Biotek has been releasing genemod fish into the wild.

2035: Antarctic War ends with signing of Revised Antarctic Treaty, prohibiting national claims to the continent.

2045: International Tribunal for the Law of the Sea disbands, leaving jurisdiction of international disagreements over oceanic territory to the World Court.

2049: A multinational science mission lands on Europa. Ice-penetrating cryobots explore the Oceanus Noctis and discover life.

2052: Northern right whales are cloned from tissue samples, using southern right whales as surrogate mothers, and the subspecies is reintroduced into the Northern Pacific Ocean.

2057: Centre de Recherche AstroBiologique d'Europa (CRABE) base established in Pwyll impact crater on Europa.

2058: Aquacrete developed and first used to build underwater structures.

2061: Manannán Station built by CRABE personnel on Europa.

2064: United States builds a major power generation system with turbines in the Gulf Stream off the Florida coast.

2066: Valles Marineris on Mars is flooded.

2067: Iceland joins European Union after protracted disagreements about its fishing rights are resolved.

2072: GenTech Pacifica begins construction of Elandra (p. TS33). CRABE abandons Manannán Station due to budget cuts. Humans arrive at Huygens Station, establishing permanent settlement on Titan.

2074: An unknown group of Preservationist activists forms the terrorist group Blue Shadow.

2075: GenTech Pacifica's Aquamorph parahuman design becomes generally available.

2077: Bhuiyan Genetics begins producing Aquamorph parahumans and variants using pirated designs, for Bangladeshi government initiative to settle Bay of Bengal.

2079: Avatar Klusterkorp arrives on Europa and begins building Genesis Station.

2080: GenTech Pacifica begins commercial production of Sea Shepherd bioroids.

2081: Green Duncanites sponsored by Avatar Klusterkorp begin secretly seeding Europa's ocean with altered life forms.

2083: Incidents occur between TSA submarines and Chinese arsenal ships.

2084: The Pacific War begins. TSA forces fire cruise missiles at Chinese ports and naval vessels.

2085: The Pacific War ends in a European-negotiated truce. Thai ocean-tech company Sakolpok relocates to Indonesia.

2086: Ondala floating settlement off Panama granted free city status by Caribbean Union.

2088: U.S. Coast Guard destroys "Sovereign State of Zeeham," a small drift community, after finding evidence of bioroid smuggling activity in U.S. waters.

2089: Elandra gains seat in Australian Federal Parliament.

2090: United States demonstrates first successful use of a laser weather satellite to deflect a hurricane from the South Carolina coast.

2091: China's People's Liberation Army Navy (PLAN) and the Japanese Maritime Self-Defense Force (JMSDF) stealth submarines accidentally collide over the Japan Trench, forcing the deepest rescue mission ever attempted.

2092: Blue Shadow attacks Elandra's aquaculture facilities, prompting a concerted campaign for independence of the settlement. Residents preferred GenTech Pacifica's protection to that of the Australian government. A separate raid on the U.S. Navy's Pearl Harbor research base releases two E-model WarDops. CRABE expands with the building of Chyba Station on the Europan sea floor.

2093: Chinese weathersat heats large regions of the East Pacific Ocean in an effort to trigger an El Niño event; an El Niño occurs, but experts argue over any causal link.

2094: Under pressure of memetics campaign by GenTech Pacifica, Australian government grants Elandra free city status. China and Korea engage in military standoff over economic zone of new Chinese arcology in Yellow Sea.

2095: Failed U.S. attempt at controlling Hurricane Ophelia results in massive damage to Nassau.

2096: Caribbean Union initiates action in World Court against U.S. weather control program. Biotech Euphrates laboratory ship *Gregor Mendel* is destroyed in the Mediterranean, the first action of terrorist group Irukandji. CRABE scientists discover pantropic life forms, exposing the Europa Project's existence.

2098: Europa Defense Force (EDF) arrives on Europa and launches attacks on Avatar Klusterkorp operations, beginning the War Under the Ice.

2099: Infomorphs at Vostok Station in Antarctica report their humans are showing signs of nanovirus infection, then go offline. Journalist Copernicus Jones escapes EDF captivity and reports on the War Under the Ice.

THE BLUE WORLD

Water covers 71% of the Earth's surface. The oceans, seas, and lakes may look similar from the surface, but they hide a vast variety of terrain, resources, and human activity that make each body of water unique.

PACIFIC OCEAN

The Pacific Ocean covers nearly half the globe. Almost anything that happens in the oceans of Earth can be found here. The Pacific basin is surrounded by 30 continental nations and holds another 17 island microstates and dependencies, ranging from the wealth of the United States and the might of China to dirt-poor Kiribati. Many of the tiny island nations are in serious danger of vanishing as global sea levels continue to rise. Technology may provide ways to build more land or adapt people to live without it, but most of these nations can't afford such solutions. Some of the boldest experiments in transhumanism and Fifth Wave culture are taking place in the Pacific, and also some of the greatest human tragedies.

Change and Development

As the 21st century began, scientists saw the Pacific Ocean as an indicator of global climate change. Its surface waters were warming measurably, resulting in the bleaching and death of coral reefs off the Australian coast and around Pacific island nations. The increased heat of the ocean triggered intense El Niño phenomena (p. 27), causing altered climate patterns such as severe droughts and violent storm activity around the world.

The nations of the Western Pacific have seen longer and more intense droughts than at any time in recorded history. Many island nations began importing fresh water in the 2020s, until advanced solar technology and D-T fusion reactors made large-scale desalination plants practical in the 2030s. D-T reactors in some of these countries remained in use long after their neighbors had switched to solar power or helium-3 fusion, because the nations running them were too poor to upgrade and too isolated to be of concern to radiation-wary developed nations. The western coast of the Americas has benefited from increased rainfall, making nations such as Chile and the United States reluctant to combat climate change.

The tropical regions of the Pacific are among the best sites for floating arcologies and submarine settlements. The first Pacific arcology was built in the northern Great Barrier Reef off Australia from 2042-47, following a promising start with similar projects in the Mediterranean Sea. Spurred by the industrial explosion of the "Booming Forties" (p. FW8), many such settlements were built over the following decades in the shallow seas around Australia, New Guinea, Indonesia, Malaysia, Japan, and off the southern coast of California.

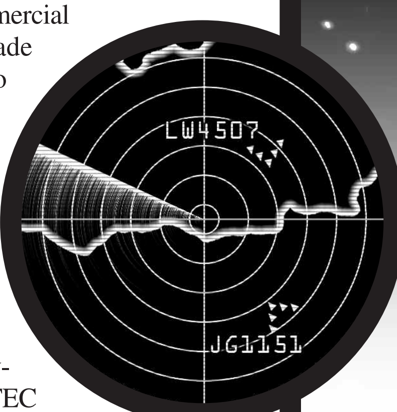
A new era in pantropism began in 2072 when GenTech Pacifica began building Elandra 350 miles off the coast of Fiji (see p. 32). As the first permanent underwater settlement, it provided a base of operations for aquatic parahumans within their own domain – something they hadn't had before. It is also spearheading and encouraging further development of underwater regions as habitats. Since then, several other sea-floor habitats have been built in various places throughout the Pacific.

The Pacific War

The Pacific War of 2084-85 was fought across the entire Pacific Ocean. Hydrofoil and submarine forces of China and the TSA engaged in fierce naval actions in the South China Sea. China bombed the ports of Haiphong, Ho Chi Minh City, and Bangkok, and marine commando raids released devourer microbot swarms on Vietnamese and Thai naval facilities. Several floating cities from both sides were destroyed. The sinking of Malaysia's Bandar Lautang arcology by a Chinese torpedo attack killed 10,300 people in the highest fatality action of the war.

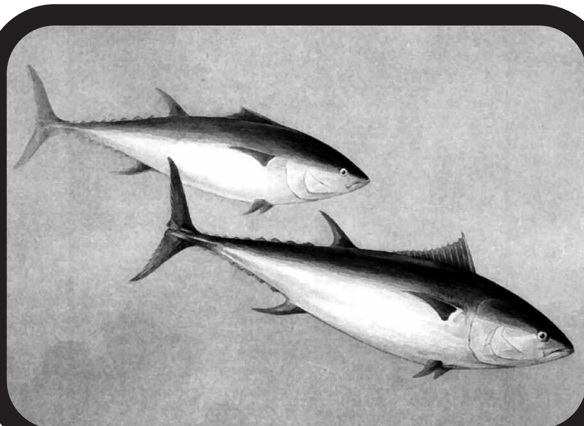
Although China succeeded in preventing the release of alleged "black" nanovirus weapons with its preemptive strikes, the TSA had some simple nanoviral agents designed for use on animals ready. Submarine NAI cybershells released these into Chinese aquaculture facilities, rendering a significant portion of China's farmed fish toxic. Similarly affected fish continue to turn up in the South China Sea occasionally, suggesting that some of these ecohostile weapons are still active today.

In the aftermath of the war, the TSA had to rebuild much of its energy infrastructure. The vulnerability of solar power satellites had been clearly demonstrated when China crippled the system in the first hours of the war. Unable to acquire commercial quantities of He-3 due to trade embargoes, the TSA looked to Earth-based power sources with new determination and focus. The location of all the TSA nations in the tropics led to the choice of ocean thermal energy conversion (p. 30) as the primary solution. Corporations in Indonesia and Peru, partially subsidized by their respective governments, have built large OTEC power stations in the seas of the Indonesian archipelago and off the Central American coast, and have many more under construction.



Current Events

In 2100, the Pacific remains the most militarized of the world's oceans. The Chinese Peoples' Liberation Army Navy (PLAN) and the navies of the TSA and PRA patrol its waters, engaging in tense games of cat and mouse along their maritime borders. The U.S. Navy tries to monitor the activities of the adversaries in this three-way cold war. Recent shifts in foreign policy mean the United States is more likely to intervene in external conflicts, though its ability to moderate open aggression has not yet been tested.



Hostilities remain restrained for the most part. The last serious incident was in 2094 – a standoff between China and Korea over control of part of the Yellow Sea around the construction site of a new Chinese arcology. After some negotiation with the United States as a mediator, the PRA reluctantly agreed to have Korea withdraw its effective Exclusive Economic Zone (EEZ; see p. 45) boundary by 20 miles, but resentment still simmers.

Despite these tensions, the majority of traffic in the Pacific is commercial. Cargo tonnages have dropped in recent years with the rise of general-purpose robotic construction facilities and minifacturing using common blueprints, but more goods are still shipped globally than at the beginning of the 21st century. Two major economic blocs span the ocean, making shipping densities in parts of the Pacific the highest in the world.

The Pacific is the also most dynamic ocean geologically. The "Ring of Fire" – the zone of tectonic activity that encircles the Pacific Plate – produces deep earthquakes that can create devastating tsunamis. Subduction zones and hot spots produce volcanic islands, and feed volcanic activity in the Americas, Russia, Japan, and New Guinea. Upwellings of magma below the sea floor create hydrothermal vents where strange life forms flourish, and where eager corporations collect and process rich ores for industrial use. Many of the poor Pacific island nations are finding they can earn much-needed income by selling exploitation rights to underwater resources.

ATLANTIC OCEAN

The Atlantic Ocean has been witness to some of the bloodiest episodes in human history, as the great naval powers of Europe fought over the division of the pre-industrial world. In the 21st century, only one naval campaign was waged in the Atlantic: the battle over the Falkland Islands in the Antarctic War of 2033-34 (p. FW25). Perhaps of greater importance was the final battle in a long, one-sided campaign of man against fish.

Fishing and Mining Rights

It is when man shall have discovered the means of restocking the sea and of controlling its supplies that his "dominion over the fish" will be perfect. The power to deplete, which so far marks the utmost limit of his advance, is mere tyranny.

– F. G. Aflalo, ***The Sea-Fishing Industry of England and Wales****, 1904*

There are no bluefin tuna left in the North Atlantic. Our tyranny over the fish is now perfect.

– Selig Moore, First International Conference on Fish Stocks, 2013

In 2011 the tuna fishing fleet in the North Atlantic Ocean landed a total of 97 bluefin tuna, less than 2% of the previous year's catch, and about 0.1% of catches just a decade earlier. Commercial tuna fishing in the Atlantic became unprofitable and the industry collapsed along with the bluefin population, which had clearly passed a critical point and was considered on the verge of extinction. A major international conference was held two years later to discuss the state of fisheries worldwide, but it failed to resolve anything amidst a plethora of competing interests. Fishermen and governments, convinced that if they didn't catch the fish, someone else would, continued to ignore the call for drastically reduced quotas. As the fish became scarcer, tensions between fishing fleets rose to boiling point.

Ongoing incidents between the Canadian navy and Spanish- and Portuguese-owned fishing vessels in the Grand Banks region erupted into violence in 2031 when shots were fired. The Canadian government, rapidly losing ground to seceding provinces, engaged half-heartedly in the ensuing series of hearings and appeals in the international courts. The loss of authority over its fishing grounds was one of several factors leading to the secession of Newfoundland from Canada in 2039.

Fishing rights also played a pivotal role in Iceland's reluctance to join the European Union. Under original E.U. rules, all member nations have the right to fish within each others' Exclusive Economic Zones (p. 45). Iceland wished to maintain sole control of its fisheries to the 200-nautical-mile limit, citing cultural and economic imperatives, rather than allowing nations who traditionally encroached on its waters to share its bounty. The disagreement was only resolved when computer-modelled ecology studies in the 2050s established the fragility of Iceland's fishing grounds and the European Union established new joint management rules that prevented other member nations from exploiting them.

Sea-floor mining first became an international concern when the United States began mining methane hydrate (p. 25) on the Blake Ridge, midway between Florida and Bermuda, in 2029. As this was in international waters, the United Nations requested a share of the profits, as specified in the U.N. Convention on the Law of the Sea (p. 45). The United States, not being a signatory to the treaty and having withdrawn from the United Nations in 2025, refused – an act that signaled a significant erosion of U.N. power and furthered its decline into irrelevance. Developing nations, supported by the European Union, demanded compliance from the United States, but it still refused to comply, triggering a temporary cooling of relations between the United States and the European Union.

Current Events

The Atlantic still supports a vast amount of shipping. With E.U. members on both sides of the ocean, trade is brisk on northern shipping routes. And in the South Atlantic, Argentina, Brazil, and South Africa generate considerable traffic.

Sea-floor mining is now taking place in several locations. The Faeroe Islands, Azores, Cape Verde, and the tiny British dependency of Ascension are all bases for nearby mining operations. There are also deep-sea operations in international waters, with several countries following the United States' lead and exploiting the resources for their own profit. These include Argentina, South Africa, The Netherlands, and Germany.

The Atlantic is home to many aquatic settlements. Franklin City, situated not far from Puerto Rico, is the next largest sea-floor settlement after Elandra, and others dot the Caribbean Sea and the shallow waters around the Azores. Floating habitats can be found in almost every corner of the Atlantic, clustered most densely in the Caribbean, the Gulf of Mexico, along the east coast of the United States, and north of Brazil.

Despite warmer global temperatures, there are more icebergs in the North Atlantic than at the start of the 21st century. The Greenland ice sheet is breaking up at an increased rate and northerly winds, strengthened by frequent El Niño conditions (see p. 27), blow the resulting icebergs down the Newfoundland coast.

Hurricanes in the Caribbean are less frequent than at any time in recorded history, but those that do form are often intense. El Niño events suppress Atlantic hurricane activity, but the strong La Niña events occurring between them generate strong hurricanes with greater likelihood of landfall on the U.S. and Central American mainlands.

Indian Ocean

The Indian Ocean differs significantly from the Pacific and Atlantic in that its northerly extent is bounded by the Asian landmass. This affects climatic patterns and produces the characteristic monsoon seasons of South Asia.

Politically, the Indian Ocean is bounded by more power blocs than the larger oceans, making it a lively place for territorial and resource disputes. However, most of the nations bordering it are poor and undeveloped; India dominates the region, but the Islamic Caliphate and South African Coalition have considerable naval strength and press their claims opportunistically.

The ocean itself is less developed than the Pacific or Atlantic, with far fewer aquatic settlements, arcologies, and sea-floor mining operations. The government of Bangladesh, which is establishing large communities of aquatic-adapted parahumans and uplifted sea animals in the Bay of Bengal, supports the major settlement initiative. Most other settlements are Islamic floating arcologies in the Persian Gulf.

Southern Ocean

The Southern Ocean is the coldest and roughest in the world. Throughout the 21st century, global warming caused the harsh southern winds to strengthen, creating mountainous seas with waves regularly exceeding 25 feet at latitudes from 50°S to 60°S. Pack ice still forms every winter, extending north to nearly 60°S at its maximum in October. This quickly melts over the summer, leaving clear sea lanes to most parts of Antarctica.

Pack ice severely restricted the British campaign against Argentine oil drilling bases on the Antarctic Peninsula for the first eight months of the Antarctic War in 2033 (p. FW25). It was only with the summer thaw late in the year that the United Kingdom managed any solid gains against the Argentine forces.

The slow breakup of the Ross and Ronne ice shelves occasionally injects enormous icebergs into the eastward-flowing circumpolar current – floating islands up to 200 miles long, 60 miles wide, and 2,500 feet thick. The accelerated flow of many Antarctic glaciers produces prodigious numbers of smaller icebergs in the southern summer. These drift as far north as latitude 50°S with some regularity, and occasionally as far as 40°S in the Atlantic Ocean.

There are no known sea-floor or floating settlements anywhere in these inhospitable seas. The Argentine company Agua Negra (p. 83) has recently begun sea-floor mining on the continental shelf near the Antarctic Peninsula, using submarines to keep the bases supplied throughout the winter.

Arctic Ocean

The Arctic Ocean, surrounded by Russia, Norway, Greenland, Nunavut, and Alaska, is the smallest and least developed ocean. The first four are disinclined to, or incapable of, exploiting the ocean's resources, while the United States has far more promising and less difficult projects elsewhere. The major initiatives dealing with the Arctic Ocean are environmental and cultural preservation. Nunavut is leading a campaign to protect the ocean and its ecosystems from damage caused both by direct industry and by climate change.

Most of the ocean is covered by polar ice that never fully melts. Seasonal pack ice covers the remainder of the ocean in winter (see *Ice*, p. 24). It melts in summer to leave open sea north of every landmass except Greenland, although the water does contain scattered icebergs. Commercial fleets and navies use these passages in the summer months, significantly shortening the trip between the North Atlantic and Pacific oceans. The ice circles slowly clockwise in the Arctic current.

Mediterranean Sea

At the heart of the cradle of civilization, the Mediterranean Sea remains one of the busiest waterways of the world. Vast numbers of ships ply age-old trade routes between European nations, Northern Africa, and the Middle East. The last open hostilities in the Mediterranean were the final naval actions of the Aegean War in 2013. Since then the sea has been at peace, with tensions between Israel, surrounding Islamic states, and the European Union lessening gradually over time.

Being almost fully enclosed by land, the Mediterranean experiences almost imperceptible tides and maximum wave heights of only three to five feet. Because of this, and the mild climate, it is an ideal location for floating settlements, and the largest in the world are found here. Scores are anchored off the coasts of Italy, France, Catalonia, and Spain. Three spectacular floating cities of metal and glass lie off the coast of Monaco, more than doubling the living space available to the tiny country and drawing wealthy tourists from around the world – and off-world – to lose money in the casinos. Sea-floor habitats are less economical and only a few corporate bases exist.

The Mediterranean is relatively poor in useful sea-floor mineral deposits, so mining is not a major industry. The Mediterranean does, however, hold treasures of a different kind – most deep-sea expeditions in its waters are archaeological in nature (see *Marine Archaeology*, p. 85).

Water flows into the Mediterranean from the Atlantic Ocean at surface level. Evaporation increases the salinity of the water, which sinks because of the resulting density increase. At depths up to a mile, this dense saline water flows back out into the Atlantic through the Strait of Gibraltar. Submarines can take advantage of these currents and ride silently through the Strait simply by selecting an appropriate depth.

Antarctic Subglacial Lakes

The strangest bodies of liquid water on Earth were discovered in 1995. Hidden deep beneath the Antarctic ice sheet are dozens of lakes of fresh water. The largest, Lake Vostok, measures 140 miles long, 30 miles wide, 2,000 feet deep, and is buried beneath 2.5 miles of ice near the Russian Vostok research station. The lakes have been isolated from the atmosphere for 500,000 years.

These lakes were a perfect testing ground for equipment designed to land on Europa and penetrate its icy shell to explore the ocean below (see p. 57). Joint U.S. and E.U. projects from 2018-2051 used prototype cryobots to reach and study several lakes beneath the East Antarctic ice sheet. They took great care to avoid contaminating the lakes' pristine waters with surface chemicals or microorganisms – precautions that would be even more important on Europa, where some scientists expected to find nonterrestrial life. The Antarctic lakes contained primitive microbial life of their own, supported by the geothermal heat sources that kept the lakes liquid.

The Russians based at Vostok also researched, but by drilling rather than using robotic vehicles. The vast expanse of Lake Vostok was theirs alone to explore, although the political strife in Russia throughout much of the 21st century stifled their efforts. They sank shafts through the ice in 2076 and built a research habitat in the lake. It produced scientific results for 16 years before being officially shut down.

Some radical Preservationist groups claim to have testimonies from ex-Vostok workers that the subglacial base remained operational, experimenting on classified biotech and nanotech programs in the isolation of the lake environment. Skeptics pointed out that Russia was busy rebuilding its economy and that Vostok was too remote to be a useful military base. But the Preservationists' fears seemed vindicated in December of 2099, when Vostok's infomorphs reported a massive nanovirus infection in the base and then went offline. Russia has been strangely reluctant to send a rescue team to Antarctica.

Other Bodies of Water

Black Sea

Although linked to the Mediterranean via the narrow Bosporus, the Black Sea has virtually no exchange of water with the greater ocean system. Currents do not mix the water below 600 feet, beyond which the water contains no dissolved oxygen. The deep waters contain hydrogen sulfide, and support only anaerobic bacteria. This makes the Black Sea a prime site for marine archaeology, as organic relics in the anoxic region do not decay. Biological researchers study the local bacteria for gene sequences useful in extraterrestrial and terraforming applications. Overfishing, pollution, and the accidental introduction of non-native jellyfish in the late 20th century destroyed many commercial species in the sea. With careful ecomanagement, the sea recovered remarkably and once again supports significant fisheries.

Caspian Sea

The brackish Caspian Sea was the site of one of the worst environmental tragedies of the 21st century. Its fragile ecosystem was already under stress because of reduced fresh-water inflow and consequent rising salinity, when Armenian forces bombed Azerbaijani oil drilling facilities in 2021, releasing 300 million gallons of crude oil into the sea. Over 90% of fish species in the sea died out, as well as Caspian seals and several shorebird species. A dead zone for several decades, the Caspian is slowly coming back to life thanks to gengineered oil-eating bacteria and the reintroduction of species cloned from archived DNA.

Red Sea

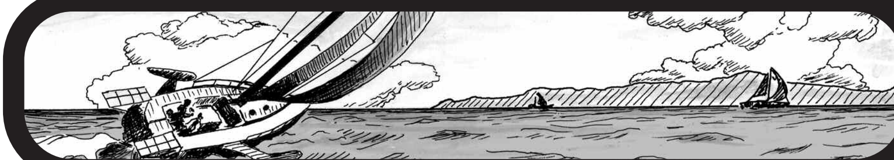
A narrow arm of the Indian Ocean, the Red Sea contains several unique geological and biological features, making it a region of considerable interest for research and industry. It has coral reef ecosystems that have evolved independently of those in the greater oceans for millions of years, providing a treasure trove of genetic material. The sea-floor rift that slowly widens the Red Sea produces hot brine pools (see p. 30) that concentrate valuable minerals. The Islamic Caliphate controls the Red Sea and operates mining facilities and a few floating arcologies.

The Great Lakes

The Great Lakes have remained major shipping channels for the United States and Canada. Cleaner industry and active ecomanagement have returned the lakes to an almost pristine state. There are few aquatic habitats and no mining activity, but there are extensive fish farms in all five lakes.

Lake Baikal

This Russian lake is 5,400 feet deep and holds more fresh water then all five Great Lakes together. It suffered minor pollution in the late 20th century from a large paper mill, but recovered quickly after the mill closed down in 2013. The lake supports a unique ecosystem with over 1,000 endemic species, including the world's only non-marine seals. Lake Baikal is a focus for Preservationist groups, who have successfully lobbied to keep it free of genemod species. It supports a limited amount of tourism and several deep neutrino telescope facilities (see p. 43).



The Fight For the Oceans

The oceans of 2100 are a battleground for philosophical, political, and technological clashes between many different groups.

Environmentalists

When the bluefin tuna stocks in the Atlantic and then the Pacific Ocean collapsed in the 2010s, followed soon after by the extinction of the northern right whale, it provoked the environmentalists to fight for the oceans The bluefin tuna was a powerfully symbolic species for the state of fisheries in general. Suddenly the public began to take notice of the vast damage that had been done to wild fish. It became clear that early 21st century commercial fishing levels were not only unsustainable, but grossly beyond what could be justified.

International commissions charged with the task failed to produce any whole-ocean fish management policy for the next 30 years. Individual countries and alliances produced a patchwork of local policies, which were enforced with increasing rigor, often leading to international political conflicts that sometimes threatened to escalate to outright war. But pressure from fishing industries and nations reliant on seafood destroyed any chance of the drastic global reductions in fishing quotas that environmental experts agreed were necessary. It was only in the 2050s that a consensus of powerful nations, convinced by extensive and detailed computerized ecological models, agreed on the overwhelming urgency of the problem and established strict limits.

Meanwhile, global warming caused by industrial pollution had altered the ocean environment radically. It had destroyed thousands of square miles of coral reefs, disrupted ocean currents, climate, and ecosystems, and caused sea levels to rise, submerging islands and devastating coastal regions.

Progress has been made in environmental management since the early 21st century and most industrial activities on Earth adhere to strict regulations. However, it is difficult to police regulations in remote parts of the world, such as sea-floor mining operations. Companies sometimes cut corners, resulting in disastrous changes to the seabed environment that can affect ecosystems for hundreds of miles around.

Traditional environmentalists are horrified at the havoc wreaked on Earth over the past century. They campaign fiercely for international protocols designed to prevent further destruction and to repair the damage already done. Some environmentalists take a more active approach to restoring the Earth, developing technology to repair and manage disturbed environments (see *Eco-proactivism*, p. 18). Others, known as *Deep Environmentalists*, take the stance that humans are bad for the Earth, and want to return the world to the way it was before mankind evolved.

Preservationists

Mainstream Preservationists (p. TS92) see the ocean as a major environment threatened by genetic pollution. Gengineering corporations tinker with the human genome, spurred by the challenges of the sea to produce parahumans able to live in the oceans and, ultimately, to breathe water. Biotech companies modify aquatic species for specialized uses in industry and release genemods into wild populations. Most ambitiously, some researchers are "uplifting" species such as dolphins and octopuses to sapience (see p. 100), creating entirely new intelligent species. And Preservationists decry it all.

The Preservationist-leaning European Union and Preservationist factions within the United States operate sustained campaigns aimed at curbing these gengineering programs and addressing the problems caused by modified species. These Preservationist groups are making a major effort to establish international cooperation on a new treaty governing the oceans, including clauses to regulate the modification and release of oceanic species. Preservationists argue that because the oceans are shared by all humanity, they must be maintained in their natural state as a heritage resource.

Radical Preservationist groups take their disgust with the manipulation of the oceans beyond the political sphere. Some organize public protests at biotech labs or Web campaigns aimed at destroying corporate reputations. Criminal groups such as Blue Shadow (p. 77) take direct action, sabotaging facilities and "rescuing" – or destroying – uplifted sapients.

A significant fraction of uplifted cetaceans have become outspoken Preservationists, campaigning against the alteration of their genome. They argue that being unwillingly transformed by humanity into intelligent companions – or slaves – is a travesty against their integrity as a species.

Biotech versus Machines

A philosophical schism exists between pantropists and transhumanists over the best technology for colonizing the sea. Some feel that "wet" biotechnology is the best solution for the considerable problems of living underwater. The wet camp holds that by adapting humans physically, any reliance on technology can be minimized, resulting in larger populations that are better able to sustain themselves. Members of this group prefer to use genemod life forms such as squidpacks, maintstars, and fibrokelp, rather than artificial equivalents.

The "dry" group, in contrast, believes mechanical technology is more useful and customizable than biotech, and should be utilized in full. Life support systems for air-breathers living underwater still require largely mechanical components, and robots and cybershells are far easier to build than gengineered sapients or bioshells capable of surviving without air.

Pantropists tend toward wet philosophies, while transhumanists make up the bulk of the dry community. This dichotomy is not universal however, and there is a large middle ground of people who happily use whatever approach gets the job done.

Pantropists

Opposing the Preservationists are pantropists (p. TS91), those who believe humans should be adapted to live in extreme environments. The most extreme environment on Earth is underwater. Adapting the human body to aquatic life is an immense engineering problem – changes must be made to provide oxygen, withstand pressure, avoid heat loss, and allow senses to function. Yet the reward for success is greater still. Parahumans able to live underwater gain access to over 90% of the volume able to support life on Earth.

Pantropists support research and development of radical human gengineering designed to allow this exploitation. They also believe in spreading human culture to the seas by uplifting marine species and integrating their intelligences into human society.

Oceanic biotech companies such as GenTech Pacifica and Bhuiyan Genetics are strongly pantropic, supported by various nations within the PRA and TSA.

Transhumanists

Transhumanists (p. TS93) take a different approach to colonizing the oceans than the pantropists. Non-germline nanovirus and surgical treatments can transform existing humans into forms better capable of living underwater. Some transhumanists exercise morphological freedom by taking such treatments and spending time living in underwater settlements.

A more radical transformation involves destructive uploading into ghost form and the use of aquatic cybershells or bioshells. This allows complete adaptation to the oceanic environment. Cephalopods or transgenic gillmorphs (p. 94) are popular choices for aquatic bioshells, since they have manipulating limbs, but a significant subculture favors those based on cetaceans (see *Cetanism*, p. 16).

Political Idealists

The oceans have become a refuge for those whose political and social beliefs are at odds with those of prevailing governments and societies. Nanarchists (p. TS90) and Decelerationists (p. DB26) are among those seeking lives away from the bustle of the Fifth Wave.

Many people unsatisfied with national governments or the onrush of transhumanity have made the move into aquatic habitats outside national borders and away from the excesses of Fifth Wave culture. Cheap fusion or oceanic energy sources and 3D printers allow such people to survive comfortably outside mainstream society in their own "states."

Some nanarchists use PNCs (see box, p. 17) to establish a minimal-maintenance nationality and allow them to renounce their prior citizenship in a legal manner. Others see this as inconsistent with strict nanarchist principles and prefer a simple renunciation of all citizenship. This has the disadvantage of not being legally recognized – the renounced state still considers such people citizens. This is rarely an issue, however, since nanarchists seldom generate a taxable income and there is no incentive for nations to chase these itinerant citizens.

Decelerationists fear that technology is advancing too rapidly for the good of humanity. A significant fraction of them forgo anti-technology activism and simply settle in places remote from civilization. Although their reasons are based on fear, rather than idealism, Decelerationist settlements otherwise resemble nanarchist colonies, except for less reliance on nanofacturing.

Other idealists have taken to the seas to get away from political systems or regimes they find oppressive (or occasionally, too free). By creating their own extranational colonies, dreamers and rebels get to set up their own administrative and legal systems. Some are peaceful near-utopias, while others are tiny totalitarian or slave states. Visitors to the many somewhat rustic oceanic settlements can find widely varying receptions, depending on why the inhabitants are there.

In 2100, there is a growing population of third-generation idealists living in oceanic habitats. It is rapidly becoming impossible to trace lines of citizenship among the new generation, resulting in many people effectively having no citizenship at all and being Zeroed (p. CI32) in the global society. For the nanarchists this is the beginning of their dream. For the nations who occasionally have to deal with them, it is an administrative nightmare.

Corporate Interests

The pursuit of profit drives the vast majority of development in the oceans. Sea-floor mining is highly lucrative for companies with the right equipment, and can be done far from the reaches of government regulations. Fishing companies continue to press the limits of "sustainable" quotas set by ecoscientists who still don't fully understand the interrelationships of the ecosystem. Transhumanists and parahumans want new aquatic technology to improve underwater life. Some Preservationists accuse companies such as GenTech Pacifica of developing aquatic sapients specifically to create a captive market reliant on underwater technology for life itself.

Corporations have relocated offshore in droves. Building a new island in international waters and operating from it puts companies outside the jurisdiction of national governments. Research can proceed unregulated, to the consternation of nations, Preservationists, and the Genetic Regulatory Agency. And some companies set themselves up as *de facto* governments of their own, practically enslaving workers and producing outcry amongst sapient rights groups – if they learn about it at all.

But once the threshold is crossed you can turn back slowly and look up . . . Behind the looking glass the sky is made of water.
– Philippe Diole, *The Undersea Adventure* (1951)

Criminals

Pirates and smugglers still prowl the oceans of 2100. Their motive is the same as it has been for centuries – profit – but their methods and equipment have evolved to try to keep a step ahead of the law enforcement agencies which dog their every move. With cargo ships increasingly automated and often having no live crew, boarding and taking control may seem easy, but boarders must overcome security devices and safety protocols. A modern pirate is as likely to be an electronic surveillance systems and computer security expert as a good shot. Pirates favor rapid deployment and retreat options over stealth, and will often have fast hydrofoil or biphibian craft for surprise attacks, particularly in archipelagos with plenty of remote hiding spots such as the Philippine and Indonesian islands (heavy with PRA and TSA traffic) and the Caribbean.

The smugglers' trade has also changed considerably over the 21st century. With biogenetic manufacturing and the legalization of many drugs it is no longer profitable to physically transport narcotics, but the smuggling of weapons and advanced technology into developing nations is still viable. One of the most notorious examples of overwater smuggling is the illegal movement of bioroids – either individuals escaping from nations where they have few civil rights to the European Union or South African Coalition, or the trafficking of restricted models to unscrupulous buyers (see p. TS106). Although smugglers can use ingenious methods of disguise or concealment to slip bioroids past customs inspections, the old standby of landing on an unpatrolled stretch of rugged coastline is still popular.

Memes

Living in an aquatic environment encourages the creation and spread of new philosophies. Land-based society is also affected by ideas that have their genesis in the oceans.

Amniotism

The oceans spawned life on Earth, and nurtured it through three billion years of evolution before the first organisms colonized the land. Now there is a growing movement to return to the water to live.

Advertising companies originally spread a meme promoting life in newly developed aquatic habitats as novel and safe from the ravages of heavy weather, in the loving embrace of the "mother ocean." Some transhumanists and pantropists took this message to heart and started the amniotism movement. It is a small "new age" movement, but slowly gaining in popularity. A handful of sea-floor habitats are entirely populated by amniotist communities, and amniotists can be found in most others, although there is nothing about their way of life that makes them stand out.

Archaeobiology

One of the most important gengineering breakthroughs of the 21st century was the ability to clone organisms from preserved tissue. With so many species driven to extinction over the previous centuries by hunting and habitat loss, re-establishing viable populations has been instrumental in maintaining ecological diversity and ecosystem health. Archaeobiology is the practice of resurrecting extinct species, and the support of this process by activist sections of the community. Glamorous archaeobiology projects have successfully resurrected the Tasmanian tiger, Florida panther, and northern right whales, but more important work is done with little-known species of fish, corals, crustaceans, and algae, preserved in sample jars before being wiped out in the late 20th and early 21st centuries.

Atlanteanism

Some people see living in the ocean as a challenge to be met head-on. The technological and physiological difficulties are considerable. Self-styled Atlanteans argue that the ocean is a harsher environment than space, and that spacers are taking the *easy* route to spreading humanity.

Atlanteanism is popular with the gruff worker-types who do much of the hard labor building and maintaining aquatic habitats and machinery. There is a semi-formal Atlantean Society, which operates much like a 20th-century fraternal lodge, with groups meeting for social activities and offering hospitality to visiting members. Some major port cities host Atlantean lodges, but most are based in floating or sea-floor habitats.

Although anyone can agree with the philosophy or join the Society, the stereotypical Atlantean is a rough-and-tumble pioneer with an overbearing personality and short temper, but a heart of gold. Spacers and other detractors refer to Atlanteans derogatively as "Kelp Kowboys."

Cetanism

For hundreds of years people have been drawn to dolphins because of their intelligence, possible sapience, and supposed spiritual awareness. With the advent of bioroid bodies and destructive uploading, some people chose to become ghosts in order to inhabit dolphin bioshells. The practice has grown until there are now a few thousand cetanists swimming the world's oceans. Most transfer to other bioshells or cybershells part of the time, but a few live permanently in their dolphin bodies.

Natural and augmented dolphins (see *Cetacean Uplift*, p. 100) accept cetanist shells readily, and with CeTalker interpreter software allowing basic communication it is arguable whether they can tell the difference between a shell and a dolphin. Doolittle dolphins and Delphí (see pp. 101) can understand what a bioshell is, and generally look on cetanists as faintly repugnant, avoiding them where possible.

An offshoot of cetanism is *whalesinging*, in which infomorphs are loaded into rented humpback whale bioshells (see *Cetapods*, p. 98) to spend time communing with natural whales and participating in whale songs, usually during breeding season. Although studies have not uncovered any discernible meaning in whalesong, scientists and whalesingers have compiled an abstract vocabulary of sounds, and it is possible for humans to compose songs that natural whales will mimic. Some Preservationists see this as polluting a natural animal "language" and campaign against it.

Drifting

Many small- to medium-sized habitats float on the ocean surface and travel slowly around the Earth. Most have propulsion systems and follow routes designed either for sightseeing or staying in desirable weather patterns. The people inhabiting these craft are known as drifters. Drifting is not a strict nanarchist movement – drifters have to deal with customs and immigration laws of the nations whose waters they visit, and happily take on supplies and luxury items they cannot produce themselves.

In order to deal with these laws, most drifters retain their citizenship in established nations. Some simply maintain their current citizenship, though this results in certain administrative obligations such as paying taxes. An increasingly popular option is to transfer citizenship to a *citizenship haven* country (see box).

Drifting has its roots in the biotech explosion of the 2020s, when some disenchanted people began buying disused cargo ships and converting them into small floating communities. There was a small surge of interest in the 2040s, when booming economic conditions created a class of *nouveau riche*, some of whom sought alternative lifestyles or wanted to avoid taxation. Drifting became popular with the Transhuman Awakening and Majority Cultures movement of the 2060s (pp. FW12-13). By the outbreak of the Pacific War in 2084, there were over a thousand cataloged drift habitats roaming the seas. Several were destroyed in the war, with great loss of life, dampening enthusiasm for the drifting lifestyle for the next decade or so. In 2100, drifting seems to be in the early stages of another revival.

Citizenship Havens

Citizenship havens are nations that offer a no-frills citizenship to people wishing to purchase it. A *permanent non-resident citizenship (PNC)* gives the bearer an internationally recognized home country and a passport. The bearer may not seek residence in the issuing nation and receives varying amounts of diplomatic support if he gets into trouble in another country, but in return pays only a relatively small annual fee. To the haven nation, PNCs are an inexpensive source of income.

Most nations that grant PNCs perform some minimal background checks to make sure applicants are not wanted criminals. A few undertake more comprehensive checks and rigorously enforce a policy of rescinding PNCs issued to people convicted of crimes. Some nations simply take the cash from anyone who cares to apply for a PNC.

Popular Citizenship Havens

Jamaica: Jamaica has the highest PNC fees of any nation, but to many drifters the price is worth it. Background checks for applicants are extensive and a Jamaican PNC is seen as equivalent to a standard Fifth Wave citizenship by most customs and immigration services. Jamaica offers extensive diplomatic assistance to its PNC holders, including legal advice and representation and, where necessary, arranging for deportation or extradition from foreign territory. Drift habitats flying the Jamaican flag are generally allowed free passage in most parts of the world. Nations offering similar levels of service include Königsberg, Singapore, Kuwait, Montreal, and the Seychelles.

Madagascar: Madagascar is a mid-range citizenship haven. It tries to deny PNCs to people who may be using them for illegal purposes, but with thinly stretched government resources it is not nearly as successful as Jamaica. It does have an active policy of revoking PNCs of criminals, however. Legal assistance is available from Madagascan consulates in many countries, but often this is no more than a cheap case lawyer ready to revoke the PNC at the first sign of trouble. People with Madagascan PNCs are allowed entry by most nations, although those aligned against the TSA eye them with suspicion. Other mid-range PNC providers include the Philippines, Cuba, Ukraine, Armenia, and Uruguay.

Eritrea: Eritrea is a poor nation that issues PNCs freely as a source of badly needed revenue. Showing an Eritrean PNC passport at some ports of entry will result in a thorough search and swift ejection from the country, with good reason. Holders attempting to recruit help at an Eritrean consulate will be laughed at and shown the door. Many smugglers and other criminals are known to use Eritrean PNCs to establish alternate identities. The major benefit of an Eritrean PNC is very low fees, so it is a common choice for nanarchists who don't plan to visit nations. Similar budget PNCs can be had from nations such as Liberia, Belize, Afghanistan, Bolivia, and Fiji.

Ecoproactivism

Ecoproactivism is an environmental movement based on the philosophy that it is no longer sufficient simply to avoid damaging the environment – the damage has been done, and now it is time to clean it up. Early ecoproactivists were behind the efforts to set up the replenishment project that has successfully reversed the decline of the ozone layer.

Although some ecoproactivists are Preservationists, most believe that enough damage has been done to the environment and wild ecosystems that only full utilization of technology can restore the Earth to its former cleanliness and biodiversity. The introduction of genemod species is a means to the end of producing a clean planet with a balanced ecosystem. Obviously, some species can never be replaced, so the next best thing is artificially engineered equivalents. Nanotech and biotech can also be used to tackle some problems, producing cybernetic organisms such as leviathan filterers (p. 123).

Genesthetics

Some gengineers see their work as more art than science. A few take this more literally, deliberately producing outré genemods designed to change morphology in arbitrary ways and produce living works of art. This is referred to as "gene sculpture" or, more commonly in recent years, "genesthetics." On land this is mostly restricted to plants, but aquatic animals provide raw materials of exceptional malleability that live in an environment able to support outlandish body shapes. Cnidarians are popular base creatures – corals can be made to produce marvelously intricate limestone accretions, while jellyfish and anemones are altered into breathtakingly beautiful creatures of filigree and color. More avant-garde genestheticists produce spiky crustacean creations or weird mollusk shells.

Real Food Movement

Growing numbers of people, particularly from heavily traditional Asian cultures, believe that the best-tasting meat and seafood comes from natural sources, not fauxflesh vats. The Real Food Movement lobbies for the repeal of laws banning hunting and farming of terrestrial animals, although many consider that battle already lost. Current efforts are concentrated on supporting aquaculture and commercial fishing, and campaigning against the introduction of fauxfish. The ultraconservative Japanese are leading the campaign for real seafood, and many people who think the movement's attitude to terrestrial animals is barbarically antiquated are coming to agree with them about fauxfish. Conspiracy theorists might wonder who stands to profit from the spread of this meme – see p. 75.

Fringe Memes

Some memes are well outside the mainstream, though they maintain small cores of adherents. Examples include:

Krakenism: Some believe the ocean hides things better left undisturbed. Krakenists are extremely worried by the continuing exploration of the deep sea. What lies down there varies between believers, from monstrous animals, to lost civilizations of surface-haters, to implacable forces of pure evil. Whatever it is, once it knows about people living on the surface, terribly fury will be unleashed. Many krakenists seek safety, either well inland or in space. Some campaign for the end of deep-sea exploration, posting diatribes to the Web or engaging in more sophisticated memetic activities. A few join terrorist groups, where they can actively deter undersea development with force. Particularly paranoid krakenists are often alien contact believers or survivalists (pp. TS87-88, TS92-93).

Nanogaianism: The Gaia Hypothesis, formulated by Dr James Lovelock in the 1970s, states that the Earth is a "living organism," striving through chemical and biological processes to produce optimal conditions for life. Nanogaians believe that nanotechnology is the inevitable next step in this evolutionary process. They wish to see wholesale release of self-replicating biological nanobots designed to clean up pollution, moderate climate, and keep the ecosphere in good condition. Current efforts are focused on the seas, as the environment most suitable for wide dispersal and sustenance of nanobots, although the JOVIAL project (p. DB40) seeks to apply the same principle to Jupiter. Research into self-replicating nanobots is heavily restricted by anti-von Neumann laws in most states, so nanogaians use nanarchist black labs or run secret experiments in legitimate facilities. Some commentators wonder about the fate of the Russian Vostok station in Antarctica (see box, p. 12). Extreme nanogaians take the view that once Earth is seeded with self-replicating nanobots there will be no further need for humans . . .

Prometheanism: Prometheans believe that humanity is destined to know – and to do – *everything*. They advocate the complete exploration and settlement of the Earth and the solar system, from the bottom of deep-sea trenches on Earth to beneath the Europan ice, by whatever means possible.

Surfism: A social behavior meme, based on emulating the lifestyle of late 20th century surfer culture. So-called *surfis* dress in garishly patterned clothing and spend time catching waves or listening to 130-year-old music.

Technodarwinism

Based on Charles Darwin's theory of natural selection, technodarwinists have taken the "survival of the fittest" credo to include the fruits of human ingenuity. Those with a scientific and technological advantage are, in some sense, *meant* to survive hardships that kill those without.

Technodarwinists invariably live in Fifth Wave societies. They look down upon less technologically advanced cultures and the people who live in them. Many of the corporate executives and some political leaders of Fifth Wave nations have technodarwinist leanings, leading to disregard for less developed nations when it comes to matters such as resource exploitation, ecosystem management, and weather control. The subtle spread of this meme is responsible for much of the resistance to a more equitable spread of wealth and technology in the world. Technodarwinism is one of the discriminatory memes that has largely replaced racism in Fifth Wave cultures.

Extreme technodarwinists are known as *neomalthusians*. They delight in the disasters that strike undeveloped nations, killing thousands and bringing the Earth's population back toward "reasonable" levels.

Universalism

There have always been parts of Earth not controlled by any nation-state. Antarctica and the high seas fall into this category in 2100, and universalists want to keep it that way. Universalists are not necessarily Preservationists or nanarchists, though there is some overlap with these movements. Pure universalists oppose the extension of state control into unclaimed areas, believing that some regions should be left to the common stewardship of transhumanity. Ocean floor and Antarctic colonization and mining are universalists' main targets of protest. Depending on secondary leanings, universalists believe either nobody should live in such areas, or individuals wishing to escape government should. Universalism has obvious application to extraterrestrial environments as well.

The Physical Ocean

The ocean is a complex and unfamiliar environment. Understanding its physical features will allow GMs to set campaigns and adventures there, and take advantage of unusual conditions to bring interest and excitement to the setting.

Marine Geology

The oceans lie in basins between the continents. Pieces of the Earth's crust, known as *tectonic plates*, float on the underlying magma and slowly drift with respect to one another, creating fault zones and volcanic chains such as the "Ring of Fire" that encircles the Pacific Ocean. The various features of the ocean's terrain are products of this structure.

Continental Shelf

The continents are slabs of granitic crust, less dense than the thinner basaltic crust that comprises the ocean floors. They thus float higher on the magma, producing the raised areas of land we know. The oceans overlap the edges of these landmasses, forming the *continental shelves*, which are geologically part of the continents.

The shelves lie at depths of up to 600 feet. Their width varies from just a few hundred feet (in parts of the west coasts of Africa and the Americas) to 800 miles (north of Siberia and North America), averaging 45 miles. They have a shallow slope, dropping an average of 10 feet per mile out to sea.

The continental shelf regions support the bulk of the ocean's macroscopic organisms, since much of their area is within the *euphotic* zone – the shallow depths where enough sunlight penetrates to allow photosynthesis. For this reason, and because of their relative shallowness, the shelves are disproportionately populated with commercial enterprises and submarine settlements.

Much of the continental shelf is covered by a layer of fine sediment derived from the erosion of land and coastlines. Rivers and rainwater runoff sweep vast amounts of silt into the ocean. It accumulates until currents wash it downslope over the edge of the shelf.

Continental Slopes

Beyond the continental shelves are the *continental slopes*, where the sea floor drops at an average gradient of 200 feet per mile until it reaches the abyssal plains. Some slopes are as steep as 1,300 feet of vertical drop per horizontal mile.

The main features of the continental slopes are submarine canyons – steep-sided valleys that resemble deep river canyons on land, and occur every one to six miles whenever the slope has a gradient of more than 150 feet per mile. Tributary channels on the continental shelf feed into them. The canyons are formed by underwater avalanches called *turbidity currents* – flows of sediment-rich water moving along the sea floor and falling down the slope. These currents are not continuous like rivers, but sporadic, usually initiated by seismic activity. A large earthquake can spawn major turbidity currents that wash thousands of tons of sediment down the slope in massive underwater landslides that move at up to 20 miles per hour.

At the bottom of the slope, the current deposits the transported sediments in a deep-sea fan formation, much like alluvial fans deposited at river mouths. The largest such fan is the Amazon Cone – the product of millions of years of sediment pouring out of the Amazon River – which stretches 450 miles into the Atlantic Ocean northeast of Brazil.

Unusual Ocean Environments

They say life itself got started in the deep sea. Maybe. It can't have been an easy birth judging by the life that remains.
– Peter Watts, ***Starfish***

Hydrothermal Vents

The spreading of mid-ocean ridges opens tears in the sea-floor crust, through which water penetrates into deep rock layers. Heated by proximity to magma, the water rises and shoots into the ocean in geyser-like *hydrothermal vents*. The hot water carries dissolved minerals leached from the rocks, which precipitate out of solution as it mixes with the cold sea water, forming large "chimneys." Active vents produce billowing jets of particulate matter of varying composition, the appearance of which has led to the nicknames "black smoker" and "white smoker," depending on the color of the plume.

The emerging water can be as hot as 750°F, although 400°F is typical – the high water pressure prevents it from boiling into steam. It is rich in metal and hydrogen sulfides, which form commercially useful deposits, and also provide chemical energy for unusual ecosystems. Far from sunlight, *thiotrophic* (sulfur-metabolizing) bacteria use the vent chemicals and warmth to sustain metabolic processes, forming the base of a food chain that includes giant tubeworms, clams, crabs, and other creatures. The discovery of these communities, which thrived totally independent of solar energy, in the 1970s led to the development of theories regarding the evolution of life on worlds such as Europa. Since the 2049 discovery of Europan life, evolutionary biologists have given vent communities on Earth unparalleled attention.

Cold Seeps and Gas Hydrates

In some places (e.g., the Gulf of Mexico, Eastern Mediterranean, and off the coasts of California and the Aleutian Islands) deposits of hydrocarbons such as petroleum or methane (see *Gas Hydrates*, p. 25) slowly seep through the overlying rock and emerge on the sea floor. This phenomenon is known as a *cold seep*. Gas hydrates form when the cold seep hydrocarbons become frozen into a solid matrix. *Methanotrophic* bacteria metabolize these chemicals to form the base of an ecosystem independent of solar energy. Seep communities resemble the sulfide-powered vent ecosystems, both having clams and tubeworms further up the food chain. Cold seeps are at shallower depths, however, so fish and other creatures visit and interact with them.

In addition to the bacteria, macroscopic creatures also live within gas hydrate deposits. Burrowing worms dig through the ice-like compounds, obtaining energy by metabolizing hydrocarbons.

Brine Pools

Large deposits of salt exist under the sea floor, being particularly common in the Gulf of Mexico and the Red Sea. Water seeping into these deposits returns to the sea floor and collects in pools of brine up to seven times as saline as sea water. The high density of the brine prevents it from mixing with the water above, so the pools are stable features.

Brine seepage is associated with methane seeps, and the regions around brine pools are rich ecosystems composed of mollusks, worms, crustaceans, and predatory fish. Any creature unlucky enough to fall into the brine dies from the salinity, and bodies of animals often float on the brine-sea interface.

Most brine pools are cold places, at the ambient sea temperature, and less than 100 feet across. In the Red Sea, however, pools a mile or more wide form on the mid-ocean ridge that runs beneath the sea, and are heated by volcanic activity to temperatures as high as 130°F. These immense brine lakes are being considered by the European Union as testing grounds for equipment designed to be used in Europa's basal seas (p. 59), but the Islamic Caliphate is reluctant to allow E.U. research vessels near what it sees as a natural resource.

There are very few submarine bases anchored on the continental slopes because of the danger of turbidity currents. Only the shallowest slopes, in regions of low seismic activity, are relatively safe.

Abyssal Plains

At the bottom of the continental slopes lie the vast, flat *abyssal plains* that cover 53% of Earth's area. The sea floor here lies 12,000 to 20,000 feet deep. Any small-scale topographic features are covered by a layer of sediment averaging 2,000-feet thick. The deeper regions – such as much of the North Pacific – are covered by *abyssal clay*, a reddish clay formed of wind-blown particles from land that settle on the ocean and drift slowly down. Shallower plains are covered with a biologically derived sediment known as *ooze*, which is actually the calcium carbonate or silicon dioxide shells of microscopic plankton, not a decaying mass of organic matter as the name might suggest.

Organic material does drift down to these depths from the surface. The decaying remains of fish and other creatures living near the surface form a constant, slow rain of particles called *marine snow*. This is the primary food source of many of the creatures that live in the dark depths.

The abyssal plains are dotted with thousands of submarine volcanoes, forming seamounts that rise from the depths. Most are extinct and simply form vast underwater mountains, unseen by human eyes. Some break the surface to form islands such as the Hawaiian chain. As these islands erode, coral growth can keep them in touch with the surface as atolls.

Trenches

In some places – notably the margins of the Pacific Ocean – the continental slope does not stop at the depth of the abyssal plains, but plunges more steeply into long, narrow *trenches*. These are *subduction zones* caused by the slipping of one tectonic plate beneath another, dragging the sea floor down with it. The deepest parts of the ocean are in these trenches – the Marianas Trench south of Japan plunges to 36,160 feet (6.8 miles) deep. Trenches are hundreds to thousands of miles long and 25 to 75 miles wide. The average slope of trench walls is quite shallow – they are not tight canyons with vertical walls, although local variations can produce such features over a restricted area.

The trenches are the ultimate frontier on Earth. With the availability of deep-diving cybershells, there are no reasons for humans to venture into these depths other than curiosity and thrill seeking. A few tourism companies operate deep submersibles for wealthy clients who wish to experience the trip to the bottom. The highlights of the trip are the bizarre fish that inhabit the deeps. Although they are few and far between, they are easy to see because lights on the submersibles attract them. Cybershells plumb these depths for geological research, but little other activity takes place in the trenches.

Mid-Ocean Ridges

Mid-ocean ridges are the longest chains of mountains on Earth, rising an average of 2.5 miles above the abyssal plains. The Mid-Atlantic Ridge stretches 6,100 miles down the Atlantic Ocean; other ridges run through the Indian and East Pacific oceans. The ridges are areas of continuous volcanic activity that creates new crust on the sea floor, increasing the area of the ocean plates. This is balanced by the destruction of sea floor that occurs at subduction zones. Mid-ocean ridges sometimes penetrate the sea surface – Iceland is part of the Mid-Atlantic Ridge.

Ridges spread at rates of a few inches per year. They have broad, shallow valleys running down their centers, from hundreds of feet deep and wide to three miles deep and 10 miles wide; slower spreading ridges having larger valleys.

Geologists study mid-ocean ridges intensively because they are the most dynamic expression of plate tectonics and show continuous geological activity. Marine biologists also concentrate much of their attention on the ridges, as they are home to the unusual hydrothermal vent communities (see box, p. 20). For these reasons, the majority of deep-sea scientific research in 2100 is carried out along ridges and their associated fault systems.

Oceanography

Pressure

The weight of water causes the pressure in Earth's oceans to increase by 1 atmosphere for every 33 feet of depth. Pressures range from 10 to 20 atm. on the continental shelves to between 350 and 600 atm. on the abyssal plains. At the bottom of the Marianas Trench the pressure reaches 1,090 atm.

Pressure affects living beings in dramatic ways – see p. 51 for the game effects of pressure on characters. Animals are adapted to the normal range of pressures they experience in their lives. Those that spend their entire lives in the abyssal depths will suffer horrible deaths if brought to the relatively low pressure of the surface.

Chemistry and Electrical Properties

Seawater contains dissolved salts, at concentrations from 3.2% to 3.8% by weight, averaging 3.5%. The vast majority of the salt is sodium chloride, though many other substances are dissolved in sea water, including sulfates, silicates, metals, and rare trace elements. The most saline of Earth's major seas is the Mediterranean, though local seas can reach much greater salinities – the Dead Sea is 10 times as saline as the oceans.

The upper ocean is saturated with calcium carbonate – the material used by many sea creatures, from mollusks to microscopic plankton, to form shells. This means the shells do not dissolve. Below 12,000 to 18,000 feet (depending on local conditions), however, the water is cold enough to dissolve additional carbonates. Any shells falling from above dissolve at this depth, and animals living below cannot form shells of calcium carbonate. Abyssal oozes (p. 20) at the lowest depths are thus made entirely of silicon dioxide shells, with no calcium component.

The salt content means sea water conducts electricity reasonably well – a fact used by several sea creatures, which have evolved electricity-generating and -detecting organs for defense and sensation. It also means that electromagnetic waves such as radio and light are absorbed very rapidly. Radio is essentially useless underwater, except for specialized Very Low Frequency (VLF) and Extremely Low Frequency (ELF) transmissions, which require antennae hundreds of feet in size.

Temperature

The uppermost layers of Earth's oceans are influenced by atmospheric circulation and solar heating, making them the warmest part of the seas. Below a certain depth, seawater is uniformly cold. The layer in between, where the temperature changes rapidly with depth, is known as the *thermocline*. The depth and thickness of the thermocline depends strongly on latitude, season, and time of day.

In the tropics, the water is heated to temperatures up to 80°F near the surface. This drops to 40°F around a depth of 1,800 feet, with a strongly defined thermocline between the warm upper layers and the cold waters below. In mid-latitudes, the thermocline is deeper because water mixing is greater than nearer the equator. The surface temperature varies between 50°F and 70°F depending on season, but between 200 and 3,000 feet deep the temperature drops gradually to 40°F. At high latitudes, the upper water temperature is near 40°F, not significantly different from the cold water below – here, the thermocline is weak to non-existent. The uppermost layers of the polar oceans can even be *colder* than the deep water below.

Below the thermocline, temperature decreases slowly with depth – two miles down the temperature is 37°F.

Winds and Currents

Differential heating of Earth by the sun generates three large atmospheric convection cells in each hemisphere. Warm air rises at the equator and near latitude 60°, and cool air falls at the poles and near latitude 30°. The *Coriolis effect* – a deflection of objects traveling along the surface of a rotating sphere – acts on these cells, causing wind flowing toward the equator to deflect westward (in the tropics and polar regions), and wind flowing toward the poles to deflect eastward (in the mid-latitudes). Prevailing winds in the tropics are thus easterlies (blowing from the east), and are called *trade winds*. In the mid-latitudes, winds are predominantly westerlies.

These winds act on the ocean surface, driving the movement of the upper layers of water. Again, the Coriolis effect complicates matters – water is actually driven perpendicular to the wind direction. Also, unlike the wind, water movement is restricted by the continents. The overall result is that surface ocean currents generally circulate clockwise in the northern hemisphere, and counterclockwise in the southern hemisphere. These circulation cells can be as wide as an entire ocean, or can be constrained in size by peninsulas, islands, and other currents. The greatest movement of surface water is the Antarctic Circumpolar Current, which circulates eastward around the frozen continent.

Surface currents carry warm water from the tropics toward the poles. Particularly notable are the Gulf Stream, which flows north along the east coast of North America, carrying warm water north and then east toward Europe, and the Kuroshio Current, which performs a similar function near Japan. Cold water is carried away from the polar regions by other currents. The best example of this is the cold Peruvian current, which brings Antarctic water north along the west coast of South America. This water is rich in nutrients and supplies raw material for the rich fishing grounds off Peru.

Sea Breezes

Land heats up more quickly than water during the day, setting up convection cells in which warm air rises on a coast, flows out to sea at high altitude, sinks over the sea, and blows inland at the surface. This is called a *sea breeze*. As the land cools at night, warmer air rises over the sea, reversing the convection and creating a *land breeze* blowing out to sea.

The moist, rising air of sea breezes produces tall cumulus clouds over coastlines, islands, and even floating arcologies. These clouds rise up to 4.5 miles high and can be seen from sea level up to 180 miles away. Ocean navigators without access to GPS systems would be wise to know this . . .

Thermohaline Conveyor Belt: Currents also flow deep in the ocean. Water in the Norwegian and Labrador Seas of the North Atlantic sinks as it becomes colder and denser, then it flows south along the Atlantic floor. This *North Atlantic Deep Water* (NADW) flows as far as latitude 50°S, where it merges with similar cold water sinking off the coast of Antarctica. The resulting *Antarctic Bottom Water* (AABW) flows east, south of Africa, then splits: one current going north-east into the Indian Ocean where it warms and rises south of India; the other, larger current going south of Australia into the South Pacific Ocean, eventually warming and rising in the Mid-Pacific.

Surface currents bring warm Pacific surface water between Asia and Australia into the Indian Ocean, where it joins the rising AABW there and flows west around Africa back into the Atlantic. Surface water flows north in the Atlantic to complete the circuit, which is known as the *thermohaline conveyor belt* because it depends on the temperature and salinity of the bodies of water involved. This circulation plays a crucial role in regulating global climate, transferring vast amounts of heat around the globe.

Waves

As wind blows across the sea, it forms ripples on the surface. These build up to form waves with height dependent on the wind speed. The Beaufort wind scale (see box, p. 23) shows how high the waves are for a given wind speed.

Waves contain energy and transfer it across the sea by their propagation. They lose energy as they travel,

THE BEAUFORT WIND SCALE

Scale	*Wind Speed*	*Wave Height*	*Control*	*CRM*	*Sea Condition*
0: Calm	0-1	0	–	0	Sea like a mirror.
1: Light air	2-3	0.1	–	0	Ripples only.
2: Light breeze	4-7	0.6	–	0	Wave crests have a glassy appearance.
3: Gentle breeze	8-11	1	1 day	0	Wave crests begin to break.
4: Moderate breeze	12-18	3	4 hrs	0	Some whitecaps.
5: Fresh breeze	19-24	6	2 hrs	-1	Many whitecaps.
6: Strong breeze	25-31	10	1 hr	-1	Spray begins to form.
7: Near gale	32-38	14	30 min	-1	Foam blown in streaks downwind.
8: Gale	39-46	19	15 min	-2	Wave crests break into spindrift.
9: Strong gale	47-54	24	5 min	-2	Sea is a dense foam, visibility affected.
10: Storm	55-63	30	1 min	-3	Heavy sea roll, visibility impaired, surface white.
11: Violent storm	64-73	36	1 min	-3	Visibility poor.
12: Hurricane	74+	46	1 min	-4	Air filled with foam and spray, visibility bad.

Scale: The wind force levels and names on the Beaufort scale.

Wind Speed: Measured in miles per hour.

Wave Height: The average wave height in feet. Maximum wave height is just over *twice* this value.

Control: The time interval between control rolls for surface vehicles (see *Naval Action*, p. 151). Shift one row up per positive Size Modifier point, to a maximum of six rows.

CRM (Control Roll Modifier): This penalty applies to *all* control rolls made by surface vehicles.

Sea Condition: Description of the appearance of the sea.

which decreases the height of the wave. When the rate of energy loss equals the rate at which energy is gained from the wind, the waves can grow no larger – a condition known as a *fully-developed sea*. This occurs only if a constant wind blows over a long enough distance for a sufficiently long time, such as during storms in the open sea.

Once a wind dies down, the waves no longer gain energy and simply travel across the sea, gradually losing energy and height. The waves spread out to form a *swell*, the familiar bobbing of the sea that can occur even in calm wind conditions as waves propagate from distant places.

In deep water, waves travel unhindered. As they approach shore and travel into shallower water, their speed decreases because of interaction with the sea floor, and their height increases in response to conserve energy. As the wave height builds up, the top tends to keep traveling faster than the bottom, resulting in the curling, breaking waves beloved by surfers. The energy carried by the wave is released with a crash of noise and foam along the shore. Depending on local geography, this can cause erosion of the shoreline, which is an important factor in coastal development and ecoengineering.

Waves also interact with ocean currents. A current flowing in the same direction as a wave increases the speed of the wave, but decreases the wave height as the wave imparts energy to the current. Conversely, if the current travels in the opposite direction to a wave, then the wave speed decreases, but the current imparts energy to the waves, which increases their height. This can produce giant waves that can be higher than 100 feet. An example is the Agulha Current, which runs against storm waves generated in the Southern Ocean. This ocean is the most violent on Earth, since the currents and winds circumnavigate the globe around Antarctica, producing fully-developed seas with giant waves.

Tsunami are very energetic waves caused by undersea seismic activity. In the open ocean, they are almost indistinguishable from any other type of wave and pass by ships without drawing attention. As they approach a shore, the waves slow down and dramatically increase in height. By the time they reach land they can be over 300 feet high, causing massive destruction on the shore and for miles inland. Tsunami are mostly restricted to the Pacific Rim and islands such as Hawaii.

Tides

The gravitational effects of the Sun and Luna deform the oceans and atmosphere of Earth into a non-spherical shape, producing a *tidal bulge*. Fluid flows toward the point on Earth nearest the attracting body and to the point directly opposite.

Luna causes the dominant tide on Earth. As Earth rotates, it moves through the tidal bulge, which is fixed with respect to Luna. It takes 24 hours and 50 minutes for Earth to rotate once with respect to Luna, producing two high tides and two low tides over this period.

The Sun, although much more massive than Luna, is further away, and causes a tidal force about half as strong, with a period of 12 hours. When the Sun and Luna are aligned (either both on one side of Earth or on opposite sides) the tidal effects combine to form the strongest, or *spring*, tides. When the angle between Luna and the Sun is 90° the weakest, or *neap*, tides occur. Both extremes occur twice a month, with a week between opposite types.

In practice, the tidal bulge's motion around the planet is affected by the shapes of land masses and ocean basins, Coriolis force, and astronomical effects such as Luna's orbital inclination and eccentricity. This means that the timing and height of tides depend heavily on local geography. Some places have almost non-existent tides (e.g., most of the Mediterranean), while some bays and inlets have large tidal variations, up to a maximum of 56 feet in the Bay of Fundy, in the Maritime Union.

In some places, local geography (e.g., a narrowing bay, shallowing sea floor, or steep river channel) amplifies high tides so that the water comes in at great speed, forming a visible wave called a *tidal bore*. The Fuchun River in China experiences the Qiantang bore, a wall of water 15 feet high traveling at 15 mph up the river. The Amazon and Seine rivers also have large bores.

Ice

The freezing point of seawater is 28.6°F. When the air is below this temperature, ice crystals form on the surface and grow until the sea is slushy. Wave action prevents this forming into a solid sheet – further freezing produce discrete chunks of ice known as *floes*. These range in size from "pancakes" one to 10 feet across, up to five miles or more. This temporary winter *pack ice* reaches a maximum thickness of six feet, and can be penetrated by icebreaking ships. Pack ice can form rapidly when temperatures are very low, around -20°F.

Permanent *polar ice* covers the central regions of the Arctic Ocean, reaching maximum thicknesses in excess of 160 feet in winter. In summer it melts to an average of six feet thick, and in some places holes called *polynyas* form. Ice can also develop from the shore outwards into the sea; this is known as *fast ice*.

Icebergs are large chunks of fresh water ice that break off from continental ice shelves or glaciers. They are carried by surface currents and slowly break into smaller icebergs as they melt. They are usually found at high latitudes and can last up to a year in cold conditions, but some drift into warmer waters and can be a danger to shipping. Prevailing climate conditions can increase the dangers of icebergs considerably (see *El Niño and La Niña*, p. 27).

SUBMARINE ACOUSTICS

With radio and vision severely limited by the absorptive properties of seawater, transmission and reception of sound is the most effective form of communication and perception underwater. Sound travels faster in water than in air because it is a denser medium – around 3,300 mph compared to 770 mph in air – and low frequency sound can carry over far greater distances. Most sonar detections involve simple direct-path contact, but there are many ways in which the sound path can be bent or distorted.

The speed of sound varies considerably depending on the temperature, pressure, and salinity of the water. As one travels downward through the layers of Earth's oceans, sound speed initially increases with increasing depth. Within the thermocline, sound speed decreases rapidly as the temperature drops. Below the thermocline, the sound speed increases again with increasing pressure. This general pattern can be modified by surface conditions, particularly in polar seas where surface waters are very cold.

The changing speed causes sound waves to *refract*, or bend, as they pass through the water. Where the sound speed increases with depth, the sound waves will bend upward. If the sound speed decreases with depth, the sound waves will bend downward. Sound generated above the thermocline therefore bends upward, where it can reach the surface, reflect off the water-air boundary, and travel down again. This can repeat several times, trapping the sound within a shallow layer near the surface known as a *surface duct*.

At the top of the thermocline, the sound speed starts to decrease with increasing depth. The depth at which this occurs is called the *layer depth*. Sound waves traveling at shallow angles to the horizontal above the layer depth are bent upward, while sound waves traveling at steeper angles pass the layer depth and are then refracted downward. The region between the upward and downward bending waves receives *no sound waves at all* from a given source, creating what is known as a *shadow zone*. Submarines often operate at depths within this zone, since they cannot be detected there beyond a certain range by sonar devices above the layer.

At the base of the thermocline (1,000 to 3,000 feet deep), the sound speed starts to increase again. If the water is deep enough – around three times this depth – sound waves emitted near the base of the thermocline are refracted back toward the same depth, forming a layer in which the sound is trapped, called the *deep sound channel*. Sounds trapped in the deep sound channel can travel vast distances. Many sonar buoys are built to operate at this depth, and whales use this layer to communicate with pods hundreds of miles away.

As the depth increases, increasing pressure refracts sound waves upward again. If the sea floor is more than 700 feet below the base of the deep sound channel, the sound waves may be bent back up to the surface without hitting the sea floor. If the sound is emitted from a surface vessel, the sound waves refracted from deep water converge in a ring a few miles wide around the vessel known as a *convergence zone*. The waves bounce from the surface and are bent back again, forming multiple convergence zones at regular intervals around the ship, separated by 20 to 30 miles. The zones form an effective early warning system; anything traveling through any of the rings will be detected by sonar, although it is difficult to know in which ring the contact is located.

Sound waves reaching the sea floor can bounce directly off it and on to targets within 10 miles. This only occurs if the sea floor is hard and flat – soft ooze is insufficiently reflective. Sea-floor topography can also block sound waves and create shadows in which submarines can hide.

Another complication in the use of sonar is the *deep scattering layer* (DSL). This is a layer of planktonic organisms and the fish that feed on them. They are so dense in many parts of the sea that they reflect a considerable amount of sound, potentially blocking sonar visibility beyond the layer. The DSL lies at 2,000 to 3,000 feet during the day, but rises at night as the plankton come to the surface to feed in darkness, ranging from 600 to 1,200 feet, depending on the brightness of the moon.

There are also horizontal differences in sound speed within the ocean, caused by salinity and temperature differences near river mouths, melting ice, or ocean current boundaries. Sonar crossing such boundaries can be degraded or blocked entirely.

GAS HYDRATES

Gas hydrates are solid compounds composed of gas molecules locked in a matrix of water. The result resembles water ice. Methane hydrate is stable at the low temperatures and high pressures found at ocean depths below 1,000 feet. It is present in sea-floor sediments along continental margins, particularly of the Americas, Russia, Japan, and Scandinavia. Methane hydrate can permeate sediment up to 3,500 feet thick. The amount of methane stored in suboceanic hydrates is enormous – over 10 trillion tons, or 3,000 times the amount in the atmosphere – representing more than half the organic carbon on Earth. This methane comes from the decay of organic matter by anaerobic bacteria.

These immense reserves were mined in the early 21st century as a fuel source by the United States, Canada, and Japan. Mining was stopped when practical fusion became possible in the 2030s and hydrocarbon fuels lost favor. The mining efforts barely made an impact on the remaining deposits.

In 2100, methane hydrate is a serious concern. The surface heat from global warming is slowly raising the temperature of the deep sea. There are large hydrate deposits in regions where a small temperature rise will cause instability and release the trapped methane. Hydrates act as a cement, stabilizing loose sediment. If a small area releases its methane, the resulting instability can cause large-scale turbidity currents (see p. 22) and release methane over a wide area. In these events, large quantities of gas bubble to the sea surface, producing a foamy liquid with a low average density. Ships sailing in such areas can find themselves unable to displace enough water to stay afloat, making these events serious hazards. A ship caught in a methane outburst will simply drop into the foamy sea, be swamped, and likely sink to the bottom very quickly.

What is worse, methane is a greenhouse gas with 20 times the efficiency of carbon dioxide. Large scale release of methane into the atmosphere will accelerate global warming, resulting in a feedback cycle releasing more methane and driving temperatures 10 to 15 degrees higher.

To date there have been a few small-scale methane releases, but evidence is mounting that they are becoming larger and more frequent. Ecoscientists and engineers are working desperately to find a way to stabilize the immense quantities of methane hydrate covering the seabed, but so far without any success. Several governments are also seriously concerned about the possibility of a rogue terrorist group deliberately triggering methane release, possibly with a nuclear device.

Climate

Earth's climate is determined by complex interactions between the oceans, the atmosphere, and landmasses. The climate has changed considerably throughout the 21st century, due to the effects of industrial pollution. The sea's mean surface temperature has risen by 3°F, causing its level to rise by five feet. These changes mean more energy is available in the climate system, producing more frequent and more intense storms than at any time in history. It is an age of heavy weather. For details about climate change and the effects of heavy weather on land, see pp. FW21-22.

Hurricanes and Typhoons

These intense tropical storm systems originate in latitudes from 10° to 30° in both hemispheres, where the sea surface temperature is greater than 80°F. In 2100, this means almost every sea area in the appropriate latitude band in which it is currently summer or autumn. Storms are called *hurricanes* (Americas), *typhoons* (Asia) or *tropical cyclones* (Australia) depending on local custom – *hurricane* is used here to refer to all such storms. South Atlantic hurricanes are rare because of upper atmospheric conditions. Hurricanes are characterized by sustained surface wind speeds in excess of 74 mph – sustained winds exceed 156 mph in a Category 5 hurricane.

Once formed, hurricanes tend to move toward the west and away from the equator. As they cross latitude 25°, they deflect eastward as they continue away from the equator. These are generalities – individual hurricane movements are chaotic and predictable only by probabilities. In general, hurricanes are most likely to hit landmasses in the southeastern United States, Japan, southeastern and southern Asia, and northern Australia. Hurricanes rapidly moderate into less dangerous rainstorms as they move inland, although they cause great destruction to coastlines.

At sea, hurricanes create mountainous waves that can swamp and destroy ships. In the northern hemisphere, where hurricane winds circle counterclockwise, the area to the right of a hurricane's movement track is the most dangerous. Here, the wind speed is combined with the hurricane's motion, producing the strongest winds and roughest seas. Additionally, the wind tends to draw ships into the path of the storm. On the left side of a hurricane, wind speed and wave height are substantially less, and ships can run with the wind to be taken out the rear of the storm. These directions are reversed in the southern hemisphere.

The terrific winds of a hurricane push a mass of seawater ahead of the storm, creating a bulge of water that can be 25 feet or more above mean sea level. This *storm surge*, combined with rainfalls as heavy as 30 inches in 24 hours, can cause disastrous flooding of coastal areas.

Weather Control

Being able to control the weather has long been a dream of humanity. The first tentative steps were taken in the 20th century with cloud seeding experiments designed to induce rainfall – with mixed results. Meterorologists began to realize in the 2030s that technology might soon allow the manipulation of weather patterns on a large scale, which would be more effective over the long term than attempting to direct local conditions. The unveiling of the Ares Conspiracy (p. TS19) in 2041 and the subsequent birth of the Preservationist Movement dampened any enthusiasm for weather control for the next few decades. However, as temperatures and sea levels continued to rise, and storms became more frequent and ferocious, pressure mounted for the implementation of some sort of mitigation system.

Cloud seeding operations proved ineffectual at modifying hurricanes. In 2089 the first weather control satellite was launched. Operated by the United States, it used wide-beam microwave lasers to heat air masses near

Other Climatic Oscillations

In addition to ENSO, there are several other quasiperiodic climatic variations. Some, such as the cycle of ice ages and interglacial periods, are very long term, and will not feature in a ***Transhuman Space*** game without the use of nanostasis (pp. TS166-167). Two shorter-term cycles are:

North Atlantic Oscillation: This is a variation in the prevailing atmospheric pressure systems over the North Atlantic Ocean. Approximately every 10 years, unusually low pressure near Iceland produces winds that bring warm, wet winters to Europe and the eastern United States, and dry conditions to the Mediterranean. In the opposite phase – currently at its peak in 2100 – these conditions are reversed.

Pacific Decadal Oscillation: This cycle varies with a period of 20 to 25 years. In the *warm phase*, sea surface temperatures off the southern coast of Alaska are elevated. This brings warm, dry conditions to the northwestern United States and cold, wet conditions to the southern United States. It also enhances the effects of an El Niño on North America and partially mitigates a La Niña. The reversed effects of the opposite *cool phase* include enhanced La Niñas. A cool phase is beginning in 2100.

Hurricane Foster in 2090, successfully turning it away from Charleston, South Carolina. Since then, a new science of meteorological engineering has developed, mostly in the hands of AIs running millions of simulation models to help predict the outcomes of a particular piece of atmospheric heating.

The legal ramifications of weather control, already mired in international politics, were complicated in 2093 when China unilaterally used a similar satellite to heat parts of the East Pacific Ocean. Some climatologists claim this triggered the intense El Niño of 2093-96, which brought disastrous climatic conditions to many TSA and PRA countries. Others disagree with this, but most political analysts agree on China's intentions. International pressure has prevented another such incident.

Manipulation of hurricane tracks continues, however. Japan and Australia launched their own weathersats in 2097 and 2098. Malaysia, although not normally threatened by typhoons, is rumored to be working on a weathersat – conspiracy theorists speculate it will be used offensively rather than defensively.

The European Union has protested to all nations involved with weather manipulation, but their responses, if any, usually allude to the fact that Europe never experiences hurricanes, making it easy for them to ignore the damage they cause. In 2095, an attempt to prevent Hurricane Ophelia from damaging Miami went awry and caused the storm to hit Nassau, resulting in the loss of 62 lives and $13 billion in damage. The Caribbean Union brought a lawsuit before the World Court (p. FW55) in 2096, demanding that the United States use its weathersat only after consultation and agreement with the Union, and to compensate the Bahamas. The United States has so far declined to accept a ruling from the Court, so the case remains in limbo.

El Niño and La Niña

El Niño and La Niña are the opposite phases of a climatic cycle known as the El Niño/Southern Oscillation (ENSO). The cycle has an irregular period ranging from two to 10 years.

El Niño phases are characterized by a warming of the East Pacific Ocean, and a linked reduction in atmospheric pressure difference between the East and West Pacific. This weakens the Pacific's tropical easterly trade winds and can even replace them with mild westerlies. In turn, this generally causes drier than normal conditions in the Western Pacific and wet conditions in the Eastern Pacific. Ocean currents are also disrupted, particularly the cold Peru current that causes upwelling of nutrients along the South American coast. During El Niño years, the disruption to the base of the food chain in the East Pacific wreaks havoc on marine ecosystems. The effects are not restricted to the Pacific basin – shifts in high altitude jet streams cause unusual weather around the globe. In particular, densely populated parts of North America and Europe experience warm weather with heavy rainfall.

La Niña events occur shortly after the end of an El Niño, as the Pacific overshoots its equilibrium position. The sea surface temperature and atmospheric pressure differences between the East and West Pacific are increased, resulting in stronger trade winds. This brings heavy rain and typhoons to the West Pacific, while causing droughts in much of the Americas.

The warming of the Earth in the 21st century resulted in the production of more frequent, longer, and stronger El Niño events. Slow-moving subsurface waves in the Pacific act to prevent El Niño events from being sustained indefinitely, and when one finally ends after three to five years it is invariably followed by a severe La Niña. The La Niña usually only lasts a year, but causes massive destruction to heavily populated regions of the Pacific and Atlantic before ocean warming begins another El Niño. The last La Niña was in 2097, and 2100 is expected to be the first year of the next El Niño.

Oceanic Resources

The oceans are at least as rich in resources as the land. Being more difficult to reach, underwater resources have withstood exploitation and now form the greatest storehouse of material wealth on Earth.

Food

The seas have provided a bounty of food since prehistoric times. For most of history, harvesting wild seafood was sufficient. As demand grew and technology advanced in the 20th century, natural stocks were depleted and commercial farming of marine species – mostly mollusks – became profitable. The early 21st century saw the rise of aquaculture, with non-migratory fish raised in captive habitats supplying an increasing percentage of demand.

The fishing industry changed forever in 2034 when an environmentalist group revealed evidence that the Indonesian company PT Payabetung Bioteknologi Terbuka had been releasing gengineered food fish into the wild, causing the decline of several natural species by competition for food sources. Over a hundred genemod fish species have now been identified in the wild, many with unknown origins. Some have prospered and now support significant fisheries. Many have wreaked havoc on natural species. Researchers try desperately to stabilize the ecosystem, while Preservationists decry what has happened and try to prevent further genetic pollution.

The development of AI technology and ecoengineering in the 2060s led to improved management of stocks and increased fishing efficiency. AIs allowed humans to predict and control migration and local movements. Much of this effort was initially focused on preventing the loss of species due to climate change and the warming of the oceans, but it proved to be a losing battle. Attention shifted to managing the altered ecosystems and minimizing destructive species interactions. In the ever-changing marine environment, fishery scientists have their hands full.

The technology that produced fauxflesh and liberated millions of farm animals from Fifth Wave kitchens is starting to replace some seafoods with fauxfish. The plight of fish, crustaceans, and mollusks as food animals has never attracted as much attention as that of mammals and birds, however, and market penetration is still small. The engineering problems are greater too. People are used to oysters that look like oysters, not undifferentiated slabs of oyster-meat, and memetic changes to eating habits are meeting growing resistance, led by the Real Food Movement. There is not enough moral difference between most natural seafoods and vat-grown versions to sustain research and development costs.

Fishing Methods

Traditional fishing methods such as trawl nets and long lines are still in use by Third Wave fishing fleets, but most nations have banned them because of their environmentally destructive natures. Most fishing is carried out with new technologies such as intelligent pearlweb cyberswarms or LAI-controlled dolphin bioshell schools that can swim through the ocean seeking out fish, herd them into a tight school, then entrap them and signal for a service vessel to pick them up with relatively small nets. Such fishing avoids the wasteful bycatches of unwanted species typical of older methods.

Ecoengineering also makes fish more abundant and easier to find. Artificial reefs provide habitat for increasing numbers of shallow-water species. Pelagic fish are attracted to pieces of flotsam, which serve as protection, markers for food, and reference points for assembling into schools. A small raft of seaweed can support a large community of species covering an area of a square mile or more. Strategically placed ecoengineered flotsam habitats can attract vast numbers of fish, making harvesting more efficient.

Fishery managers boost populations by manipulating the base of the oceanic food chain – the plankton. In most regions of the sea, plankton growth is limited

Aquaculture

The alternative to fishing is raising aquatic species in captivity. Mollusks are the easiest to cultivate and many species can be raised with nothing more than wooden frames set up in estuaries and tidal zones, as has been done for centuries. Crustaceans and fish require considerable space and effort to breed, grow, and feed, but the rewards can be worthwhile. Some natural species are unsuitable for aquaculture because they are difficult to breed or consume too much feed for the amount of meat they produce, but more productive genemod versions are often available. Lobsters, for example, become cannibalistic in cramped enclosures, but GenTech Pacifica's "Sandy Claws" germline grows happily in confined quarters.

In 2100, some 60% of seafood is produced by penned aquaculture. (Some people argue that, with the active management of free-ranging species in almost all parts of the globe, *all* seafood is now cultured.)

by the availability of iron as a mineral nutrient. Simply seeding the surface with soluble iron compounds produces dramatically increased plankton growth, and subsequently higher fish yields. Following disastrous experiments in the 2030s, the amounts of iron introduced are strictly controlled to avoid toxic plankton blooms.

Bioresources

The oceans contain vast quantities of biomass, including representatives of every phylum of life on Earth. This abundance and diversity provides scientists, industrialists, and even artists with a broad range of raw material for many purposes. Gengineers modify species for particular purposes, creating enhanced food animals, pharm animals, and organisms for use in construction, transport, ecoengineering, and industrial processing. Some species have been subjected to uplift experiments designed to enhance intelligence and engender sapience (see *Cetacean Uplift*, p. 100). Others have provided new organic compounds usable for drug development.

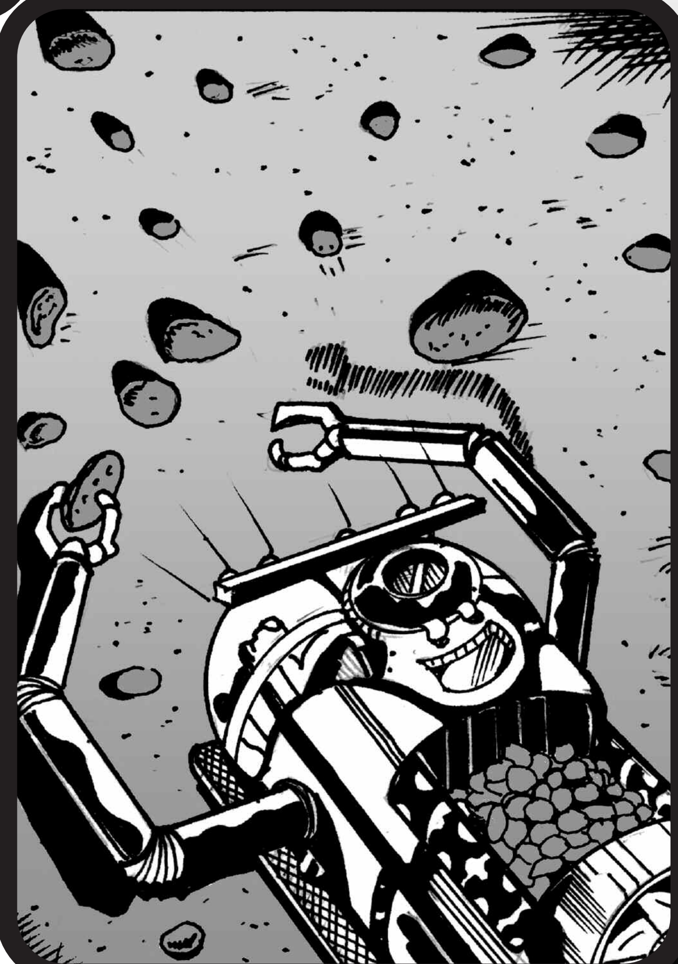
In 2100, the race is on to catalog and genetically sequence as many life forms as possible. Many unknown species live in the oceans, and companies such as GenTech Pacifica and Atlantec have labs dedicated to studying specimens newly discovered in deep and remote habitats. Candidate genes for commercial use are rushed through the patent process to become potential future sources of income. The collecting of specimens and subsequent research are prime targets for industrial espionage and subtle sabotage attempts.

Minerals

Historically, the most important oceanic mineral resources have been petroleum and natural gas. The development of fusion power in the 2030s has dramatically reduced demand for these commodities, but there are still offshore oil platforms drilling for the fossil fuels used in Third Wave regions and for some specialized purposes. These have steadily dwindled in number over the latter half of the 21st century, creating a supply of disused floating platforms suitable for conversion into habitats. Most of the remaining active platforms are in the Persian Gulf, supplying oil for the Islamic Caliphate.

The sea contains many other sources of minerals, which are exploited to various degrees by the mining corporations of 2100.

Manganese Nodules: These are potato-shaped lumps of ore from one to eight inches in diameter, densely scattered across vast regions of the deep sea bed, forming one of the richest sources of industrial metals. Manganese nodules grow slowly by the deposition of metal oxides from the water, catalyzed by micro-organisms, and contain up to 30% iron and manganese by weight. However, it is lesser constituents such as nickel, cobalt, and copper – half a percent each – which make mining the nodules worthwhile. Nodules litter up to 20% of the sea floor, at an average density of 6,000 tons per square mile. Several companies specialize in retrieving nodules, mostly using deep-diving cybershells to collect and transport them to surface ships.



Metallic Sulfides: The hot, mineral-laden water around hydrothermal vents reacts with surrounding seawater to produce metal sulfides, which precipitate out of solution. Black smoker chimneys are the most visible and fastest growing accumulations, but large regions of the sea-floor along the oceanic ridges are covered with older deposits of iron, copper, and zinc sulfide.

Cobalt-Rich Crust: The upper slopes of oceanic islands and seamounts, between depths of 3,000 and 8,000 feet, contain cobalt in concentrations twice as high as manganese nodules. This forms a significant resource for small island states such as the Faroe Islands, Cape Verde, the Maldives, and several Pacific island nations.

Abyssal Clay: The abyssal plain north of Cape Verde is covered with a clay formed from sediment blown off the Sahara Desert. This clay contains 20% aluminum and is mined simply by scooping it off the bottom at depths of three to four miles.

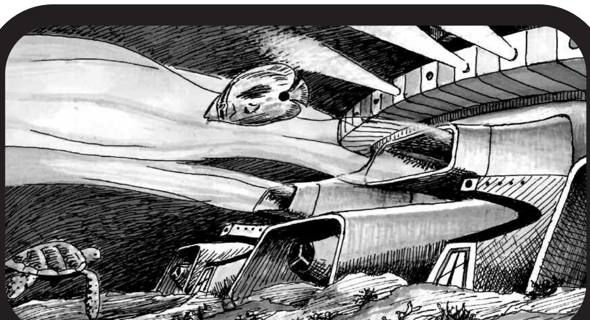
Volcanic Calderas: In rare circumstances, submarine volcanoes can form calderas similar to those formed on land. The Izu-Ogasawara Arc of volcanoes, south of Japan, is one such place. Hydrothermal fluids leach heavy metals out of subterranean rock and deposit them in the caldera, creating fields rich in gold and silver. These lodes can measure 1,000 feet across and 100 feet thick, and are located at depths of one to four miles, at the summits of submarine volcanoes. Mining them is lucrative, but dangerous, as the volcanoes are still active.

Hot Brine Pools: The hot brine pools of the Red Sea (p. 13) accumulate a mud consisting of 40% zinc, as well as usable quantities of copper, silver, and gold. As former pools were covered by sediment, they left this ore behind in deposits up to a mile across and 300 feet thick, scattered across the Red Sea bed.

Dissolved Minerals: Seawater itself is an important source of industrial chemicals, including hydrogen, deuterium, chlorine, bromine, ammonia, methanol, magnesium, and aluminum. These are extracted by self-contained processing stations powered by OTEC or other oceanic energy systems (see *Energy*, see below). Although seawater contains other valuable elements, notably gold, it is still commercially impractical to extract them.

Energy

A vast amount of renewable energy is collected and stored by the oceans in various forms. Extracting this energy is often easier than direct solar conversion, and has the advantage of power being available around the clock. Even deuterium-helium-3 fusion is dependent on the deuterium supply available from the oceans. In 2100, fusion supplies just over half the power requirements of Earth, but much still comes from other sources, with oceanic energy supplying 15% of demand.



Ocean Thermal Energy Conversion (OTEC)

Most of the energy stored in the ocean is in the form of heat. The surface waters of the tropics can be 40°F to 50°F warmer than below the thermocline. Ocean Thermal Energy Conversion systems use this temperature difference to drive a reverse refrigeration cycle in a fluid, usually an ammonia-water mixture. Warm surface water boils the fluid, which drives turbines as it descends to the thermocline, where the cold water condenses it again.

OTEC installations are anchored in deep tropical water. The largest measure 600 feet across, have a main shaft descending to a depth of 1,500 feet, and weigh over a million tons. A station of this size generates 1 GW of power. Many of these facilities have been used as bases for arcologies, housing up to 5,000 people each.

The amount of heat redistributed by an OTEC plant is trivial compared to the bulk of the oceans. It would take a gigawatt plant half a year to reduce the temperature of a cubic mile of surface water by 1°F, assuming the sun wasn't reheating it. Still, some Preservationists and ecophysicists condemn the proliferation of these facilities, arguing that they may cause subtle changes to the world climate, with unforeseeable results. The potential damage of an attack on an OTEC plant, spilling millions of gallons of ammonia into the sea, has been enough to deter ecoterrorists from any such action, so far.

Other Energy Sources

Waves: After heat, the kinetic energy of waves is the next largest oceanic energy reservoir. The most efficient power converters use the heavy swells of the mid-latitudes to wash water through fixed turbines. The largest engineering problem is keeping the turbines still, rather than bobbing on the swell. This means wave generators are usually fixed to the shallow sea floor not far from shore. Wave power generators have an additional benefit, in that they reduce the energy carried inshore, thus slowing shoreline erosion and protecting fragile coastal areas. Many Fifth Wave nations have barrier formations of wave power generators guarding parts of their coastlines, particularly the eastern seaboard of the United States, the European nations bordering the North Sea, and Japan.

Currents: Ocean currents can drive turbines anchored in their flow. Swift currents such as the Gulf Stream are a significant power resource. An array of generators off the southeastern coast of Florida generated up to 20 GW at its peak in the 2070s, but began falling into disrepair when NAHGI (p. TS20) started shipping cheap He-3 back to the United States. Japan operates a more modest facility in the Kuroshio Current off its south coast.

Tides: Although tidal motion carries relatively little energy, tidal power generators are easy to build and common in places with large tides, including Rangoon, Shanghai, Auckland, the Gulf of California, the Bay of Fundy (Maritime Union), Sao Luis (Brazil), and La Rance River (France). Most are barriers built across bays or estuaries, with turbines driven by the tidal motion of water. These facilities each generate a few gigawatts, but power output is variable according to the state of the tidal cycle. Tidal power stations can also convert exceptional tides and storm surges into usable power.

2 LIVING IN THE OCEAN

Kirby sat in the decompression chamber, idly flipping InVid channels. Ten minutes in and he was already bored. He could barely wait to get out of here, board the transport sub, and get back to the surface. The air was in the process of being switched from hydrox back to the real stuff. The only way he could tell was by the decreasing effect on his voicebox, but his LAI was monitoring his blood gases and would sound the alert if anything went wrong. Kirby rubbed the wetskyn patch on his arm and felt renewed gratitude for the perflubron transfusion he had received. Twelve hours to decompress was bad enough – five days of decomp would have been a nightmare. He wanted to feel a draft that didn't come from a duct, smell the evening sea breeze, wafting in off the ocean, with its tangy scent of salt, and of life. The air down here was . . . too clean. Sterile.

The bioroids didn't help either. They made his skin crawl. Few jobs in Elandra needed the expertise of a human, but when one did, there was no option but to endure the compression and live amongst the 'roids for a while. The other down side was the decomp time. But at least he was being paid for it.

The job had required some outside work as well. The Octosap he'd been partnered with had peppered him with questions about what life was like on Fiji, but somehow he could relate to that more easily than to the bioroids who'd been built to look like humans. They were adapted to the pressure down here, of course, which was why there were so many of them, and relatively few humans. The suffrage decision of '95 hadn't caused enough change to affect the '97 council, but a lot of people were nervous about this year's impending election.

Kirby found a news channel. Some riot somewhere. He turned on the InVid information stream. A Biodroiden Befreiungsfront protest in Sao Paulo had turned violent.

Well, at least the revolution here was taking place peacefully. So far.

Elandra

Elandra was the first major ocean-floor settlement and is still the largest. It is located at a depth of 380 feet on a seamount at latitude 22.34° S, longitude 173.12° E, some 350 miles southwest of Fiji. This is in the Hunter Ridge, a chain of volcanically formed seamounts stretching in an arc from Fiji to Vanuatu. The nearest land to Elandra is Vanuatu's remote Hunter Island – a tiny uninhabited volcano poking 970 feet above the ocean, 130 miles to the west.

History

Following the election of a conservative government with an aggressive territorial agenda in 2068, Australia adopted a policy of vigorously defending its interests in the Asia-Pacific region. This resulted in a diplomatic showdown with Indonesia in 2069 over the autonomy of ex-Indonesian microstates, and the initiation in 2070 of the Whaleshark Project.

This project involved the construction of a large underwater habitat operated by the Australian government as a colony, a base for sea-floor mining operations, and a naval support depot. GenTech Pacifica won the construction contract early in 2071 and began drawing up plans for the intended Timor Sea petroleum fields location. Moderate elements in Australia denounced the chosen site as dangerously provocative to Indonesia; political analysts now consider this to have been a major factor in the defeat of the government in the 2071 election.

Unable to cancel the project without an enormous contractual payment to GenTech, the incoming government decided to move the facility to a more neutral location. It chose the remote Hunter Ridge between the friendly states of Fiji, Vanuatu, and the Kanaky Republic. This location provided close access to workable copper and gold deposits on the seabed, industrial metals and sulfur from nearby hydrothermal vents, and a bounty of unique biology for study. The project's name was changed to Elandra, meaning "home by the sea" in the language of a coastal Australian Aboriginal tribe.

Finally given the green light, GenTech Pacifica began construction late in 2072. The initial base expanded slowly with simple prefabricated habitats populated by air-breathing humans and genetic upgrades. The introduction of water-adapted parahumans and bioroids, such as Aquamorphs in 2075 and Sea Shepherds in 2080 (p. TS116), greatly sped up the construction process. They also facilitated mining of nearby resources, creating a boom in the settlement. In 2081, GenTech's new heavy mining division moved in and added significantly to the base. The mineral wealth of the colony, and the burgeoning population, led to the formation of a special interest political community (see p. FW40). With the help and promotion of GenTech, Elandra was eventually granted a seat in the Australian Parliament in 2089.

Blue Shadow activists staged a major raid on Elandra's surface aquaculture facilities in 2092. Unable to mount an effective defense, Elandra lost its stock of genemod food fish before the Australian Navy could respond. GenTech Pacifica increased security and used the Elandrans' dissatisfaction to instigate a campaign for independence that rapidly built momentum. The company had much to gain by removing Elandra from Australia's laws, and its memetic engineers launched devastating attacks against the Australian government's credibility as a competent administrator of the facility. In 2094 Elandra formally applied for free city status as a member of the PRA. Under pressure on a range of other domestic issues, the government granted the request in an ultimately futile attempt to win back support.

The next Australian government quickly re-established cordial relations with Elandra, which included a mutual defense treaty – obviously to Elandra's benefit. What Australia gained was an additional friendly voice in the PRA, which helped it and the Union of Alberta and British Columbia to exert more influence over the three Asian first-tier PRA members.

Physical Description

Elandra has grown to become a medium-sized town, with a population of just over 14,000 humans, parahumans, bioroids, infomorphs, and sapient uplifted animals. It is not a monolithic structure, but rather a collection of separate habitats ranging in size from houses for single families to the central administration complex that is home to 2,000 people and contains workspace for hundreds more. These sprawl over the summit of the Elandra seamount, which has a relatively flat top, shaped in a rough wedge covering three square miles. East and west of the summit area the sea floor slopes gently downward before rising to the adjoining seamounts 15 miles away, while to the north and south the bottom falls away alarmingly to the abyssal plain some 10,000 feet below.

Most habitats are mid-sized and contain apartments for 10 to 30 families. Many of the larger apartment structures are connected to each other and the administration complex by transit tubes, either laid on the seabed or burrowed through it. Transit tubes range from narrow walkways nine feet in diameter to mass transit corridors with slidewalks and lanes for personal scooters.

A typical habitat is sited on or next to a mass transit corridor, with access doors on the lowest level. On each of the two to four levels are several apartments, linked by hallways. Most buildings have a communal moon pool, allowing direct access to the water. These moon pools are all at the same depth because they must be placed where internal pressure matches the water pressure – so lower-set buildings have them on upper floors, while some buildings are not at the right level to have one at all. The oldest habitats are sturdy designs made of stainless steel, with porthole style windows. Slightly newer ones are made of titanium steel, with windows of high-tensile glass. Windows in the pressurized sections can be surprisingly large because there is little pressure difference to withstand. Most new habitats are aquacrete (p. 112), having been grown in place and then lined with nanocomposite – these resemble giant barnacles or coral formations from the outside. Some older habitats have been overgrown with algae or aquacrete to make them look more organic, while others are kept scrupulously clean.

Flooded apartments, preferred by uplifted aquatic animals, are mostly grouped on the eastern side of the seamount, where the inhabitants have formed a cultural enclave. Some have a single air-filled room for air-breathing visitors, accessed through a moon pool.

Toward the edges of the town are more isolated habitats, connected only by walktubes or not at all. Large vehicles are berthed on the outskirts, where a submarine dock connected to the central complex by a wet rail system (with both air-filled and open cars) handles any high-volume traffic.

Industrial facilities are mostly located on the southern edge of town. These include a fusion power plant, water desalination plant, and waste processing and recycling installation. Three large buildings contain hydroponic farms growing fruit and vegetables, as well as fauxflesh vats. Floating above Elandra proper are bubble fence aquaculture cages, in which fish, shellfish, and crustaceans are grown for food. These are tethered to the seamount with cables that double as commlines to floating satellite dishes, giving Elandra access to the global communications network.

Organization

Political

Elandra is an autonomous free city and a full member of the Pacific Rim Alliance. Upon its independence in 2094, it adopted a complex constitution drafted by a committee of several citizens and approved by a general referendum.

The city is administrated by an executive council of seven members, each of whom is directly elected by eligible citizens for a three-year term. The council elects one of its number as the Mayor, which is mostly a ceremonial title. A 30-member legislative parliament is selected by cyberdemocratic random choice (see p. TS89) from volunteer citizens. Legislators serve four-year terms. With AI assistance, the members of the parliament draft laws – often based on citizen initiatives – debate them, and vote on them. Those passed by a two-thirds majority are sent to the executive council for approval. Judiciary members are selected by the executive council, and must be approved by a two-thirds majority of the parliament. They serve 10-year terms, unless impeached sooner.

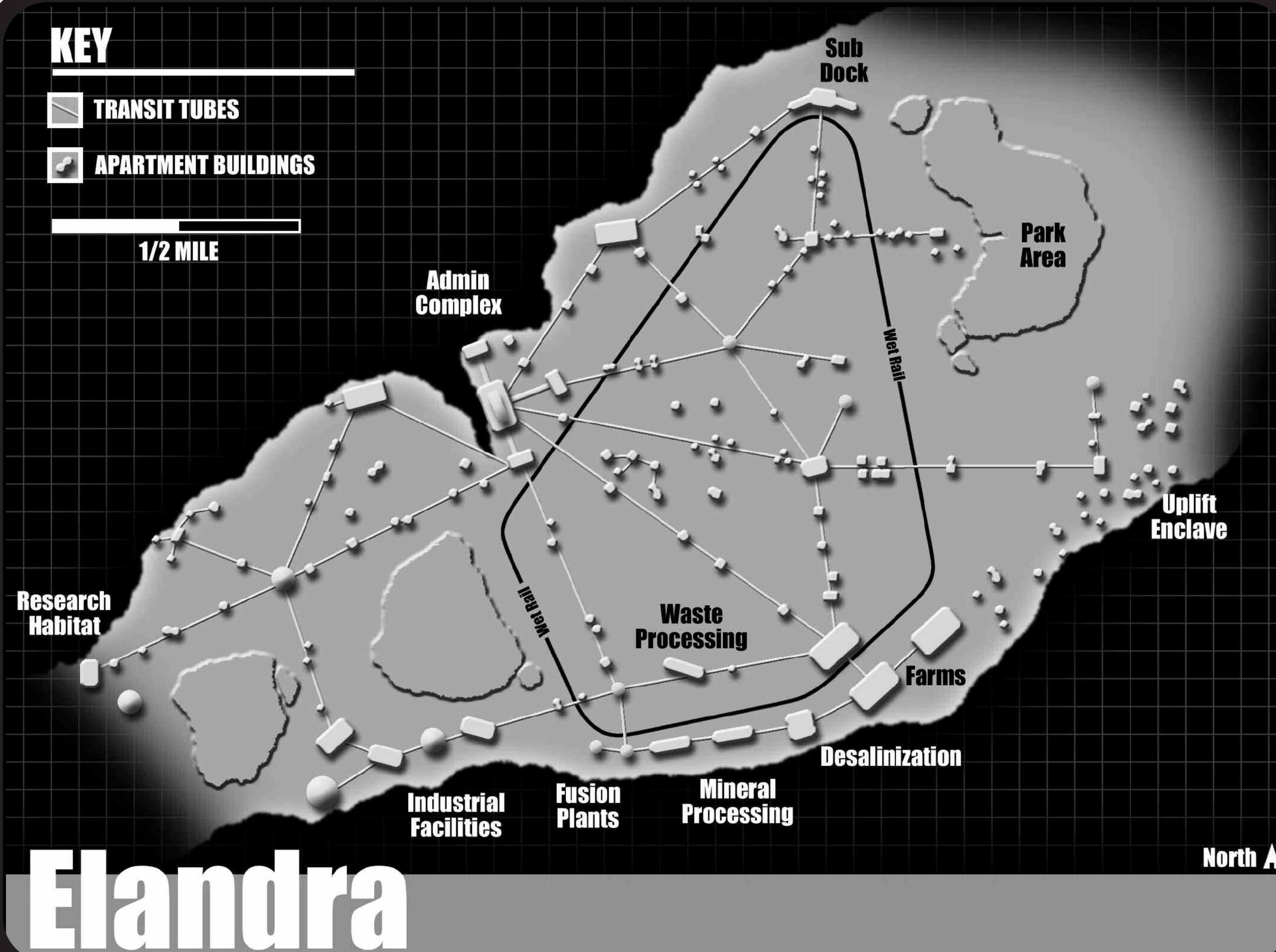
Enfranchised citizens become eligible to vote for the executive council by paying a poll tax at each election. There is no minimum age to vote, but voters must be capable of following voting procedures. Compared to the rest of the PRA, and even some E.U. states, Elandra is strongly pan-sapient. Currently, ghosts, SAIs, and some uplifted animals – including Doolittle dolphins (p. 101), Delphí (p. 101), and Octosap IIs (p. 101) – are legally allowed to vote. A judiciary decision in 2095 established that unindentured bioroids may also vote if they pay the poll tax. Since then the number of free bioroids taking the opportunity to do so has risen dramatically, and there are concerns among the human residents – and other members of the PRA – that Elandra may be turning into a “bioroid state.”

The current Mayor is Hiram Farrell, a conservative capitalist seen by many as being a puppet of GenTech Pacifica. Farrell has several investments in various GenTech projects being undertaken at Elandra and promotes policies which are sympathetic with the transnational’s goals, sometimes at the expense of the citizenry. Although popular when elected, his support has waned as his term has progressed.

Civic

The Elandran administration has drawn up a list of civic duties, each of different value to the community. All residents – including minors – are required to fulfil a certain quota of civic duty each year. Serving in a public office fulfils all civic requirements for the term of office. Jobs paid by the government, such as city security or medical practice, also fulfil civic responsibility quotas. Learning from a kindercomp (p. FW34) or taking higher education courses count too, being the primary way in which minors serve their duty. Casual work on tasks such as building maintenance, litter collection, or fish farming accumulates partial credits. Volunteering for selection in the Parliament also grants credit. Citizens who do not meet their quota by performing public service may make up the remainder in taxes – minors too young to be educated may accumulate it or have it paid by guardians.

This arrangement allows for agreements between citizens to pool resources and make their duties easier. “Marriage” in Elandra is a social contract between any number of people, under which the members agree to share responsibility for the civic duties of all the others.



The system of civic responsibilities makes Elandra an egalitarian society with respect to social services. Health care and education are free to permanent residents of Elandra. Citizens who do not earn a minimum income are supported by the state at a basic subsistence level, but must perform community service to cover their duties. Enterprise and capitalism are encouraged by the means of discharging duty by paying a fixed tax rather than performing service.

The poll tax and civic duty tax raise enough revenue to cover a third of government expenditure. The remainder is made up from corporate taxes charged to companies operating in Elandra. GenTech Pacifica contributes the most, as it is by far the largest corporate presence in the city.

Social

Humans with no aquatic adaptations were the first inhabitants of Elandra. They built reinforced structures enclosing habitat space at one atmosphere of pressure, where people could work without needing to decompress to return to the surface. External work required the use of hydrox breathing gear and lengthy decompression. The difficulties of working at Elandra's depth encouraged the rapid development of parahumans and bioroids with adaptations to allow them to work in the water for extended periods. Once such inhabitants were available, it became convenient to pressurize parts of the town to the ambient water pressure. People living in these areas could live at ambient pressure permanently and enter and leave the water at will.

The number of bioroids, bioshells, and cybershells in Elandra has grown much more rapidly than the human population. Most new residents live in pressurized habitats, so the fraction of Elandra that remains at one atmosphere has slowly dwindled to its present level. Humans are now a minority amidst the cosmopolitan mix of biogenetic, infomorphic, and uplifted sapients. The nonhumans are officially encouraged to participate fully in Elandra's political system, but there are interspecific tensions driven by subtle biochauvinism on the part of some of the humans.

Security

Elandra has a small civic police force for internal law enforcement. Crime is relatively rare, with petty theft the most common offense. Occasionally a personal disagreement escalates into an assault, brawl, or even murder. Criminals convicted of minor crimes are assigned additional civic duty quotas, which can either be worked or paid off. Dangerous criminals are deported to Australia for imprisonment under a mutual agreement.

Police are generally unarmored, and armed with a truncheon and a police armgun. Rooms with moon pools in them qualify as humid, giving a -2 penalty to hit with the electrolaser of an armgun (see p. TS155). Air-conditioning systems keep the rest of Elandra's air dry enough for electrolasers to work with no penalty.

The Elandran Environment

You'd be surprised at the stuff people try to smuggle down here. Because of the presh-diff and the hydrox we need to be careful what we allow in and out. Small sealed containers are the worst, because their strength-to-weight is high enough to maintain 12 atmospheres of delta-P . . . until it takes a knock. Then you've got an explosive gas mix, glass or metal fragments, and a lot of energy. One time we had to contact a guy: "Sorry about your aunt Martha's prize peach preserves – they just blew out a pressure lock and killed two 'roids."

– Jean Ranvier, Elandra customs officer

Elandra contains three distinct environments. Most internal areas contain *hydrox* – a mixture of 96% hydrogen and 4% oxygen – pressurized to just over 12 atmospheres to match external water pressure. This mixture allows humans to breathe without dangerous effects, but makes their voices squeaky (see *Breathing*, p. 48). The gas mixture is generated by electrolysis of water, with excess oxygen removed and used to produce other breathing gases. The air-purification system injects oxygen to keep the level at 4% and scrubs carbon dioxide from the air.

The low-oxygen atmosphere actually smothers flame and cannot be ignited by any means, but attempting to light a fire is banned in case of oxygen leaks. There are other disadvantages to a hydrogen-rich atmosphere. Hydrox carries body heat away much more efficiently than air, so the temperature is kept at a cozy 80°F to avoid hypothermia. Because of its small molecular size, hydrogen diffuses into and through exposed metals. Metal walls are lined internally with biopolymer to prevent hydrogen diffusing through the metal and leaking into the sea. Hydrogen-soaked metal also becomes brittle within a few weeks; metal tools and machinery in Elandra must be coated with biopolymer or diamondoid to avoid frequent breakages.

The pressurization allows access to the water through moon pools – holes in the floor open to the external water – that can be covered with simple hatches, rather than bulky airlocks. Inhabitants of these areas can enter the water and work at depth without changing pressures. An inhabitant wishing to move to a one-atmosphere environment must decompress for up to five days to avoid suffering the bends (see *Breathing*, p. 48), unless he has the Pressure Support or Resistant to Poison (Dissolved Gases) (p. 104) advantage.

About 20% of Elandra contains air at one atmosphere, drawn directly from the surface. This is mostly in older sections of the habitat, including the old control center, submarine dock, and many of GenTech Pacifica's labs. Half the administration complex is also at one atmosphere. Transit tubes at this pressure run parallel to pressurized hydrox gas tubes from the dock to administration. These areas are connected to the rest of Elandra via airlocks. Some locks contain fully equipped accommodation for multiple people undergoing decompression. Others are small chambers for the rapid compression or decompression of bioroids and shells who do not need to decompress slowly.

Lastly, some individual rooms and buildings in Elandra are flooded with seawater. These are either living quarters for uplifted animals or research environments.

Outside the Habitat

The sun warms the tropical waters above Elandra and the thermocline is well below the settlement. At Elandra's depth the water temperature averages 59°F, varying by 2° to 3° seasonally and up to 5° during El Niño or La Niña events. There is no significant daily temperature variation. A full-body wetsuit will keep a baseline human comfortable in the water.

Sunlight reaching Elandra has all colors but blue and a little green filtered out of it by the mass of water above. What light remains is about as bright as a dimly lit room (-1 to Vision). It is impossible to distinguish colors in the ghostly blue dimness without artificial light. At night, the water is pitch black except for the glow of bioluminescent creatures and artificial lighting (-8 to Vision). The water transparency rating, T, near Elandra is 20 (see Light Attenuation by Water, p. 52).

The peak of the Elandra seamount sits near the depth limit for photosynthetic organisms. The highest points are covered with several species of algae that support a sparse community of animals – mostly sponges, worms, sea urchins, crabs, and a few types of mollusk. Pelagic fish are drawn to the food source and in turn attract the occasional shark. These life forms are generally left alone, providing some park space for the settlement.

External security is taken seriously, following the Blue Shadow raid in 2092. Some citizens perform external security duties, but the bulk of the force is made up of members of GenTech Pacifica's Security Project (p. 75) in a commercial arrangement with the Elandran administration. GenTech has a vested interest in protecting Elandra from external threats because of the number of important facilities it has there, and the legal freedoms it receives on genetic research that cannot be found in most jurisdictions.

GenTech's security personnel are well trained and lethally armed. In the absence of an actual navy, they are the next best thing. A *Flinders*-class defense boat with standard armament, two *Alopias*-class combat submarines, five *Kasatka* light submersibles (p. 129), and several small support vessels are permanently attached to Elandra. This fleet carries 34 human and parahuman troops, and 26 submarine RATS cybershells (p. 98). A War-Dop squad (p. 102) and a squad of Seawolf bioroids (p. 95) are based in Elandra proper. If needed, GenTech can assign larger armed vessels and more combat cybershells.

Activities

Mining

The bulk of Elandra's income is derived from seafloor mining. The abyssal plains on either side of the Hunter Ridge seamount chain contain significant deposits of copper and gold. These are at depths of 10,000 to 12,000 feet, far below routine operating depths for biological sapients. The mining work is carried out by cybershells.

Mining begins with the erection of a containment barrier covering the seabed. This prevents disturbed sediment from escaping and clouding the water. Although not a great inconvenience to the mining shells, a disturbance like this would severely disrupt the benthic ecosystem within a wide radius.

At any time the cybershells are working approximately five separate sites, each typically taking a year to be exhausted of resources. AI cybershells spend weeks at a time at a mining site, removing ore and loading it into cargo submarines for transport back to Elandra. At least one cybershell is relieved each day to return to Elandra carrying news and for servicing. This is the only communication line with the deep mining facilities. Their isolation and lack of instant communication back to base make them vulnerable to hostile actions, so the outposts are patrolled by GenTech Pacifica's submarine RATS.

Hydrothermal vents are located along a fault system that approaches to within 30 miles of Elandra. Cybershell expeditions visit these to gather black smoker chimneys, which are rich in metallic sulfides. The chimneys grow at fantastic rates and can be harvested from the same vent every few months.

Biotechnology

GenTech Pacifica's major underwater laboratories and factories are located in and around Elandra. Several other companies also operate smaller facilities. The labs perform research and development on genetic modifications designed for aquatic adaptation, produce biological products such as aquacrete, and uplift marine animals. Researchers also tinker with species such as tuna and deep-sea clams, to maximize productivity of food resources.

The biotech companies collect specimens of species living near Elandra and study them for useful organic compounds and gene sequences. Organisms of particular interest include algae, sponges, deep-sea corals, sea urchins, starfish, squid, and fish. Many species are being fully genetically sequenced for the first time, giving Elandran companies a valuable resource in the development of new drugs, genemods, and bioproducts.

Biological Research

The waters around Elandra are home to a wide diversity of species. Plots on other seamounts in the Hunter chain are used as biological laboratories to study interactions between benthic organisms in relative isolation. Some have been seeded with particular species, including many genetically modified ones for environmental testing. Eco-engineers monitor these experiments carefully, ready to step in and shut down any that looks like getting out of control. One deep site near a newly erupted hydrothermal vent is also being used to test gengineered chemosynthetic organisms.

Behavioral scientists are studying several species in the waters around Elandra. Swift cybershells and bioshells chase pelagic fish, dolphins, and squid, observing and recording migration, feeding, mating, and other behaviors. The numerous spinner and bottlenose dolphins in Elandran and Fijian waters are the subjects of intense research activity. Most of the dolphins are baselines, but there are two small colonies of Doolittle uplifts in the area, who keep mostly to themselves. GenTech Pacifica monitors them closely. Blue Shadow activists claim GenTech is performing experiments on the uplifts, capturing individuals for surgical and psychological treatments, then releasing them to study behavioral modifications and interactions with fellow uplifts.

Elandra's Population, 2100

Humans	
Baseline	1,692
Genetic upgrade	749
Parahumans	
Aquamorph	2,171
Other	387
Free Bioroids	
Sea Shepherd	1,246
Nemo	9
Other	434
Indentured Bioroids*	
Sea Shepherd	1,865
Nemo	2,391
Gillmorph	28
Other	483
Infomorphs	
Ghost	170
SAI	1,318
Uplifted animals	
Doolittle Dolphin	235
Delphís	137
Octosap II	739
Other	81
Total population	*14,135*

* Not eligible to vote.

Humpback whales migrate from the Antarctic Ocean during the southern winter to calve in the waters near Fiji, passing close by Elandra as they travel and spending several months in the vicinity. The whales suckle new calves and mate, before departing for their Antarctic feeding grounds late in the year. Infomorphs using bioshells and cybershells observe whale social behavior and record whale songs. Humpbacks most commonly sing during the breeding season, so Elandra is a popular base for cetanists and whalesingers (p. 17). Several other species can be found in Elandran waters, including minke, pilot, killer, and Bryde's whales, which live in the region year-round, and sperm and southern right whales, which migrate through the area.

Oceanography and Climatology

Elandra operates oceanographic and climatological observation and research programs, affiliated with the Global Ocean Institute (GOI, see p. 85) and collaborating with many other research groups around the world. Observations made by Elandran scientists are valuable in establishing baselines for global studies of ocean physics, chemistry, and biology, and climate patterns and change. The GOI has sponsored a major international oceanographic conference, scheduled to be held in Elandra in April 2100.

A small group of researchers is studying the deep ocean trenches and hydrothermal vents in the Elandra area, analyzing aspects of plate tectonics and vulcanology. They use some of the deep-sea cybershells to visit these remote locations, record data, and set up continuous monitoring equipment.

Conflicts

Internal Factions

Like most sizable towns, Elandra has competing political, social, and corporate factions. These create subtle undercurrents of competitiveness, snobbery, and discrimination between various groups, although for the most part the expression of these is at a low-key level. The city appears peaceful enough to most casual visitors – it is only with familiarity that the internal frictions become noticeable.

Although GenTech Pacifica has a long history of supporting Elandra's infrastructure and autonomy, there are a growing number of voices within the community who feel that the transnational's influence on the city is too great. Three of the current executive council members are of this group and have been encouraging local investment by other companies in an effort to water down GenTech's dominance. Mayor Farrell's term expires in October 2100, and many pundits are predicting a fourth anti-GenTech council member will be elected, changing the balance of power. GenTech's Memetics Project is working overtime to develop a campaign designed to install its preferred councillor.

Almost all other companies with a stake in Elandra are more or less united in efforts to undermine GenTech's position in the city. Most stick to standard economic and memetic tactics to build their positions, but there have been a few incidents at GenTech facilities in the past few years. In 2098, GenTech security personnel arrested and charged two Aquamorphs with sabotaging an algae processing plant under orders from Reef Systems Pty. Ltd. The Aquamorphs were found guilty and deported to Australia, and Reef Systems was forced to pay damages and ordered to cease operations in Elandra. A few voices on the local Web continue to speculate that the entire affair was a set-up, while others claim it proved that desperate competitors would use any tactics to usurp GenTech's position. Only a few minor cases of mysterious damage have been reported since, but many people assume there is more industrial espionage occurring than the public knows.

Socially, the various parahumans, bioroids, and infomorphs in Elandra tend to interact among themselves and with uplifted animals, while the humans form their own social groups. There are some elements of rivalry between the groups, which occasionally escalate into interspecific tensions and violence, but for the most part the city is a collection of people who just prefer to associate with "their own kind." The greatest social tension is from a small group of humans who are alarmed that Elandra is turning into a "bioroid state," and who engage in memetic engineering on the Web to raise international ire. This group has had little success at anything other than increasing social disharmony in the town.

The Atlantean Society (p. 16) boasts some 500 members among Elandra's residents. Most of these are nonaquatic humans and parahumans, but there are a few Octosap and uplifted dolphin members. The Atlanteans are fiercely devoted to defending Elandra's position as a sovereign free city and a viable, self-sufficient habitat. On the international stage, this aligns them with GenTech Pacifica, but within Elandra the Atlanteans are behind a determined drive to decorporatize the government and put policy decisions firmly in the hands of the citizens. Atlanteans all volunteer for parliamentary selection and there are usually two or three in the parliament, where they are among the most active members.

Eating Under Pressure

High-pressure environments pose unusual problems for the growing and preparation of food. Flames are usually prohibited – or impossible – so chefs are restricted to baking, broiling, steaming, and microwaving their dishes, or preparing raw food. Given the usual abundance of edible marine life around the habitats, colonists generally eat well. Shellfish and various types of sushi supplemented by seaweed are popular since these require little preparation. Genetically modified kelp and algae are used to create flours, tofus, and nutrient bars. Dishes prepared in pressurized habitats tend to be more strongly flavored than their surface counterparts, because high air pressure slightly dulls the tastebuds.

Isolation from the surface means that certain foods are not as common in submerged habitats as they are above. While hydroponic gardens can grow fruit and vegetables, these remain uncommon and expensive because gardens require valuable air space. Fauxflesh is less space-intensive and more common. Real meat derived from terrestrial animals must be imported, and is usually eaten only on special occasions. Regularly eating "surface meat" is regarded as a sign of wealth in underwater communities, if not outright decadence.

External Threats

The greatest external threat to Elandra is the possibility of sabotage or outright attack by militant terrorist groups such as Blue Shadow and Irukandji. Some of the biological research projects being carried out in the town and its surroundings are prime targets for Preservationist actions. The Blue Shadow attack in 2092 highlighted the dangers and prompted the formation of a significant deterrent and strike force to handle any future raids.

With overt attacks against Elandra's defenses now being risky, the fear is that activists may plan sabotage from inside the facility. In a sense, this is an even more dangerous prospect, since a well-placed explosive device in a critical power or environmental system could cripple much of Elandra and require a mass evacuation, with the attendant complication of decompressing thousands of people for removal to the surface.

Being a member of the PRA, Elandra is also wary of attention from the TSA. Elandra's security forces would be no match for a full military strike, so they put considerable effort into surveillance of the surrounding ocean. Surveillance satellites track any suspicious TSA movements in the Pacific Ocean, and Elandra shares intelligence with Australia, Japan, and other PRA members in the region. At any sign of a TSA threat, PRA forces would be quick to respond. In the current age of remote warfare, however, it is likely that Elandra could be destroyed with little difficulty and its PRA allies left to exact retribution on the attackers. The main defense against full-scale military attack is therefore the deterrent power of Elandra's allies.

Other Aquatic Habitats

Wilhelmsburg

Wilhelmsburg is a drifter (p. 17) arcology built on a platform supported by multiple catamaran-style hulls. The habitat was originally commissioned in 2065 and occupied by a group of drifters who wanted a place where they could be free to pursue various artistic endeavors. The concept worked, and within a few years Wilhelmsburg had become known as a hotbed for performing and visual arts. In 2100, the arcology has a permanent population of 3,100 people, and lodging and amenities for 400 transients.

Wilhelmsburg has state-of-the-art InVid and slinky production facilities, as well as equipment and materials for various other artistic forms and media. The arcology is famous for its music recording and mixing studios, and artists from around Earth (and even off-planet) visit to record songs and promotional InVids. Painters, sculptors, and dancers also come to be inspired by the surroundings and the social atmosphere provided by the drift community.

Although many of the residents have artistic occupations, there is a slowly growing segment of the population who simply find Wilhelmsburg a good place to live. It is a high-profile drift habitat, well connected to the Web, with the most modern amenities available and a peaceably minded community. Thus it appeals to people who enjoy the drifting lifestyle without having to make any particular political statement or rejection of Fifth Wave society.

Wilhelmsburg is registered as a ship with the German government. Many of its residents retain citizenship in their original home nations, while a few have transferred to Jamaican PNCs (see p. 17). The mixture of nationalities on board is complicated by the fact that third-generation residents are now being born and some parents are not bothering to sort out the bureaucratic details of citizenship for their children. Some of the second-generation residents are unlisted in any global databases and the next generation promises to be even more anonymous. Among such a group, it may not be surprising to find a few who know people like Manuel, the "King of Vrijstad" (p. FW102) . . .

The anonymity of a few of the residents and the ready availability of the latest computer hardware have produced an ideal environment for the emergence of a group of Web data pirates. Calling themselves *Die Wilhelmsburgbefreier*, this group of just four humans and one ghost has contacts on the ground in several major world cities. They utilize these contacts to plant devices such as emissions nanobugs or surveillance dust (p. TS154) in systems they wish to access. Web viruses written by the group then access the systems and store information on distributed data havens in multiple locations for later retrieval. The information Die Wilhelmsburgbefreier gathers is sold to various companies or posted anonymously to the Free Net (p. FW31). Die Wilhelmsburgbefreier has so far managed to avoid being traced to Wilhelmsburg through an elaborate series of covers and double-blind contacts – by everyone but the German government. When it discovered what the group of hackers was capable of in 2094, the Bundesnachrichtendienst (the German federal intelligence service, p. FW38) made them an offer they could not refuse: turn spy, or go to jail. Today, Die Wilhelmsburgbefreier is a curious mix of anarchic data pirates who continue cracking systems for profit and political statements, but who also form the most effective computer intelligence arm of the Bundesnachrichtendienst.

Physical Description

Physically, Wilhelmsburg is a flat platform, 290 feet wide by 840 feet long, supported 35 feet above water level by its multiple hulls. Most of the area is covered by separate structures, up to nine stories high. There are exposed walkways running the length and breadth of the platform and a plaza near the center. Many of the individual buildings are connected at higher levels by bridge tubes. Structural components are largely metal, but the exposed surfaces have been covered with a variety of other materials such as plaster, stone, wood, and polymers, to produce a more aesthetically pleasing environment. There are small gardens on the tops of the buildings and the plaza is paved with Italian granite cobblestones.

Below platform level, the multiple hulls are filled with an engineering plant and machinery, including fusion generators and motors that can drive the miniature city at speeds up to 30 mph. There is also some residential space in this area, inhabited by the mechanics and engineers who keep the arcology functioning.

Wilhelmsburg cruises the Pacific, Indian, and Atlantic Oceans, plying back and forth around the Cape of Good Hope once every few years. At the beginning of 2100 it is in the mid-Atlantic, heading northeast toward Europe.

Sea-floor Habitats

Dhamchos Thupten Khusu Monastery: A Buddhist monastery, built into the vertical cliff face of a seamount in the Laccadive Islands off Southwest India, at a depth of 110 feet. The 400 resident monks claim the tranquility of the site is unmatched.

Franklin City: A large U.S. settlement, in 80 feet of water, nine miles north of Puerto Rico. Population 12,000.

Kuratani: The deepest site permanently inhabited by humans, this Japanese research station is a heavily reinforced one-atmosphere facility at a depth of 31,200 feet in the Nankai Trench. Thirty scientists and support staff work in shifts, relieved by a weekly supply submarine.

Floating Habitats

Al-Dhahalab: The Saudi company Isam Alizera Biotech operates this corporate island in the Red Sea. It is used as a mobile ocean research laboratory to study coral reef ecosystems.

Dao Duac-Pho and *Cam-Duong*: These two ex-Vietnamese floating island arcologies are moored 200 miles north of New Guinea. They declared independence after the Pacific War and are now associate members of the PRA. Population 9,000 each.

Îles de Lumière: Three large and luxuriously appointed floating cities moored off the coast of Monaco. The population is about half residential and half hotel accommodation.

Isla Santa Fe Córdoba: A floating corporate base in the South Atlantic Ocean operated by the Argentine company Agua Negra Profunda to support deep-sea mining operations. It is home to 12,000 people: workers, families, and infomorphs.

Jazireh-Ye Fahrum: A small Iranian arcology in the Persian Gulf, used as a prison island and a psychoneural treatment facility for political and religious dissidents.

Schuyville: A curious mixture of high and low technology, this is a sail-propelled floating town populated by a religious sect that prohibits the use of electrical and nuclear energy. It sails slowly back and forth between Europe and North America.

Faridganj

Faridganj is one of the burgeoning group of sea-floor settlements under construction in the shallow Bay of Bengal. It is a project of the Bangladeshi government (see p. FW69), which is investing heavily in aquatic habitat and parahuman technology in order to establish a population base less susceptible to climatological disasters. The settlement is in 55 feet of water, two miles off the coast, northwest of Chittagong. Currently, Faridganj houses 9,300 humans and parahumans, but the population is growing rapidly and is projected to surpass Elandra's by 2105.

The majority of Faridganj's inhabitants are aquatic-adapted parahumans – Aquamorphs, Purushagor (p. 95), and variants – with gene sequences copied or created by Bhuiyan Genetics (p. 84). There are 1,400 non-aquatic humans and parahumans, and 250 uplifted animals, mostly Octosaps.

Similar settlements are spaced every 10 miles or so along the Bangladesh coast and in the Ganges delta, at various stages of completion. Faridganj was the first to be begun, in 2077, and is planned to be the largest. Some smaller sites are already considered complete. Faridganj also has four satellite "suburbs" – small habitats a few miles from the city proper, where Aquamorphs and Purushagor live and can commute in to work.

The main activities in Faridganj are construction, aquaculture, and biotech research. Fully a third of the inhabitants are employed in the physical expansion of the city infrastructure, from heavy construction to wiring, plumbing, and interior decorating. The region for miles around Faridganj is used as a vast aquatic farm, with pens for fish, prawns, and crabs, as well as large oyster and mussel beds. The fields also produce commercially useful quantities of seagrass and various algae. As a model community for the Bangladeshi government, there is a strong emphasis on applying new techniques to demonstrate improvements in productivity. The farms produce far more food and other organic products than are required by the city itself, and much of it is exported to Chittagong and further afield.

Bhuiyan Genetics has its main submarine research facility in Faridganj. Several teams of gengineers work on projects as varied as improving cultivated shellfish growth rates and adapting pirated gene sequences to create new species of parahumans. These include species with legs fused into a muscular tail-like structure, making them efficient swimmers but clumsy on land (see *Purushagor*, p. 95). The most exciting project, and one which is shrouded in secrecy, is the research being done on parahumans with gills (see *Gilled Humans?*, p. 42). The intention is to produce a Bangladeshi parahuman species that can survive underwater permanently without requiring technological assistance.

Given its reliance on biotechnology, Faridganj qualifies as a mature Fourth Wave settlement, but economically it operates almost at a subsistence level. This is because of a conscious choice by the Bangladeshi government to make its aquatic settlements self-reliant and to foster further colonization of the sea by its parahuman citizens. It is thus difficult to find connections to the Web in Faridganj outside of the biotech labs, and augmented reality is not available in most of the settlement. Much of the equipment used in Faridganj does not have inbuilt computing capability and v-tags are entirely absent. For visitors used to augmented reality, Faridganj seems either hopelessly primitive or actively disturbing. One advantage for visitors bent on mischief is that the security systems are also relatively low-tech.

Physical Description

Faridganj is a collection of dome and cylinder habitats anchored to the seabed. The domes range in size from two-story buildings 45 feet in diameter to massive structures 120 feet in diameter that poke above the sea surface. There are almost 200 domes, sprawled over half a square mile, and connected by tubes running along the sea floor. More are being added every few weeks.

The domes are prefabricated on the Bangladesh mainland and towed out to sea on pontoons, then sunk in place and connected up to the rest of the settlement. They are made of multilayered polymer reinforced with carbon nanofibers, and have a uniform bland appearance on the outside. The suburb habitats are constructed from the same domes.

All of Faridganj's air-filled space is at one atmosphere of pressure. Some of the largest domes are often open to the air above sea level – they are battened down during storms. Fresh air is circulated throughout the settlement by integral air-purification units in each dome.

The water is accessed through airlocks able to be pressurized to match the water depth before the external hatch is opened. Each dome has at least one airlock. The external hatches are in the floor, so the airlock chambers can function as moon pools and do not have to be flooded. The airlocks are capable of rapid pressure change, to allow Aquamorphs to hold their breaths while being compressed, so they can enter the water and swim to the surface with no danger of the bends.

Ondala

Ondala is a small city occupying a floating arcology moored in the Caribbean Sea, home to 21,000 individuals. The structure was originally a set of five heavy rigs used in the Gulf of Mexico for petroleum drilling in the 2020s. They were decommissioned in 2047 and bought for a bargain price by a consortium of 12 wealthy eccentrics, who set about turning them into their ideal retreat from the politics of the world. They arranged for the rigs to be towed south and moored together 80 miles north of western Panama, away from potential hurricane tracks.

The owners declared Ondala an independent state and invited like-minded individuals to settle. The initial inhabitants were the families and some friends of the owners, but word of mouth spread and soon Ondala boasted a cosmopolitan population. In 2059 the owners began constructing an OTEC power generator to supply growing energy needs, causing the Panamanian government to realize that they had no intention of ever moving Ondala from its location. Panama initiated legal action in the World Court to have the structure removed, but the owners used their influence with several U.S. senators to arrange a strong legal defense team. They argued that Ondala, still registered as mobile rigs with the U.S. Shipping Board, had the right of free passage and anchorage provided it took no biological or mineral resources and dumped no pollution. This became a landmark test case for the existence of similar settlements around the world, and was decided in Ondala's favor, to much celebration.

Ondala's sovereignty, however, remained unresolved. External commentators took the appeal to the United States as an admission that true independence could not be attained, while for the inhabitants it provided the impetus needed to mount a campaign for recognized independent status. The owners hired memeticists to develop a strategy, and soon political activists across the world were promoting the cause. Ondala achieved fame in this way, but no serious momentum was ever gained amidst the numerous global political upheavals of the 2060s and 2070s. In 2086, Ondala applied for membership of the Caribbean Union as a free city. The request was granted, mostly out of a desire to bolster the Union's power and promote the cause of microstates, but no other nation has yet recognized Ondala as a free city.

Five of the 12 original owners, plus a clone of a sixth, still administer Ondala as a semi-anarchist benign dictatorship. The original five are grooming clones of themselves as replacement leaders, but have no intention of dying just yet and make use of the best life-extension technology they can afford. Their fortunes are invested in U.S. companies, so they have considerable income with minimal effort. Many other inhabitants of Ondala are known by the owners, either personally or by associates at most one step removed, so the city has the feel of a tightly-knit community. The leaders generally allow any activity that doesn't interfere with the personal rights of fellow Ondalans. All transgressions attract the same punishment: permanent exile.

Citizens of Ondala earn their keep by participating in the world economy, performing work that doesn't require them to leave the city. Many are politically active, either organizing or participating in numerous campaigns to secure the rights of anarchists, secessionists, or free independence movements around the globe. Ondala is building a reputation as a haven for political dissent of an anarchic or libertarian nature, and it may not be long before powerful governments takes a more active interest in the city.

Gilled Humans?

The ultimate adaptation to aquatic life is being able to extract oxygen from water. So far, the established method of allowing parahumans to operate in water is to gengineer traits similar to those of cetaceans and other aquatic air-breathers. This means enhancing the ability of the blood and muscle tissue to store oxygen, giving muscles the ability to operate anaerobically, and creating a ribcage and lungs capable of collapsing under pressure without injury. Given that these adaptations all exist in mammal species, it was relatively straightforward to transfer them to a human genome. GenTech Pacifica released the first Aquamorph parahumans, designed on this model, in 2075.

Producing a parahuman with functional gills is much more difficult. GenTech has been working on the problem for over 30 years. It has produced some human-based bioroids capable of absorbing oxygen from water via gill-like structures on the torso, but only under controlled conditions of water temperature, salinity, oxygenation, and flow.

As difficult as it is, giving a human-based bioroid gills is actually the *easy* part of the task. Having a large surface area of blood-rich tissue in contact with cooler water means that heat is lost from the body rapidly. The gills cannot be insulated because the need to interchange oxygen precludes any intervening material. And sufficiently oxygenated water must be run over the gills *rapidly* in order to extract enough oxygen to support a mammalian metabolism – which increases the rate of heat loss. A second problem is caused by the physical process of osmosis, in which water diffuses through membranes (such as gill linings) toward regions of higher salinity. Body tissues are less saline than seawater but more saline than fresh water, so gilled mammals would rapidly dehydrate in the ocean and bloat in fresh water. So producing a gilled mammalian bioroid capable of surviving indefinitely in open water requires changes in physiology that challenge the very limits of 21st-century biotech.

Despite the problems, GenTech continues to experiment half-heartedly. Bhuiyan Genetics gained copies of some of GenTech's gilled bioroid designs in 2089 and has been pursuing the concept vigorously since then. Unknown to GenTech and the biotech industry at large, Bhuiyan's gilled parahuman program is now the most advanced in the world. It has produced the *Purushmachh* series gilled bioroid design, which is capable of excursions of up to 20 minutes in the warm waters of the Bay of Bengal, before having to shut its gills down and breathe air to avoid hypothermia and dehydration. There are six Purushmachh bioroids undergoing intensive tests in Faridganj. Bhuiyan believes it is close to producing a viable gilled parahuman germline, although with the same activity restrictions as the Purushmachh bioroids.

The most advanced gilled parahuman project may well be off Earth – see p. 63.

Physical Description

Additional floating rigs have been added to Ondala over the years to cope with increasing population. In its current configuration, the city is made of 13 decommissioned rigs of various sizes, the OTEC facility, and two custom-built floating aquaculture farms covering several acres each. The various structures are connected by flexible bridges, some stretching 400 feet across open water. The bridges are exposed, but have safety rails and are stable in all but the worst weather, so there is little danger of falling.

The rigs and the OTEC structure bristle with multi-story apartment buildings that are more functional than aesthetically pleasing. The inhabitants like to maintain a pseudo-industrial appearance out of respect for the city's history. There are exposed catwalks, ladders, and gangways to be found everywhere. Inside the buildings, the maze-like quality is even more apparent, caused by the constant unplanned construction and rearrangement of rooms, walls, corridors, and stairs. Visitors without VIs to read the navigational v-tags are certain to get lost.

New Lands

Most humans like to live on *terra firma*. When there isn't enough land, people throughout history have found ways to make more, culminating in newly developed Fifth Wave techniques.

Coastal Reclamation

The rising sea level throughout the 21st century threatened to inundate low-lying regions such as parts of the Netherlands, Bangladesh, and many Pacific islands. With high technology and a centuries-long tradition of holding back the sea, the Netherlands not only withstood the onslaught, but reclaimed additional land. The Dutch are now experts in coastal reclamation and lead similar projects around the world.

The biggest advances in coastal reclamation came from the ecoengineering field. With new understanding of the actions of wind, waves, and currents, ecoengineers were able to design dyke systems supported by biologically-stabilized terrain on both sides. Instead of eating away at seawalls and producing a need for

continuous maintenance, the sea now helped keep itself out by depositing sediment and strengthening the barriers holding it back.

After the disaster in Venice in 2033, when the city was temporarily evacuated and much of its priceless artwork damaged or destroyed by seawater, the lagoon city adopted an aggressive strategy to prevent any future occurrence. A broad dyke system was constructed, joining the islands of Lido and Pellestrina to the mainland to wall off Venice Lagoon from the Adriatic Sea. Despite the loss of traditional tourist beaches, the newly created shoreline has now become as much an attraction as the old, and the lagoon is maintained at a water level preserving the unique charms of the city.

Land reclamation technology can also be applied to shallow water atolls or between existing islands. This has been done with some low-lying island nations such as Kiribati, the Marshall Islands, Nauru, and the Maldives. India is undertaking major reclamation work in the Maldives in exchange for the rights to seafloor resources in the Maldives' EEZ. This provides jobs and a boost to the local economy, but the work is being done crudely and the resulting land needs serious work before it resembles anything more than a concrete moonscape.

Kiribati has a more modern approach to island reclamation. Corporate interest in using the nation's scattered territory for aquaculture and deep-sea mining has allowed the government to bargain from a position of strength, they have secured the latest ecoengineering design principles and biotechnology to allow the extension and raising of its land in a natural fashion. Gengineered corals now grow on Kiribati's reefs, rapidly adding limestone structure to the islands, while seagrasses, mangroves, and terrestrial plants stabilize the coastal margins and produce arable land.

Neutrino Telescopes

The colonization of space has provided ideal locations for massive optical and radio telescope facilities such as the Tsiolkovsky Farside Observatory (p. TS36) and the Sahasara Chaksu space telescope (p. DB28). The only remaining field of astronomy in which Earth-based observatories have an advantage is neutrino astronomy.

Neutrinos are extremely light particles that travel at nearly the speed of light. They are emitted by stars, and in bursts by violent events such as supernova explosions or matter falling into black holes. They barely interact with matter at all, and most of the particles that reach Earth pass through it unnoticed. In order to detect neutrinos, a large mass of transparent material must be surrounded by light detectors – these detect the faint flashes of the few neutrinos that interact with the material. In order to prevent cosmic rays producing false signals, this material must be shielded. The more matter surrounding it, the better.

This makes the ideal location for neutrino telescopes the bottom of the ocean. Water itself is transparent enough to serve as the detection material, and no place in the solar system surrounded by so much matter is as easily accessible. An underwater neutrino telescope is simply an array of sensitive light detectors, placed at precise positions near the seabed, and linked to a computer to process the signals.

Some initial experiments in the deep ocean in the 2020s were corrupted by unexpected bioluminescent organisms. Since then, a few locations have been found with no such organisms, but most telescopes are simply covered with opaque sheeting. Major neutrino telescopes are operated on the floors of the Ionian Sea, the Japan Trench, the Puerto Rico Trench, and Lake Baikal.

New Islands

Creating wholly new land at sea is far more ambitious than extending the margins of existing land. One approach is to construct artificial islands from high-tech materials. People have been doing this since the 20th century, when oil platforms fixed to the seabed and floating oil rigs were the prime examples. Some decommissioned oil platforms have in fact been converted into settlements, either sold by the owning companies or inhabited by squatters.

Corporations wanting convenient bases for deep-sea exploration and resource exploitation have used the oil rig model to produce floating arcologies, which are anchored in place by multiple mooring lines stretching to the seabed. Some of these "new islands" are massive structures – arcologies housing tens of thousands of people – while others are tiny research bases populated by only a few scientists and infomorphs.

Such deep-water floating islands are held stable in the swell by heavy pontoon keels, which lie submerged below the turbulent surface layer of the sea. The thick steel mooring cables of the past have been made obsolete by light nanofiber cables, which are a tenth the diameter and twice as strong. A floating island typically has from eight to 12 cables, spread radially and descending to the seabed at a steep angle. The weight of the cables themselves causes them to sag slightly, but the tensions are balanced and keep the island still to within just a few feet. Most islands are permanently anchored, but a few are occasionally moved to new locations to provide temporary bases.

The new islands are mostly corporate facilities, serving as bases for deep-sea operations. As such they house workers and their families, expert infomorphs, and various vehicles, bioshells, and cybershells used to probe the briny depths. Being corporate-controlled, and in many cases outside national jurisdictional zones, some of these islands have evolved into more than simple worker habitats. Many have lively communities made up of family members who do not work for the sponsoring company, making them seem like extranational colonies. Some are run as "tight ships" by the owning company, able to demand slave-like labor from the inhabitants far from the scrutiny of governments. Others become political or data havens, where people can seek seclusion from the world for any number of reasons.

A few groups of people have banded together to commission their own floating islands, or purchase decommissioned corporate ones. There are thus some large arcology islands in the hands of nanarchists, political idealists, and those just wishing to get away from it all. Occasionally a corporate island will suddenly find itself without a sponsoring company, in the wake of a corporate collapse or war. A handful of these, such as Dao Duac-Pho and Cam-Duong (see box, p. 40) north of New Guinea, have ended up as free colonies populated by ex-workers and new immigrants.

Atoll Towers

The final method of producing new land is to build directly from the ocean bottom until construction breaks the surface. This was not practical for water depths greater than 30 feet until the development of aquacrete in 2058. Prior to then, only a few halting projects were undertaken using clumsy dumping of material on to shallow atolls, causing massive disruption to nearby ecosystems. With seacrete and aquacrete (p. 112) it is possible to accumulate larger structures in a more ecofriendly way, in water up to 300 feet deep.

Initially, companies used aquacrete to add height to shallow coral atolls, making it a form of land reclamation – as used in Kiribati. In 2069, GenTech Pacifica began using aquacrete on seacrete foundations to build new coral atolls on the flat, shallow seabed of the Gulf of Carpentaria off Northern Australia. Success led to programs of constructing new islands in the Coral, Java, South China, Red, and Caribbean Seas, and off the north coast of South America. The technique has also been used in several Pacific island nations to create new land for burgeoning populations. Islands built from a flat seabed by this process are known as *atoll towers* because of their tower-like formation under the water.

According to the Law of the Sea (see *Maritime Law*, p. 45), artificial islands are not considered land and do not extend a nation's jurisdictional or economic rights. What is "artificial" is not defined, however, and the line between artificial and natural is now blurred by atoll tower technology, which produces natural-looking coral islands by organic processes. China has built atoll towers on several submerged reefs in the Spratly Islands in order to press claims for extending its territorial rights in the South China Sea. Other nations have made similar claims, but none have been resolved satisfactorily yet.

Maritime Law

One thing is sure: "freedom of the seas" is no longer an acceptable doctrine. Freedom works and everyone wins if everyone takes care, but clearly, all lose if even one misbehaves.

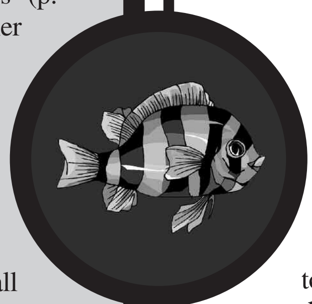
– Sylvia Earle, ***Sea Change***

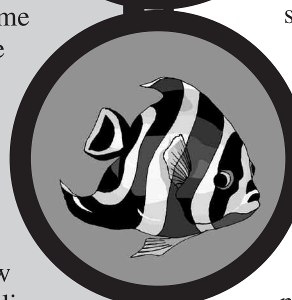
Aquatic Habitats in Space

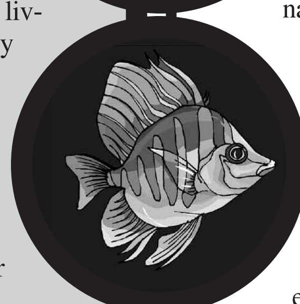
It is possible to fill, or partially fill, a space habitat with water, although seldom practical. O'Neill cylinders and Stanford toruses (p. TS75) are usually landscaped on the inner surface, and small lakes and streams are possible. Water may need to be circulated by pumping and spin gravity may be different to Earth gravity, but otherwise the lakes can make fine homes for aquatic-adapted sapients. Islandia (p. TS36) has enough water that it maintains a hydrological cycle, and houses a small community of Aquamorphs and some Octosaps. When underwater maintenance work is required, these groups carry it out.

Smaller habitats often contain large water tanks to store this valuable commodity, but the tanks are seldom accessible for swimming or living purposes. Any pools are likely to be narrow lanes for swimming laps, and unusable as living space. One L4 station operated by GenTech Pacifica is largely full of water. It is used to research microgravity effects on aquatic creatures and develop microgravity adaptation biomods for them. This seems to be pure research, though the GenTech scientists may be planning some unusual use for such creatures.

A few dolphin uplifts have been curious enough to travel into space. Launch is distinctly uncomfortable for them and they require breathing assistance for the process, but once in microgravity they adapt easily. Dolphins in microgravity do not need water to support their bodies but must keep their skin moist with a suit. Biotech Euphrates is working on germline dolphin modifications to produce a paradolphin species capable of surviving in microgravity air without desiccating.







Technically, maritime law is still governed by the Law of the Sea. This treaty originated in a United Nations Conference in 1958, though the original never took effect. A revised version was drawn up in 1982 and eventually ratified by enough nations to come into force in 1994. Several nations never ratified it however, including Canada, Denmark, Israel, Peru, and the United States. The treaty established the International Tribunal for the Law of the Sea to administer and resolve disputes. Like most U.N. commissions, the Tribunal's power was eroded in the 2030s when nations increasingly ignored its rulings, and it was abandoned in 2045. In 2100, the Law of the Sea is unenforceable, but it still serves as a traditional guide to acceptable activities and a moral high ground for disputes resolved by other means.

Territorial Rights

According to the Law of the Sea, sovereign territory of coastal nations extends 12 nautical miles (13.9 miles) beyond its shores. Foreign ships within this territorial zone are entitled to free passage and a presumption of innocence unless engaged in activities hostile to the controlling nation's interests, although submarine vessels must travel on the surface. An Exclusive Economic Zone (EEZ) extends out to 200 nautical miles (231 miles). If the continental shelf is broader than this, a nation can claim an extended EEZ over it to a maximum of 350 nautical miles (405 miles) from shore. Within its EEZ, a nation has jurisdiction over mineral and biological resources, and the prosecution of pollution. Regions outside any nation's EEZ are termed the *high seas*, and are available for the peaceful use of any nation.

In practice, these concepts apply only as far as a nation claiming such rights can enforce them. Nations have disputed maritime borders for as long as they have been sailing ships. With technology allowing the exploitation of marine resources at unprecedented levels, both nations and corporations are eager to press claims for ownership of as much territory as they can grab.

Generally, the traditional territorial zone and EEZ are respected by foreign powers. Fifth Wave and most Fourth Wave nations are able to defend their interests and few people want to deliberately instigate wars. As in many things, however, Third Wave nations sometimes bear the brunt of aggression from more developed neighbors. Fifth Wave bullying has shrunk the marine territories of Third Wave nations without recourse to any form of justice, particularly in regions with significant resources.

Squatting

The Law of the Sea provides no guidelines for the legal status of individuals or corporations who take up residence on or under the high seas. Individuals may renounce citizenship of all nations and live free of any jurisdiction. Nations like to hold on to their citizens, but the cost of administration and the difficulty of keeping track of them on the high seas makes it uneconomical.

The Law states that the high seas cannot be claimed, but in practice settlers can lay claim to as much territory as they are able to defend. Such people could not stand against the naval forces of a nation, but governments are generally not interested in squatters unless larger issues are at stake. There are thousands of free settlements scattered around the globe. Some of the larger ones have sought and received free city status (p. TS84) from a number of administrations, which accords them some of the diplomatic recognition of nation-states.

The situation is more complex for companies. It *is* possible for a company to move its headquarters to neutral territory and inform its former country that it is no longer incorporated there. Most nations would rather maintain their tax revenue, however, so they may not let them go so easily. Having the navy knock on your door to collect taxes is a large disincentive. Even if they don't pursue this course, nations often place heavy tariffs on goods imported from offshore companies, reducing their competitiveness while generating revenue. Companies can also set up from scratch on the high seas. Such endeavors are often traceable to sponsoring onshore companies, and attract the same punishment as companies that move. In most cases, a better (and cheaper) option for the company is simply to move to a "flag of convenience" nation – usually a less-developed Third Wave state with lax corporate laws.

The advantages of operating a company outside any jurisdiction are tempting, however. Workers can be virtual slaves, working long hours for little pay, under atrocious conditions. The savings in operating costs can more than offset losses due to tariffs, so unscrupulous companies can find the move profitable. Research and experimentation can also be carried out without regard for regulations. Biotech Euphrates was one of the first companies to take advantage of these benefits.

Mining

Legally, nations may exploit mineral resources as they wish within their EEZ. Government-backed operations can mine freely, and corporations may mine with the permission of the nation controlling the territory. Most companies do not have the might to operate illicitly in waters patrolled by Fifth Wave navies, but some Third Wave countries do not project enough military force to dissuade clandestine mining operations.

Nations or companies may also mine in international waters. Under the provisions of the Law of the Sea, profits from such mining must be split with the United Nations, which will redistribute its share among developing countries. With the United Nations fallen into irrelevance, the developing countries can only protest ineffectually as Fifth Wave technologies strip the high seas of wealth.

In this climate, mining rights go to whoever has the equipment and capital to stake a claim. Since sea-floor mining requires a large investment, groups engaged in it are likely to have the capability to defend their interests.

Fishing

The Law of the Sea minutely details the rights and responsibilities of nations in harvesting fish and other organisms. Briefly, nations may specify fishing laws within their own EEZ under the following restrictions: Quotas and size limits must be set to ensure maximally sustainable harvests and prevention of damage to populations of ecologically interdependent species; limits for migratory species must be set in consultation with all nations whose territory they cross; and nearby land-locked nations must be granted access to fishing in an equitable manner. On the high seas, all nations have a right to fish, subject to cooperative agreement on quotas to prevent depletion of stocks and ecological damage.

These terms have never proved satisfactory. There are disagreements over what constitutes a sustainable yield, what causes ecological harm, and what is equitable sharing. The international disputes and illicit fishing practices of the 20th century continued throughout the 21st, causing several diplomatic incidents. A particularly problematical practice is "quota hopping" – the purchase of fishing vessels registered in one country by companies registered in another. Such a ship can operate freely within the waters of its country of registration, but sail to a foreign port to land its catch in the country of the owner.

A major diplomatic incident erupted in 2031 when a Canadian navy frigate opened fire on Canadian-registered but Spanish- and Portuguese-owned vessels fishing in the Grand Banks (see p. 10). Since then there have been shots fired at fishing vessels in the North Sea, Sea of Japan, South China Sea, Timor Sea, and Red Sea by various military forces.

With many commercially valuable species being depleted or driven to extinction by climate change, pollution, ecological disruption, or simple overfishing, tensions remain high between fleets and the governments who wish to limit their activities. What little law there was to govern fishing has fallen by the wayside.

Salvage and Recovery

There are long-standing conventions and laws governing rights and responsibilities in cases of salvage and recovery. *Salvage* is the voluntary assistance and saving of imperiled vessels or cargo. In such cases, the salvor is permitted to retain possession of salvaged property until such time as a compensatory award is settled and paid by the owner. The amount of the award is usually decided by a court, and may range from 10% to 50% of the value of salvaged property, depending on the difficulties and risks faced by the salvor. While holding the salvaged property, the salvor is required to make it available for inspection and maintenance by the owner, and to release it on the posting of security sufficient to cover any potential award.

Recovery is the retrieval of property that has rested in a geographically inaccessible place, usually a shipwreck. If the owner can be determined, still exists, and has not declared the property abandoned, this becomes a case of salvage – although if the salvor makes a claim of abandonment the owner may have to defend against this in court. If nobody can successfully claim ownership, the salvor gains ownership of recovered property. Military or other property owned by sovereign states is never considered to be abandoned. Some nations have also passed laws that grant them ownership of otherwise unowned wrecks within their territorial waters.

The Law of the Sea limits the recovery of historically significant archaeological material. It states that such objects must be preserved and disposed of in a manner beneficial to all mankind. This dictum is wide open to interpretation, particularly by treasure hunters, but governments who care about such things uphold it.

Gengineering

The Law of the Sea specifically prohibits the introduction of "alien and new" species to any part of the marine environment where they might cause ecological harm, and requires that nations act to reverse any such damage. The Law was drafted prior to anyone creating genemod aquatic species, and its applicability to such species is hotly debated between biotech concerns and Preservationists.

Ethically concerned companies study and test their creations in controlled conditions before authorizing general release, build in inhibitor or dependency genes to cripple organisms which go feral, and take other precautions to prevent release of genemod species to the wild. Companies more concerned with profit than ethics, such as GenTech Pacifica, cut corners or deliberately release organisms without precautions. Proving such negligence is difficult, but Blue Shadow and other Preservationist groups are masters at collecting – or fabricating – evidence. Finding a jurisdiction willing and able to prosecute a case of criminally ecohostile gengineering is another matter, however, and such disputes are often addressed through less official channels . . .

Adventuring Underwater

The underwater environment poses several special problems for beings not adapted to it. Some creatures possess adaptations that allow a more or less normal existence in water. In ***GURPS*** terms, a character is *aquatic-adapted* if he possesses either the Amphibious advantage or the Aquatic disadvantage. Characters without either of these are *non-aquatic*. Mars-Adapted parahumans (p. TS131) are at no greater disadvantage underwater than other non-aquatic characters.

The following rules extend those for underwater environments given on pp. B91 and TS59.

Breathing

Air-breathing characters without the Gills advantage (p. CI56) are restricted to the following three approaches to venturing underwater: holding their breath, riding in a submersible vehicle, or diving with scuba gear or similar equipment. Breath holding uses the rules on p. B91. The advantages Breath-Holding (p. CI21) and Oxygen Storage (p. 103) increase the time a character can hold his breath. Riding in a vehicle requires no special rules for the character (although see p. 141 for rules regarding the vehicle). Using any equipment that subjects the body to the pressure of the water requires air to be supplied at a matching pressure.

If air must be sucked from Earth's atmosphere via a snorkel to a depth of 3 feet or more, the pressure of water on the diver's lungs will make this almost impossible – roll vs. ST every second, at -1 for every 1 foot over 3 feet of depth, to draw breath; on a failure apply the suffocation rules on p. B122.

Using air compressed to the ambient pressure avoids any breathing difficulties, but can cause several physiological problems, described below. Some of these problems can be eliminated or mitigated by breathing different combinations of gases. For pressures up to 11 atm., a mixture of helium and oxygen (*heliox*) is effective. Up to 18 atm., a carefully balanced *trimix* of helium, nitrogen, and oxygen can prevent problems. A cheaper and safer solution is to use *hydrox*, a mixture of hydrogen with less than 4% oxygen – there is no danger of combustion or explosion because of the low oxygen content. Genetic or biological modifications can also prevent some of the problems of breathing pressurized gases.

Helium and hydrogen mixtures cause the human voice to rise in pitch, making speech garbled and difficult to understand, and sound silly as well. Simple "desqueaker" programs – included in any communicator or VI for free – can fix this problem. Anyone attempting to understand someone breathing helium or hydrogen without such a program must make a successful IQ roll to interpret the speech correctly.

The Bends

The blood and body tissues of a human breathing compressed air absorb gas via the lungs. This gas escapes from solution when the person returns to lower pressure. If the highest pressure experienced is greater than 2 atm. – or 33 feet deep in Earth's oceans – the amount of nitrogen escaping on decompression can be too great to be expelled through the lungs. Small bubbles of the gas form in the blood and muscle tissue, causing sharp pains in the joints and body, dizzy spells, and breathing difficulties. In severe cases, blood flow to the heart or brain stops, leading to unconsciousness or death.

The solution to this problem is to decompress slowly, spending time at certain intermediate pressures to allow the nitrogen to escape harmlessly. The decompression time required rises sharply with maximum pressure (i.e., diving depth) and time spent under

Calculating Pressure

Pressure in a liquid on any world can be calculated with the following formula:

Pressure (atmospheres) = Atmosphere + (Depth / K)

Atmosphere is the pressure of the "atmosphere" above the liquid.

Depth is the depth in feet.

K is a number equal to 34 / (the gravity of the world in Gs × the density of the liquid relative to fresh water). It represents how many feet of depth result in a pressure increase of one atmosphere.

Pressure Parameters on Various Worlds

World	*Atmosphere*	*Gravity*	*Density*	*K*
Earth, fresh water	1	1	1	34.0
Earth, sea water	1	1	1.025	33.2
Mars	0.4	0.38	1.130	79.2
Titan	1.5	0.4	0.565	150
Europa, Mesocean	260*	0.14	1.074	226
Europa, Tropocean	1,360**	0.14	1.202	202

* From the weight of the ice shell.

** From the weight of the ice shell and Mesocean. Use these figures to calculate pressure in the Tropocean, measuring depth from the Hydropause – add 248,160' (47 miles) to get depth below the ice shell. See p. 59.

Note that on Europa gravity increases with depth in the ocean, so the figure quoted is higher than the surface gravity given on p. TS44.

Partial Pressures of Gases

The *partial pressure* of a particular gas in a mixture is equal to the pressure of the mixture multiplied by the fraction made up of the gas in question. Most commonly, the partial pressure of nitrogen in breathing gas is of concern. Nitrogen comprises 78% of a standard air mixture. For example, air at 2.6 atmospheres contains a nitrogen partial pressure of 2.6 × 78% = 2.0 atmospheres, which is enough to cause nitrogen narcosis.

Decompression Table

This table gives some of the salient decompression times for diving with compressed air (78% nitrogen).

*This is a highly simplified table for game purposes and not a substitute for professional dive tables – this table **must not** be used to plan real life dives.*

Depth	35	50	75	100	125	150	200	500	1,000	1,500	2,000
Pressure	2.0	2.5	3.3	4.0	4.8	5.5	7.1	16	31	47	62
No Decompression Time	Unlimited	80	40	22	10	0	0	0	0	0	0
Saturation Time	–	2.5	5	8	12	18	24	24	24	24	24
Maximum Decompression	–	16	21	29	43	49	66	130	240	350	450

Depth is in feet, on Earth.

Pressure is the water pressure in atmospheres. Use this instead of Depth if calculating dive times on other worlds.

No Decompression Time is the maximum time in minutes that can be spent at that pressure without requiring a decompression routine.

Saturation Time is the time in hours after which the body is saturated with nitrogen.

Maximum Decompression is the length of decompression required for a saturated diver, in hours.

This table assumes the diver is decompressing to 1 atm. (sea level on Earth). For divers decompressing to lower atmospheric pressures (at altitude, or on Mars), use an effective water pressure equal to actual pressure divided by atmospheric pressure.

pressure. Decompression can either take place at the appropriate water depth, or in a decompression chamber. The bends can also occur with other breathing gases – in fact heliox and hydrox require longer decompression and, in the case of hydrox, careful changing of gas mixtures during decompression to avoid potentially explosive combinations.

At a certain point, the body tissues can absorb no more gas – they become saturated. Once this point is reached, the required decompression time does not increase further. A technique for maximizing the amount of useful time spent at depth is to operate at this saturation level for days, weeks, or longer. When returning to the surface, the same decompression time is required. This technique is called *saturation diving*.

If a character decompresses too quickly, he must make a roll versus HT:

Critical success means no ill effects occur.

Success means the character suffers severe joint pains. He is at -2 to DX and IQ for at least an hour. Roll vs. HT each hour thereafter to recover. There are no lasting effects.

Failure means the character is completely incapacitated – he faints or is paralyzed for at least an hour. Roll vs. HT each hour to revive; each failed HT roll inflicts 1d damage. Once conscious, the victim is at -2 to DX and HT for at least another hour. Roll hourly vs. HT to recover; if the first such roll fails it indicates a permanent loss of 1 point of DX.

Critical failure indicates a sudden and painful death, although brainpeeling to produce a ghost may succeed if the procedure is begun quickly.

If an afflicted character is recompressed to the highest pressure he experienced, he rolls vs. HT+4 every five minutes to recover from all effects short of death.

Nitrogen Narcosis

At high pressures, nitrogen binds to fatty myelin tissue in the brain and inhibits normal mental processes. This causes symptoms similar to alcohol intoxication: heightened feelings of either euphoria or paranoia depending on emotional state, impaired judgment, and inability to perform simple mental tasks. If the condition progresses with further compression, it leads to fatigue, drowsiness, and loss of consciousness. Nitrogen narcosis occurs immediately, as soon as the pressure reaches certain levels.

Narcosis vanishes quickly with no aftereffects if the victim returns to lower pressure. Unfortunately, people are usually unaware they are suffering from it, and often actively resist any attempt to force them to safety.

If the partial pressure of nitrogen (see p. 48) is over 2 atm., any character susceptible to nitrogen narcosis has -1 to all IQ-based rolls, loses the Common Sense advantage (if he has it), and gains Impulsiveness. He also requires IQ rolls to perform even the simplest tasks, such as remembering to keep track of time or air supply. For each additional atmosphere of nitrogen partial pressure, an affected character acquires an additional -1 to IQ, and -2 to ST, to an effective minimum of IQ 6 and ST 3. Attribute penalties and acquired Impulsiveness caused by nitrogen narcosis are lost immediately if the nitrogen partial pressure falls below 2 atm., and lost Common Sense is regained.

Hydrogen also causes narcosis at partial pressures above 29 atm. (about 1,000 feet deep with hydrox on Earth). Apply the same rules as for nitrogen narcosis if this occurs, although the physiological symptoms are hallucinations rather than intoxication.

Nitrogen narcosis can be prevented by using heliox instead of air. This has two drawbacks, however. Firstly, helium dissolves more readily in tissue than nitrogen, and decompression times must be increased up to twice as long. Secondly, helium can cause a new problem . . .

High Pressure Nervous Syndrome

This occurs at partial pressures of helium above 10 atm. The gas diffuses into nerve tissue, causing muscle tremors, dizziness, nausea, drowsiness, difficulty concentrating, and visual hallucinations. These effects can be mitigated by using trimix instead of heliox, or by compressing slowly in stages, but can only be eliminated by switching to hydrox.

A character breathing helium at 10 atm. or more partial pressure must roll vs. HT, with a +1 bonus for either of the mitigating procedures mentioned above:

Critical success means minor muscle tremors, with no game effect.

Success indicates obvious tremors, causing -2 to all DX-based rolls.

Failure indicates tremors, dizziness, and nausea, causing -4 to DX and -2 to IQ.

Critical failure means the character suffers all the listed symptoms, causing -4 to DX and IQ. He may become paranoid and belligerent, or fall unconscious at the GM's option.

These effects last until the victim is removed from the high-pressure helium atmosphere, at which point he recovers immediately, but may stay asleep if already unconscious.

Oxygen Toxicity

Oxygen itself can cause damage at partial pressures above 0.6 atm. Exposure for a few hours can cause lung inflammation and pulmonary edema – the leakage of fluid into the air spaces. At higher pressures, oxygen toxicity can be lethal. The only way to prevent danger is to avoid high partial pressures of oxygen. This means switching to gas mixtures with smaller proportions of oxygen during compression. As long as the partial pressure of oxygen is in the range 0.15 to 0.6 atm., mammals can extract enough to survive safely.

If a person is exposed to high oxygen partial pressures, apply the following rules. Attribute penalties are not cumulative with increased pressures, but symptoms are.

0.6-1.5 atm. partial pressure of oxygen: Make a HT roll every 4 hours to avoid onset of symptoms. On a critical failure, the victim finds breathing painful and is beset by wracking coughs, causing a -2 penalty to DX. Once these symptoms begin, the victim must make a successful roll vs. HT every 10 minutes or take 1 point of damage.

1.6-2.5 atm. partial pressure of oxygen: Make a HT roll every 2 hours to avoid onset:

Failure indicates the victim suffers muscle twitches, dizziness, and nausea, causing -4 DX and -2 IQ penalties; roll vs. HT every five minutes to avoid 1 damage.

Critical failure indicates the victim goes into convulsions and automatically takes 1d-3 damage per minute. Convulsions do not stop until medical treatment is given – do not continue to roll vs. HT. If using scuba gear with a mouthpiece, make a DX roll every minute to avoid dislodging it and drowning.

2.6-3.5 atm. partial pressure of oxygen: Make a HT roll every hour. On a failure, vision and hearing become impaired; the character suffers -4 DX, -4 IQ, and an additional -2 on sense rolls. Once a diver has failed an hourly HT roll, he must roll vs. HT every minute:

Critical success indicates no further effect until the next HT roll.

Success indicates 1 point of damage from coughing.

Failure indicates the victim goes into convulsions as above.

Critical failure means death.

Greater than 3.5 atm. partial pressure of oxygen: As for the 2.6-3.5 atm. range, but make HT rolls to avoid onset every 30 minutes.

A character can only recover if removed to a lower oxygen environment and given medical attention. A successful Physician roll will stop convulsions and reduce attribute penalties to -2 on DX. Lost hit points are recovered as per recovery from disease (p. B133), with a +4 bonus on any HT rolls for appropriate nanodrug treatment ($500 per dose). The -2 DX penalty is removed only when recovery is complete.

Pressure

High pressure is not intrinsically dangerous to humans over short time scales. If compressed slowly (taking 10 minutes per atmosphere), the human body can withstand pressures up to 100 atm. without physical damage. The problems associated with pressure have to do with the process of changing pressures, the toxic effects of gases absorbed through the lungs (see *Breathing*, p. 48), and long-term exposure. The Pressure Support advantage (p. 104) will help prevent these effects.

Divers who are compressed by more than 10 atm. without enough time for their bodies to adjust are subject to crushing damage as per p. TS58. If someone is exposed to high pressure *suddenly*, such as in a breached vehicle, the result is generally instant death. People with blocked sinuses or other air cavities such as decayed teeth will feel increasing discomfort and pain when compressed, even slowly, as the cavities are squeezed. Such pain causes a -1 penalty to DX and IQ-based rolls until it is relieved. The only solutions are to vent the cavities or to return to lower pressure.

Pressure can also cause problems when it is lowered. Bodily air cavities cause pain similar to that caused when pressure increases. A worse problem is that expanding gas can rupture body tissues or penetrate blood vessels and form bubbles in the blood, conditions known as *embolisms*. This causes symptoms similar to the bends – GMs who assess a chance of gas embolism should apply the rules for the bends (p. 48), including treatment and recovery. The greatest risk of gas embolism comes from holding one's breath while ascending during a dive in which compressed gas has been breathed. As the gas in the lungs expands it must be exhaled or severe embolism is inevitable (treat HT roll results as one category worse, so any failure results in death). Panicked divers may forget this cardinal rule (IQ or Scuba roll to remember if mental state is agitated).

Prolonged exposure to high pressure causes stress to the cardiovascular and musculoskeletal systems. People living in environments more than 10 atm. higher than their native pressure must make annual rolls vs. HT+2. Failure permanently reduces HT by -1.

Aseptic Bone Necrosis

This is a long-term problem caused by the effects of decompression on capillaries in the bones. Tiny bubbles of gas coming out of solution can damage these blood vessels, weakening the bone. It most commonly occurs in the hip, shoulder, and knee joints, and leads to increased likelihood of fractures. The only cures are joint replacement surgery or nanodrug treatment ($5,000 per treatment) to rebuild the capillaries.

The GM may require an annual HT roll for any character engaging in frequent compression. A failure indicates onset of this condition, causing a permanent -1 to HT, unless treated.

Cold and Heat

The rules for cold and heat on p. B130 are for exposure to air. Water has a much higher heat capacity than air and conducts heat away from the body rapidly. It also penetrates clothing, destroying any insulating effect. Warm water prevents the body from losing heat by sweating, making it worse than hot air. The result is that a character's temperature "comfort zone" (see *Temperature Tolerance*, p. CI30) is markedly reduced when in water. A baseline human, with a comfort zone in air of 35°F to 90°F (assuming suitable "everyday" clothing), has a comfort zone of only 75°F to 85°F in water. Diving suits can extend these zones (see p. 116). Aquatic-adapted characters have a default comfort zone of 50°F to 85°F in water – many animals have this zone shifted upward or downward to some extent.

Anyone immersed in water at a temperature below his comfort zone must roll vs. HT once per minute, taking 1 point of fatigue on a failure. This represents fatigue caused by shivering – if he is actively swimming he stays warm, but takes fatigue according to the swimming rules on p. B91. If the water temperature is more than 20 degrees below the comfort zone, a successful HT roll causes 1 point of fatigue, while a failed roll causes the number of points equal to the amount by which the roll failed. Once unconscious due to fatigue, the character loses hit points instead.

Immersion in water close to freezing can also cause thermal shock. Anyone plunged into water with a temperature more than 20 degrees below his comfort zone and also below 35°F takes 1d-3 cold damage per minute, in addition to any fatigue. He must also roll vs. HT. A failure reduces DX and DX-based skills by -3 until he is warmed up. Critical failure indicates cardiac arrest, which reduces hit points to 0 if currently positive and causes death in HT/3 minutes unless CPR is given successfully (First Aid-4 or Physician roll). If someone is unfortunate enough to be immersed in a cryogenic liquid such as Titan's ethane seas, apply the cryogenic atmosphere rules from p. TS58.

A character in water *hotter* than his comfort zone also rolls vs. HT once per minute, taking 1 point of fatigue on a failure. If the water is more than 40 degrees above the comfort zone, the character also takes 1d-4 burn damage per minute. At 50 degrees above the comfort zone, the water is dangerously hot and causes 1d-4 burn damage per second.

Movement

Non-aquatic characters use the swimming rules on p. B91 to swim on the surface. Aquatic-adapted characters do not need Swimming skill. They automatically swim at their base Move without needing to roll (see *Aquatic*, p. 105).

Underwater, non-aquatic characters with an air supply must roll against Scuba skill (p. B48) every half hour, and need no Swimming rolls. They swim underwater at the same speed as on the surface, rolling for fatigue as per p. B91. Swim-fins give swimming Move bonuses (see p. 117). Non-aquatic characters may swim very long distances at a slow speed to minimize fatigue; speed is two times Swimming skill yards per minute, or three times if swim-fins are worn. Distance swimmers fatigue at the same rate as if marching on land (p. B134).

Aquatic-adapted characters move freely underwater at their full Move score. They swim long distances according to the marching rules on p. B187. Aquatic-adapted characters generally cannot make use of simple swim-fins, since their limbs and propulsion method are already optimized for pushing their bodies through water.

Swimmers can ascend or descend at their swimming movement rates, but if they are breathing pressurized gas, then descending faster than 75 feet per minute causes sinus pain and can exacerbate nitrogen narcosis and high pressure nervous syndrome, while ascending faster than 30 feet per minute requires a HT roll to avoid the bends, as per p. 48.

Light Attenuation by Water

Water absorbs visible light and suspended particles scatter it, resulting in a drop in visibility with distance. These effects are combined in a numerical "transparency" rating, abbreviated T.

Light levels underwater on a sunny day are sufficient to incur no darkness penalty to a depth of 5T yards. Below that depth, darkness penalties are -1 per additional T yards (round down to a lower penalty). If the sky is overcast or darker, darkness penalties begin accumulating from the surface, and any above-water darkness penalty is added. Water preferentially absorbs red light, but particles do not affect this; below 50 feet everything takes on a greenish-blue cast and everyone effectively has the Color Blindness disadvantage (p. B28). Artificial light sources negate Color Blindness and any darkness penalty, but their light falls off at the same rate of -1 darkness penalty per T yards.

Vision and ladar Scan suffer a -1 penalty per T yards; vision is totally blocked at 10T yards. If the line of sight crosses a typical air-water boundary with waves or ripples, this causes an additional -2 penalty.

Laser weapons have their 1/2 Damage range limited to 2T yards, and Maximum range limited to 4T yards.

Laser communicators with 20-mile range have an underwater range of 5T yards; for each factor of 10 increase in range, add an additional 5T yards of underwater range. Data rate is 1/100 the rate in air or vacuum.

Typical T Values

Pure water	50
Very clear sea water (Gulf Stream)	25
Open sea	20
Continental shelf waters	10
Coastal waters	2
River plume	1
Harbors	<1
Europan ocean	20
Martian ocean	1-5

Senses

Non-aquatic characters have their senses adversely affected in an underwater environment, and characters with the Aquatic disadvantage have impaired senses while in air. Characters with the 10-point version of the Amphibious advantage do not suffer any penalties in either environment.

Vision: The absorption of light by water gives a -1 penalty on Vision rolls per T yards of range (see *Light Attenuation by Water*, see box), in addition to any low light penalties, for *all characters*. Non-aquatic characters have a further -4 to Vision rolls and suffer a -4 penalty on manual tasks requiring vision (such as Mechanic rolls) if their eyes are directly exposed to water – goggles or a mask will prevent this problem. Aquatic characters suffer similarly if their eyes are exposed directly to air. The refractive index of water relative to air means that objects viewed through a flat window appear to be 25% larger and closer than they really are – this effect can be corrected by using a variable-thickness or spherical window, which is standard for diving masks and most submarine viewports in ***Transhuman Space***.

Hearing: The increased speed and carrying distance of sound in water distorts sounds and makes it difficult to tell where a sound originates. Non-aquatic creatures will also usually underestimate the distance a sound has traveled. Non-aquatic or aquatic-adapted characters in their non-native environment roll normally to *hear* a sound, but must succeed by 4 or more to localize or recognize it.

Taste and Smell: Non-aquatic characters cannot effectively taste or smell when underwater, even if they are not wearing masks.

Combat

The ***GURPS Basic Set*** has rules for underwater combat on p. B91. Those are appropriate for non-aquatic characters. Aquatic-adapted characters follow the rules given here.

Firstly, such characters are efficient fighters underwater. They still have to work against the resistance of the water, but they are used to this. Rather than periodically rolling against Swimming skill in a fight, they roll against HT+3 every 10 seconds, taking 1 fatigue if they fail. They still suffer fatigue based on Encumbrance at the end of long fights (see p. B134).

Aquatic-adapted fighters also use weapons effectively. Close weapons (including fists) are used at no penalty, 1-hex weapons at -1, and longer weapons at an additional -2 per hex. (Thus, an Aquamorph uses a 3-hex weapon at -5 underwater, rather than the baseline human's -12.) They also suffer only -1 to damage with Close weapons underwater, rather than the normal penalty, though with other weapons they do damage as described in the following sections.

Hand-to-Hand Combat

Thrusting, impaling weapons are more effective underwater than swung weapons – they meet relatively little water resistance, whereas a full arm-swing meets a lot. To reflect this, damage from such weapons should be reduced by only one-third, rather than one-half, while damage from any weapon that must be readied after a swing should be reduced by two-thirds. GMs may have to rule that weapons and attacks fall into which category on a case-by-case basis. Most commonly carried melee weapons underwater will be thrusting, such as knives and spears. Knives are particularly useful, since attacks targeted at the diving equipment of an air-breather can achieve lethal results without even touching the victim's skin.

Note that underwater combat is three-dimensional, with fighters able to pass over, under, and around each other. Aquatic-adapted beings can use their Athletic and Combat/Weapon skills normally when rolls against such skills are required to maneuver in combat. Non-aquatic combatants must roll against the lower of the skill in question and Swimming skill to perform such actions. Characters with 3-D Spatial Sense (p. CI31) have a +2 bonus to such rolls.

Ranged Attacks

The following rules apply to ranged weapons underwater:

Thrown weapons have 1/10 their usual 1/2 Damage and Maximum ranges, and do half their normal damage. (This means they do 1/4 listed damage between their reduced 1/2 Damage and Maximum ranges.) If this reduces the maximum range to 1 hex or less, they cannot be effectively thrown. This rule also applies to mechanically powered projectile weapons, such as spearguns or high-tech crossbows.

Guns and cannons firing conventional projectiles (not specially designed for underwater use) underwater have 1/1,000 their normal 1/2 Damage and Maximum ranges. Round 1/2 Damage range down and Maximum range up. If the modified 1/2 Damage range is 0, the bullet always does 1/2 damage underwater. Supercavitating bullets have 1/20 the normal 1/2 Damage and Maximum ranges. Indirect fire is not possible underwater. Modern guns are relatively safe to fire underwater or immediately after immersion. Older guns will malfunction and become unusable on a skill roll of 16 or higher; on a critical failure they explode.

Torpedoes are designed for use in water and suffer no penalties.

Laser weapons have their 1/2 Damage range limited to 2T yards, and Maximum range limited to 4T yards underwater (see *Light Attenuation by Water*, p. 52). This assumes tunable rainbow lasers, which are the default in ***Transhuman Space***. Obsolete or cheap lasers without the ability to emit blue-green beams have these limits divided by 5 (round fractions up).

Electrolasers do not work at all underwater. Attempting to fire one in water will simply trip a circuit breaker designed to prevent shock to the user.

Explosions are more dangerous underwater because water transmits the concussive pressure waves much more readily than air. Triple all distance increments for concussion damage (see p. B121).

Radiation is attenuated by water. A yard of water has a radiation PF of 8 (see p. TS60). Note this is multiplicative; two yards of water has PF 64, and so on.

Any ranged attack that passes from air to water, or vice versa, should have the underwater part of its range reduced as above. For example, a bullet fired from air into water treats each hex after it enters the water as equivalent to 1,000 hexes in air – this usually means it penetrates a maximum of only 1 yard into the water. Refraction at the air-water boundary makes aiming across it difficult. Ranged attacks made from air into water or vice versa are at a -4 penalty.

The Psychology of Diving

Diving is arduous work, not only because of the physical difficulty and danger, but also because of the mental hardship of functioning in an alien environment.

Panic

The underwater environment can quickly cause panic in divers dependent on a constant air supply. Any unexpected event, particularly one interfering with air supply, can require a Fright Check (p. B93). Examples include: becoming entangled in seaweed or a net or line; the sudden, close appearance of a shark; having a face mask knocked off; or failure of breathing gear. Divers may substitute Scuba skill for IQ when calculating Will for such Fright Checks.

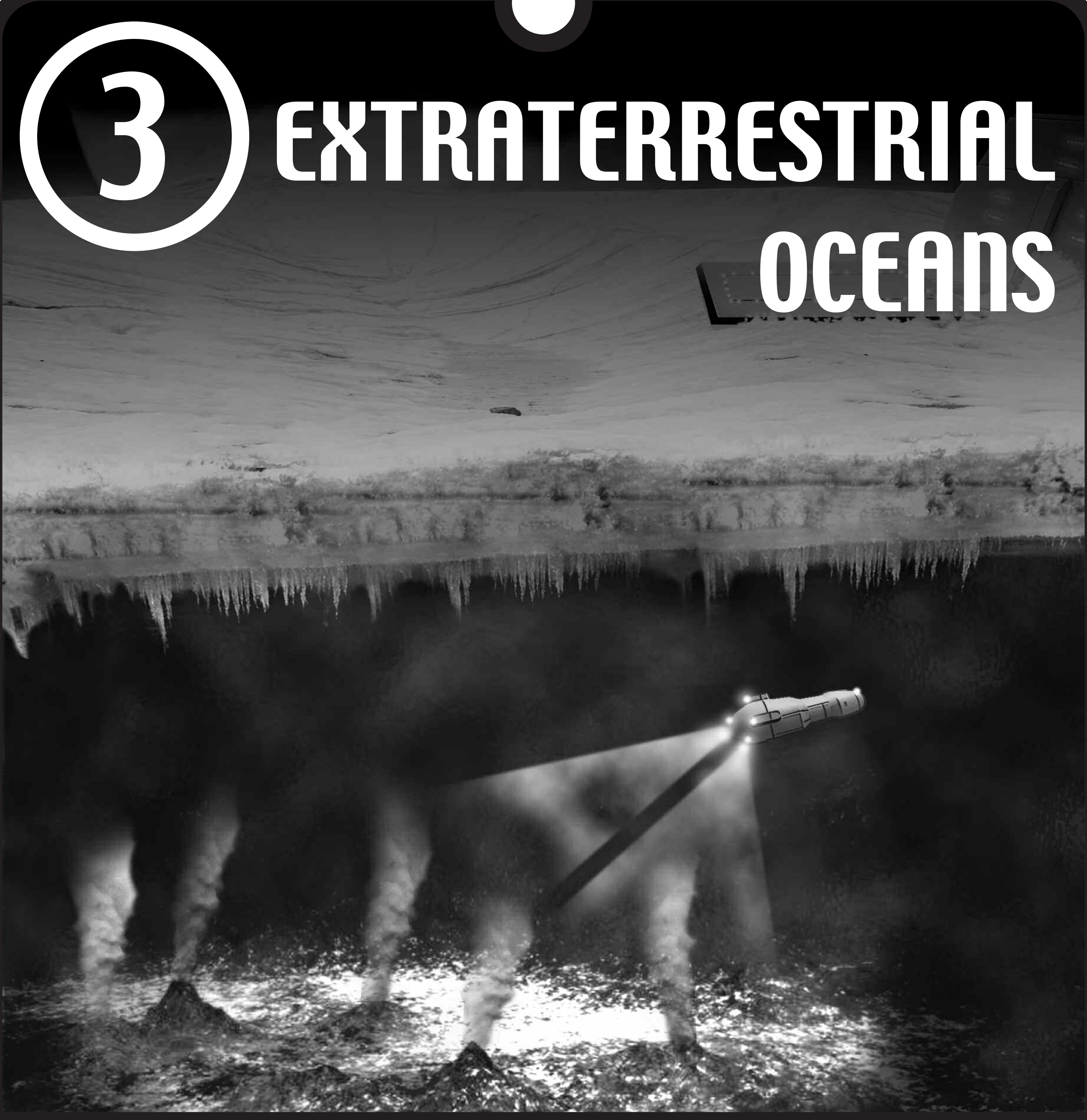
An air-breathing character who fails a Fright Check underwater must make a roll vs. HT. Failure indicates that he begins hyperventilating – if no air supply is available he must make a Will-4 roll to prevent inhaling water and roll an additional Fright Check at a -3 penalty. A hyperventilating person is unable to perform any rational action except make a Will-2 roll every 10 seconds to recover. He may behave erratically, bolting for the surface or flailing wildly; the GM may require DX rolls to avoid dislodging or damaging equipment, including breathing gear.

Long-Term Effects

In some cases, living underwater can be as lonely as existence anywhere in the solar system. The limited utility of radio for keeping in contact with the outside world means people can be truly isolated. Confinement within a cramped vehicle or habitat with limited social interaction is a recipe for stress. Some people handle stress well. Some become antisocial and aggressive, while others become withdrawn and suffer feelings of inadequacy and low self-esteem. Forcing players to roleplay these effects may not suit some gamers, but the GM can use them to give life to NPCs and create dramatic incidents.

Seasonal Affective Disorder (SAD): This is a form of clinical depression caused by a biochemical imbalance of the hypothalamus gland due to a lack of sunlight. It affects surface-dwelling humans during winter months, and can be a permanent problem for underwater dwellers. The most effective treatment is exposure to bright light for several hours per day. Most underwater habitats have strong lighting installed in commonly used areas, with a brightness approaching full daylight. The latest aquatic parahumans have a genemod that prevents SAD, but lighting systems are cheap and common, so there is little incentive to remove them.

3 EXTRATERRESTRIAL OCEANS



Angelo shifted impatiently in his seat. The zeppelin transfer from Robinson City to Sharona was the last leg of a journey that began 100 million miles away in San Diego, and he was tired of traveling.

"Nearly there," said the woman in the seat next to him. She was an Adapt, heavily set with noticeably thick brunette hair on all of her exposed skin. "Been to Sharona before?"

"Haven't been to Mars before," answered Angelo.

"Oh, from Earth?" He nodded and she continued, "Not many of you visit us up here in the frigid north, except for the terraformers. You helping with that?"

"Sort of. I'm a marine biologist, here to help with the aquaculture facilities. Seems you folks don't know how to grow fish." Angelo grinned, warming to the woman's friendly expression of interest. "Speaking of which," he turned to the window, peering at the black and brown landscape beneath, "we should be able to see the ocean by now, no? Where is it?"

"That's it." The Adapt gave a smile of her own. "Seems to me they could have sent someone who knows what water looks like."

Angelo kicked himself mentally. Of course he knew the Borealis wasn't blue and hospitable like the seas back home. This job was going to be harder than he thought.

"I've had a long trip. How about a drink when we land?"

Earth is not the only world with oceans. Some of the icy moons in the Deep Beyond contain more liquid water than all of Earth's oceans combined, kept liquid by radiogenic or tidal heating. One satellite – Titan – has oceans of liquid hydrocarbons. And Mars has seas newly created by the hand of humanity. The extraterrestrial oceans may sometimes appear similar to those of Earth, but they are even more alien and dangerous places.

Mars

The oceans of Mars are described in ***Transhuman Space: In The Well***, in terms of their relationships to settlement and terraforming. The following sections describe their physical and oceanographic characteristics.

The Borealis Sea

The high salt and mineral content (15% salinity) of the Borealis Sea lowers its freezing temperature to 14°F. This helps to keep the ocean liquid during the summer months, but in the long winter the temperatures drop below 0°F all the way down to the low latitudes, and the surface of the ocean completely freezes over. Since the impurities in the water are locked out as it freezes, the white sea ice that forms is a stark contrast to the silty, coffee-colored water on which it floats. A system of thermal boreholes coupled with a network of pumps and heat distributors on the sea floor keep the deeper parts of the ocean liquid all year round.

Despite this, the ancient north polar ice cap extends to latitude 80°N and a great sea ice cap extends southward over the Borealis Sea all year round. During the summer, the sea ice is thinner and breaks into great ice rafts, but in winter it forms a solid cap over the sea down to around latitude 60°N.

Ocean circulation on Mars is similar to that on Earth. Although there are thermal boreholes and an extensive heat distribution system on the sea floor, the temperatures there are not very high – only around 25°F, just enough to keep the water liquid below the surface. Cold water sinks from below the permanent sea ice cap and flows southwards and westwards (due to Coriolis force) toward the southern shores of the ocean and any water not covered by ice. These currents funnel icebergs calving from the sea ice shelf north of the Chryse Bay toward the settlements on the western shore of the bay, causing a major shipping hazard there.

The deepest point in the Borealis Sea is located to the north of Chryse Bay near Tempe Terra, where the water depth reaches 1.1 miles. The pressure at this depth is 75 atm.; the freezing point is slightly lower at 12°F.

The Marineris Sea

This body of water is kept liquid all year round by orbital mirrors. Ideally, cold water would flow into its depths for its whole length from the Borealis Sea while warmer water would flow from Marineris into the Borealis Sea. However, the system of giant locks and dams in the Valles Marineris hinders the natural circulation of the water (see p. ITW22) – as a result of this and the illumination by the mirrors, the Marineris Sea is much warmer than the other oceans on Mars. A complex pump system allows cold water from the Xanthe River to enter Lake Eos at the base of the dams, while cold subterranean water can enter the central part of the Sea from Lakes Ius and Tithonium. The entire sea is also allowed to cool by reorienting the mirrors for a couple of hours every day.

The Hellas Sea

The Hellas Sea is isolated from the other oceans on Mars. The deepest point on Mars is in the Hellas basin, at a depth of over three miles in the northwestern corner – the pressure on the sea floor here is 200 atm. A permanent sea-ice shelf extends into the sea from the southern shore, and the sea surface freezes completely during the winter. At other times, the liquid surface is filled with icebergs, which circulate counterclockwise around the center of the sea because of Coriolis force.

Europa

Europa is the sixth major moon of Jupiter, and the smallest of the Galilean satellites. Its surface is bright water ice, with brown and yellow bands and irregular patches of varying size. The colors are the result of salt contamination, primarily magnesium sulfate. Different rates of radiation bombardment color the salts yellow in the leading hemisphere of Europa, and brown in the trailing hemisphere.

Beneath Europa's icy surface is a vast salt-water ocean that is home to the only extraterrestrial life so far discovered. The *Centre de Recherche AstroBiologique d'Europa* (CRABE), a science foundation funded by the European Union, is studying these life forms. A Duncanite corporation – Avatar Klusterkorp – arrived later, secretly initiating a pantropist plan to colonize Europa with adapted life forms and modified humans. CRABE recently uncovered this project's existence, leading to outrage among Preservationists. A radical group – the Europa Defense Force (EDF, p. TS44), led by former Negative Growth terrorist Torsten Rademacher (see p. DB102) – has arrived on Europa to stop Avatar's research. A low-intensity conflict has broken out between the two factions as a result – a small but fierce "war under the ice," with CRABE attempting to remain neutral.

Europa and the organizations present on it are introduced in pp. TS43-44 and DB44-49.

The Surface of Europa

"The distant sun hangs low in the western sky and evening slowly draws on. I'm on my way to Manannán Station for an exclusive interview with the leader of the Europa Defense Force, those self-styled crusaders for the preservation of the indigenous Europan ecosystem. I've been traveling for hours now, picking my way over the broken landscape, wishing they'd chosen a better method of transport than the Landstrider I've ended up in. I'm tired, hungry, and more than a little nervous.

"Around me is a world of shadows. That's what you get when the sun's low and there's barely an inch of flat ground to walk on. Quite appropriate given all the conspiracies and secrets that are hidden beneath the icy surface – secrets I'm going to reveal, assuming I can get there in one piece."

– Copernicus Jones,
War in Europa *(TEN: 2099)*

Europa is covered by a network of overlapping cracks and ridge systems that reach a variety of heights. Few parts of the surface are flat and level – ground slopes usually range between 5° and 20° from the horizontal. Despite this, Europa is relatively smooth on a global scale – the greatest elevations on Europa are rarely more than 1,500 feet above the average satellite radius. There are no huge mountains or deep craters.

Travel over the Europan surface is chancy at best. The slope changes every few hundred yards, and a traveler must jump or fly over the large cracks that are encountered every few miles – simply detouring around them is not an option when they extend for hundreds or thousands of miles.

Tides and Surface Travel

Tidal forces on Europa are caused by its orbital motion and vary with location. A full tidal cycle is equal to the orbital period: 3.55 Earth days. These forces can act to open or close existing cracks in the ground, or create new ones. Millions of years ago, when the ice shell was thinner, the tides forced small amounts of water up the cracks toward the surface. If the water reached the surface, it froze to form a small mound on either side of the crevasse. Over thousands of years, these mounds built up to form the double ridges that crisscross the surface. If the water did not reach the surface, it froze underground and propped the crack open. Today the ice shell is thicker because of global cooling, and the water can no longer reach the surface. Cracks still open and close over the tidal cycle, but they no longer penetrate to the base of the ice shell. As a result, double ridges are no longer formed today, except under extraordinary circumstances.

The tide acts on entire regions, pulling double ridges apart by a few yards, opening existing cracks further – sometimes even creating new cracks that stretch for hundreds of miles, cutting straight through every type of terrain – then bringing them back together to their original configuration. At high latitudes the tides can also cause *snapback*, which occurs as stresses build up in cracks while they are closed during the tidal cycle. When they are opened later, they release the built-up shear stresses, causing one side to move suddenly to the left or right by a few yards. This is rarely troublesome, but can cause distress for travelers unfamiliar with the phenomenon of what CRABE personnel refer to as "The Lurches."

Cracks do not open and close quickly enough to trap vehicles, but the tides do cause problems by opening unexpected cracks that vehicles cannot traverse. The only solutions are to either find a way around the crack (if it is short enough) or wait 18 to 22 hours for the tidal forces to close it. As a result of the tidal effects, surface travel over Europa is rare and only undertaken when absolutely necessary, over short distances.

Ridges and Cracks: The most common type of Europan ridge system is the double ridge – two triangular ridges next to each other, occasionally with a deep fissure several dozen feet wide between them. The ridges are usually symmetrical in section, but sometimes the center-facing slopes are steeper than the outer slopes. Other types include bare cracks (deep crevasses dozens to hundreds of yards across), lipped cracks with rims that slope upward before they drop steeply into the crack itself, and complex ridges with wide bumpy plateaus at the top. Double ridge systems are typically 1,000 to 3,000 feet across, and a tenth as high. Ridges are often crossed or cut by other ridges and cracks that can deform and warp them.

Chaos Terrain: These are large areas where plumes of warm ice have broken through the surface (e.g. Thera Macula). "Warm" is a relative term – the plume is only a few degrees warmer than the surrounding ice. Chaos is the dominant terrain type being formed today, though the timescale for its formation is tens of thousands of years. Chaos areas consist of rafts of ridged terrain separated by a hummocky, salt-rich matrix, bearing a striking resemblance to enormous icebergs in a frozen choppy sea. The edges of the rafts are steep cliffs that rise a few hundred yards above the matrix. Sometimes the rafts are tilted into the matrix, with the opposite end rising high above the surface.

Lenticulae: Sometimes known as *micro-chaos*, lenticulae are irregularly-shaped pits, spots, and domes that punctuate the landscape. They can be up to 10 miles across, and usually form around larger chaos areas. The depressions have broad floors, often containing hummocky, disrupted terrain that is troublesome to negotiate. Domes warp the existing terrain, and can contain hummocky terrain at their summits. Lenticulae are formed when small plumes of water or warm ice penetrate the ice shell all the way to the surface, but at a smaller scale than the larger chaos terrains.

Secondary Impact Craters: Primary impact craters such as Pwyll and Manannán are few and far between. Falling ejecta from such impacts causes smaller secondary craters, which occur in clumps across Europa (particularly around the Pwyll impact, which scattered ejecta up to 1,000 miles). These are bowl-shaped, from tens of yards to half a mile in diameter.

Under the Ice – The Oceanus Noctis

The standard joke around here is that we work under the most pressure in the solar system, but in the end it's not much different from working in any deep underwater rig on Earth, or in a space station. Whether the pressure outside is non-existent or 1,500 atmospheres, either way we'd be dead if the hull was catastrophically breached. So you tend to forget about it. Sure, it can get claustrophobic at times, but if you want to have a break then head up to the surface and enjoy the view. There's nothing like watching Jupiter looming over the horizon with a few moons in tow to blow away the cobwebs.

– Kurt Brzinski, CRABE/Vosper-Babbage Engineering Chief

Europa's ice shell is 13.5 miles thick. Beneath it lies the *Oceanus Noctis* – the Ocean of Night – a vast sea of salty water extending 51 miles further to the geologically active, rocky surface below. The rocky body is 1,820 miles in diameter, with a solid metallic core 915 miles in diameter.

The Oceanus Noctis is so named because there is no natural light, apart from the occasional dim red glow visible at active volcanic vents on the sea floor. Its volume is almost twice that of all of Earth's oceans combined, and it is 7.5 times as deep as the Marianas Trench.

The Oceanus Noctis is about as deep as Earth's atmosphere, and unsurprisingly the most interesting part is the bottom of it. The structure is unlike that of Earth's oceans, since Europa has no atmosphere and effectively no solar heating at the top of the water to drive circulation. The Oceanus Noctis is divided into two separate layers – the upper *Mesocean*, and the lower *Tropocean* – separated by a compositional boundary known as the *Hydropause*.

The Sea Floor

Only 15% of the Europan sea floor has been mapped at resolutions greater than 3,000 feet – much of it is "Europa Incognita." Most of the floor consists of clays and muds formed by the *in situ* chemical breakdown of the basaltic lava flows that make up most of the seabed. Nearer the many eruption sites, the recently erupted volcanic rock is exposed and largely unaltered; fragments of solidified lava and broken chimneys litter the sea floor.

Europan silicate geology is similar to that of Venus – plate tectonism does not occur in the same way as it does on Earth. Instead, active rifting jostles plates against each other to form long fold belts and shear zones, and the crust is recycled by a process of thickening and melting. The dominant form of heat loss is hotspot volcanism, with the three largest volcanic centers located under Conamara Chaos, Thrace/Thera Maculae, and a region east of Morvran crater at 5°S, 140°W. There are many recent but extinct hotspots and vent fields scattered across the sea floor, indicating that heat flow within the past ten million years was greater than it is today. This was most likely due to a period of increased tidal heating, which may also have been responsible for the complete resurfacing of Europa's ice shell. Volcanic activity appears to have died down considerably since this peak, with current levels slightly lower than that of Earth. Ongoing volcanic and hydrothermal activity is focused along rift zones and around isolated active hotspots.

Mineral Resources. Metalliferous sediments – including iron, zinc, and manganese sulfides and oxides – can be found around active black smoker vents. The largest fields, however, are found around extinct vents, where the sediment has had time to be chemically weathered. Avatar Klusterkorp has set up a few automated mining stations to exploit these resources.

The Basal Seas

The bottom of the Oceanus Noctis is dominated by the effects of submarine topography. Trenches, ridges, basins, and hills can restrict the free flow and mixing of water at the sea floor, separating the bottom water into local *basal seas* with different salinity, temperature, and density from the rest of the ocean. Turbidity currents and volcanic eruptions can destroy the physical barriers between a basal sea and the rest of the ocean, causing the basal sea to mix with other water and lose its separate chemical identity.

Local variation in the hydrothermal vent chemistry determines the characteristics of the various basal seas. Some of the more isolated seas have their own divergently evolving vent ecosystems.

The Tropocean

Hydrothermal vents erupt into the *Tropocean* – the lower of the two major layers of the Oceanus Noctis. The Tropocean extends just over four miles above the sea-floor datum level (64.5 miles below the ice surface), above the basal seas and most of the topography. It consists of hydrothermal fluids composed of salts and minerals dissolved in water that have erupted from vents and are not constrained by topography to form basal seas. Its waters are generally well-mixed. The top of the Tropocean contains material from small to medium-sized volcanic eruptions that has risen above the denser hydrothermal fluids. These *megaplumes* do not have the buoyancy to penetrate the Hydropause and rise to the top of the Oceanus Noctis, and thus remain at the top of the Tropocean. They supply heat that drives the circulation in the Mesocean above. Currents within the Tropocean driven by Coriolis force distribute material over large areas of the sea floor. Most of the sea-floor topography is contained within the Tropocean. There are a few large hotspot volcanoes however, similar to Earth's Hawaiian Islands, which rise above the Tropocean and penetrate into the layer above.

The Hydropause

The boundary between the Tropocean and the Mesocean is called the *Hydropause*. Since the Tropocean is much more saline than the Mesocean above it, the strong density contrast between the two layers prevents material from mixing between the oceans. In oceanographic terms, the Hydropause is a very strong *halocline* and *pycnocline* (change of salinity and density, respectively) that separates the two layers.

The Hydropause is not a distinct layer *per se*, but is a very effective barrier to convection between the layers. This barrier is up to 200 feet thick, and varies by a few hundred feet in height above the sea floor depending on the topography and activity below. Sea-floor topography can penetrate this layer – the Thrace Rise, Mount Thera, and the Conamara Rise are examples of large volcanic edifices that rise above the Hydropause and can erupt material directly into the Mesocean.

The Mesocean

The *Mesocean* is much more extensive than the Tropocean, extending 47 miles from the Hydropause up to the base of the ice shell, comprising the vast bulk of the water on Europa. It is well-mixed by convection, with upwellings where warm plumes from the Tropocean impinge on the Hydropause, and so has a fairly uniform composition. It is also where most of Europa's weak magnetic field is induced by passage through Jupiter's magnetic field.

Hydrothermal plumes can occur in the Mesocean if they erupt from volcanoes that rise above the Hydropause, or occasionally from powerful eruptions that penetrate into the Mesocean from below. Since the Mesocean is not internally stratified, such *hyperplumes* can rise all the way to the base of the ice shell and create thermal instabilities there, driving ice shell convection and ultimately creating chaos terrain on the surface. If the plume is long-lived and powerful enough, it may melt through the ice layer completely, though this is very rare.

Material erupted by hyperplumes stays entrained in the plume as it rises, and disperses laterally when the plume hits the ice shell. The material is then convected down, or settles back into the depths.

Ocean Circulation

On Earth, water temperature varies depending on depth and geographic location, generally being warmer at the surface. On Europa however, the top of the Mesocean is always colder than its base. The water density is higher at the top of the Mesocean than at the bottom, so convection cells span that entire body of water, carrying cold water into the depths and warmer water up from its base. The Hydropause usually prevents water from the Tropocean mixing with the less saline water above it. Lateral currents also exist, caused by Coriolis effects.

In the Tropocean, volcanic eruptions and topographic effects produce complex lateral and vertical currents. Although the ocean currents are similar to atmospheric weather systems, they have so far not been powerful enough to affect facilities there.

Europan Oceanography

Pressure: The weight of the miles of ice above the water means that even at the top of the Oceanus Noctis the pressure is 260 atm., equivalent to a depth of 8,600 feet below the surface of Earth's oceans.

Pressure increases by one atmosphere per 226 feet of depth in the Mesocean (cf. per 33 feet on Earth) up to 1,360 atm. at the base of the Mesocean. It then increases more rapidly (one atmosphere per 198 feet) within the Tropocean because of the greater water density, to a crushing maximum of 1,470 atm. at the sea-floor datum. Pressures this great do not exist in Earth's oceans – they would be found at a depth of 48,800 feet under the sea, over a third again as deep as the Marianas Trench.

Salinity: The salinity of the Mesocean is 5% (cf. 3.5% on Earth). The bulk of the salt content is magnesium sulfate rather than sodium chloride. The Tropocean salinity is much greater than the water above it, averaging 10% saline.

The basal seas are always more saline than the Tropocean, since the hydrothermal output is trapped there by the topography and the saline fluid cannot circulate. Many basal seas are between 10% and 20% saline. The most saline basal sea known is located in the Kargel-Zolotov Channel, which has a salinity of nearly 30%.

Temperature: The uppermost part of the ocean is stable at 25°F – just above the freezing point given the salinity and pressure. At the base of the Mesocean, heating due to compression of the water raises the temperature to 40°F.

Temperatures in the Tropocean increase from 40°F near the top to 50°F toward the sea floor. Near hydrothermal and volcanic vents, temperatures range up to hundreds of degrees Fahrenheit depending on how far the water is from a heat source. The temperature gradient is very steep around the vent chimneys, going from 650°F to 50°F over a few inches. The vertical temperature gradient is less extreme, dropping a similar amount over several yards. Hydrothermal life can be found in the region around the vents, where the temperature range is 50°F to 175°F.

Density: Europan seawater is densest at its freezing point, and decreases in density as it gets warmer. This means that water at the top of the column is denser than water below it – the convection cells that result from this keep the Mesocean well-mixed and chemically uniform. The Tropocean has a higher density because of its greater salinity – the large density difference defines the Hydropause.

Acidity: The Oceanus Noctis is very slightly acidic because of the hydrothermal gases left over from reactions with the rocks on the sea floor. Acidity tends to be higher immediately around some hydrothermal vents and in some basal seas. The acidity is not significant enough to cause problems for life or equipment.

The War Under the Ice

We are the Europa Defense Force. We exist to defend the virgin Europan ecosystem from the intrusions of those who have no regard for the sanctity of indigenous life. Today's actions are but the start of our righteous struggle to liberate Europa from pantropic pollution and we vow to continue until all the artificial forms the Duncanites have released into the environment have been destroyed, and the pantropists are ousted from this world. Know that nothing is of higher priority to us than the preservation of the Europan ecosystem and that we shall give our lives to defend and protect it, so that our sacrifice may ensure its continuing and natural evolution into a bright future.

– Press statement, Europa Defense Force, 2098

Three recent events have significantly shaken the peaceful status quo on Europa – the discovery of the Europa project in 2096, the arrival of the EDF in 2098, and the escape of Copernicus Jones from Manannán Station in late 2099.

Oceanographers analyzing data from Chyba Station had noted a slight increase in sea-floor oxygen levels in early 2096 and had been puzzling over its significance when they made the shocking discovery of distinctly terrestrial thiotrophic spores. As more evidence was collected and the origin of the spores rapidly became clear, Giovanni Montaldo – the fiery Italian microbiologist who became Chief Scientist in the facility at the start of 2096 – flew to Genesis Station with a contingent of scientists and confronted Station Commander Judith Sigurdsson in person. Previously, relations between CRABE and Avatar had been good – the two groups had even pooled their resources and data concerning the Europan biosphere. When he discovered that the spores had been deliberately released and that Avatar had been secretly working on the Europa Project for 15 years without once consulting CRABE personnel, Montaldo felt betrayed and became extremely angry, immediately condemning Avatar's "irresponsible tinkering with a virgin ecosystem."

Avatar personnel could say little to defend themselves, and instead argued from a pantropist view – their priorities were the future human colonization of Europa, and the indigenous ecosystem was to be exploited to that end. The discussions rapidly descended into a heated and acrimonious argument, at the end of which the CRABE contingent stormed out, with Montaldo ordering an immediate data embargo on all CRABE research material to Avatar and forbidding further interaction between the two groups. Montaldo's superiors in the ESA supported his decision, and since then relations between the two groups have remained extremely frosty and they have had minimal contact. Although both groups are obliged to respond to emergency communications, neither side has made any since the rift.

While CRABE frantically rallied its resources in an attempt to document and even protect the Europan ecosphere from Avatar's contamination, a private group called XERG (Xenological Ecology Research Group) bought the old ESA base at Manannán crater in 2098. CRABE personnel were initially heartened (if a little wary, given their experience with Avatar) at the prospect of a new scientific group with whom they could exchange information. Their optimism rapidly turned to horror as hostilities erupted between Avatar and the newly-revealed Europa Defense Force.

Although Montaldo sympathized with the Preservationist view, he could not condone the EDF's violent approach. As a result, he attempted to keep CRABE out of the conflict. The only official communication between the two groups came not long after the arrival of the EDF, when Montaldo risked contacting them to declare CRABE's neutrality and non-involvement in the War. The EDF accepted this, stating that their argument was with Avatar, not with the E.U. base. So far, the EDF has not approached CRABE facilities, and CRABE has reciprocated. However, these precautions have not been enough to reassure some sponsors of the scientific facility, and nearly 50 researchers have been relocated from CRABE since the War was declared. In addition, there are a significant number of enthusiastic supporters of the EDF within CRABE. While they cannot do any more than redirect supplies to the EDF and provide some limited intelligence, their support has made a difference.

The Escape of Copernicus Jones

Lonely System reporter Copernicus Jones arrived at Manannán Station in late 2099 with the promise of an exclusive interview with the previously unknown leader of the EDF. After the interview was complete, Rademacher had second thoughts and decided that the information Jones now knew was too dangerous to release, and held the reporter as a hostage, albeit a well-treated one.

The first the outside world knew of this was when EDF defenses fired on Jones' recovery craft when it attempted to return to Manannán at the pre-arranged time to pick up the journalist. The craft survived the encounter, headed for neutral ground at CRABE for repairs, and waited.

Amy Wilson was a young ecoactivist who had arrived at Manannán a few weeks earlier. However, her enthusiasm for the cause had faded since her arrival at Manannán Station, particularly after she saw the glee with which the staff showed off their kills to Copernicus Jones. She decided that she wanted to get out of the base and escape from the EDF, and saw in Jones a chance to do so. After a couple of weeks of his incarceration, she managed to talk to the journalist in his cell and persuaded him that she could get him out of the base – so long as she came with him. He agreed, and they secretly planned their escape.

The chance came while most of the EDF personnel were listening to one of Rademacher's "pep talks." Wilson managed to steal the key to Jones' cell and set him free, and together they overpowered the guard. The cell was located in the underwater portion of the base, so they headed to the submarine dock, hoping to get there before anyone noticed Jones was missing. After a few narrow escapes, they made it to the dock, stole the EDF's only manned minisub – an aging *Asterius* – and struck out toward CRABE. By the time the EDF members found out, there wasn't much they could do about it. Despite getting lost, narrowly avoiding some EDF cryobot patrols, and nearly running out of life-support, they managed to get to CRABE. Although there were a significant number of EDF sympathizers at CRABE, there was nothing they could do to stop Wilson and Jones from leaving Europa in the recovery vehicle without blowing their cover. After their escape, Wilson placed herself in the custody of E.U. security forces on Earth, spilling the beans on what she knew of Manannán Station and the EDF, and Jones published his story, blowing the lid off "The War Under the Ice."

The escape of Copernicus Jones has considerably changed the political situation on Europa. The only reason the EDF did not take any kind of punitive action against CRABE is that they cannot afford to make yet another enemy. Rademacher himself is now more paranoid – justifiably so given that one of his crew has escaped with a lot of information about the EDF and its activities on Europa – and the EDF is growing more and more desperate in its actions. Tensions at CRABE are also high, as they are not sure whether the EDF blames them for allowing the two "fugitives" to escape from their jurisdiction.

The Current Situation

Currently, the situation is very tense on Europa. The dramatic escape of Copernicus Jones from Manannán Station and the revelations of his "War In Europa" TEN report, the defection of Amy Wilson, and the Royal Navy's interception of a shipment of combat bioroids destined for the EDF have put great pressure on the terrorists, and their actions are becoming more desperate and violent. The European Union has already sent an SDV to Europa, ostensibly to negotiate with the EDF and Avatar and to attempt to bring the conflict to a peaceful end. However, rumors have recently surfaced that China has dispatched a fully-loaded warcraft to Europa in a bid to apprehend – or kill – Torsten Rademacher and several other members of the EDF in retaliation for their involvement in the attempt to destroy the Martian Space Elevator in 2094. If this is true, a bloody end to the War Under the Ice could be imminent – depending on whether the E.U. or Chinese contingent arrives at Europa first. There is a feeling that the EDF is under siege and it could try to pull off one last desperate, major attack. Meanwhile, CRABE has a new Facilities Chief, French exobiologist Dr. Manu Marron. Dr. Marron is somewhat less volatile than Giovanni Montaldo, whose eventful three-year tour of duty finished in 2099.

Marron was endeavoring to keep CRABE outside the War Under the Ice, but this was jeopardized by the sudden arrival of Jones and Wilson at the base – Marron could not deny them entry. He also has increasing suspicions that there are some active supporters of the EDF in CRABE, and it is possible that he will take some action against the sympathizers soon.

Communications and Operations on Europa

Sonar in the Oceanus Noctis works about as well as in the Earth's oceans, although terrestrial sonar equipment must be recalibrated on Europa to account for the different sound speeds. However, the presence of a denser water layer near the Europan sea floor significantly affects sonar properties. Sound from sources in the Mesocean can be reflected at the Hydropause, causing confusing signals and false echoes.

Submersibles that do not travel far from their base of operations on the sea floor use a combination of sonar landmark tracking, sonar navigation beacons, and inertial tracking to fix their location.

The keystone of global navigation in the Oceanus Noctis is the Sonar Navigation System – a network of sonar buoys suspended on cables above the sea floor and below the base of the ice shell. To be useful on the sea floor, SNS buoys must be located below the Hydropause. If they are within the Mesocean their signals will be reflected at the Hydropause, making them useless in the Tropocean and confusing in the Mesocean. Therefore, they are usually placed either directly on the sea floor or on short tethers (up to a mile long) anchored there.

SNS buoys emit a low frequency sonar ping every second, and can be detected from 12 miles. Buoys are arranged in grid networks on the sea floor near established facilities, so that vessels are always within range of at least three of them. Exploratory routes away from the bases are temporarily delineated by buoys, which may eventually become permanently emplaced. Navigation in the Oceanus Noctis does not use latitudes and longitudes – vehicles navigate by reference to specific SNS beacons, each of which transmits a unique, identifiable ping structure.

A similar arrangement exists on the base of the ice shell, where the SNS buoys are suspended a mile or so below the ice. The areas around the main facilities are covered by the SNS ice buoys, which transmit on a different frequency to the sea-floor buoys to identify them more easily.

While the system is well established around the bases, it is still easy to get lost in the Europan ocean. If a traveler loses the sonar signal it may be difficult to reacquire, particularly if he is traveling through the Mesocean. If a person must travel large distances, it is usually more practical to go to the ice surface and travel in an OTV.

Sonar on Europa

The speed of sound in the Oceanus Noctis is greater than in Earth's oceans. It increases constantly with depth in the Mesocean since temperature increases gradually and salinity remains uniform. Sound speed ranges from 3,340 mph at the top to 3,850 mph at the base of the Mesocean. The sharp density contrast of the Hydropause produces a sudden change in sound speed over the few dozen feet of the boundary. At the top of the Tropocean, the speed of sound jumps by 90 mph to 3,940 mph, and then increases further with depth, up to a maximum of 4,010 mph at the sea-floor datum. (compare with the speed of sound in Earth's oceans, which ranges from 3,130 to 3,510 mph.)

The speed of sound increases rapidly with the rise in temperature around hydrothermal vents and volcanic hotspots, reaching values of up to 4,500 mph.

The temperature variation with pressure is the opposite of that which generates deep sound layers (p. 24) on Earth – these are therefore not found on Europa.

Life on Europa

Europa's native life consists largely of thermophilic microbes, concentrated around vents and hotspots in the basal seas and the Tropocean. The Europan biosphere is less abundant and less diverse than Earth's, because the energy and mass of material available to sustain an ecosystem is much smaller. Some Europan life forms are relatively advanced – simple invertebrates such as the nematode-like vent worms (up to an inch long) – but these are rare. The hydrothermal ecosystems are generally similar to those found on Earth, though they largely consist of microbial mats, rather than more complex creatures.

The Mesocean is largely lifeless; there is insufficient heat and nutrient flux to support life. Some psychrophilic (cold-loving) microbes have evolved there, from thermophiles that were entrained in hyperplumes. The psychrophiles lie dormant until they encounter another hyperplume (or settling material derived from one), then wake up, feed and rapidly reproduce, and then enter a state of stasis again until they float into another warm plume. Because of their state of total shutdown while dormant, some individual psychrophiles may be many thousands of years old.

Vent Life

The dominant indigenous life forms on Europa are bacteria. Of the 30 known active vent fields, all have some bacterial activity around them. There are two types: methanogens, which anaerobically metabolize carbon dioxide and hydrogen emitted from the vents, producing methane as a byproduct; and rarer photosynthetic bacteria, which metabolize carbon dioxide by photosynthesizing infrared radiation emitted by the hydrothermal vents and produce oxygen as a waste gas. Methanogens live around all the life-bearing vents discovered so far. Thiotrophs and methanotrophs that are commonly found around vents on Earth (see *Unusual Ocean Environments*, p. 20) are not present on Europa, since their metabolisms require free oxygen that is not available in sufficient quantities.

Individual vents have limited lifespans, from years to decades. When they shut down, everything around them dies from lack of nutrients if the cessation of activity is sudden. Bacteria spread between vents by being entrained in erupting plumes. The microbes usually enter a dormant spore state until they drift into a suitable zone of habitability around another vent. Most spores do not make it that far, however, and eventually die in the cold, uninhabitable water between vents.

The Europa Project

The Europan submarine environment is not naturally conducive to terrestrial life. The indigenous photosynthetic bacteria can only survive in a limited range around the vents (as far as the infrared light they require to survive can penetrate), and do not produce enough oxygen to significantly oxygenate the water. Because of this, unmodified gills are useless in Europan water. This presents significant difficulties for bioroids and terrestrial life forms that cannot survive without oxygen.

Avatar realized that the Europan environment was potentially habitable, and began the Europa Project (see p. DB47). The aim of the Project is to increase the satellite's biomass by enhancing the indigenous life forms and adding adapted terrestrial forms – the ultimate goal is to create parahumans that can survive there. So far, Avatar has modified the gill structures of its Europan bioroids so that they are full of highly efficient symbiotic methanotrophic and thiotrophic bacteria – enhanced versions of the ones found in the gills of worms and bivalves around vents on Earth. The bacteria process the methane and sulphide in the water that is drawn into the gills and convert them into energy that the bioroid uses. In addition, Avatar has set up automated oxygen-cracking stations in the Kargel-Zolotov Channel, which produce large amounts of oxygen to enrich the local environment of its basal sea. Many of these have been placed around the vents in the Channel, along with imported thiotrophs and methanotrophs. The oxygen crackers produce just enough oxygen to sustain the imported life in close proximity to them, but so far have not significantly increased the amount of dissolved oxygen in the Tropocean as a whole. Even with modified gills, Europan bioroids can currently survive only in areas around the oxygen crackers. These stations are key targets for EDF raids.

Avatar has been performing extensive terraforming around Mount Thera and in the K-Z Channel – installing oxygen crackers, introducing new bacteria, and setting aside large areas of the sea floor as farms of modified mussels for the Europans to harvest. The imported life has survived reasonably well in the Europan environment, despite the high salinities and low concentrations of oxygen. The War Under the Ice – and protests from CRABE – have significantly slowed progress in recent years.

While the Europan biosphere appears to be largely intact, the EDF claims that indigenous life near the Avatar farms has been adversely affected by increased oxygen toxicity in the water and competition from imported Avatar bacteria. Avatar strenuously denies this, but it is enough justification for the EDF to step up their offensive.

LOCATIONS

There are three major settlements and several smaller research stations located near interesting geological features on Europa. Most are situated near the surface under several yards of ice, though some are on the sea floor or attached to the base of the ice shell.

Manannán and Manannán Station (2°N, 240°W)

Manannán Station was built in 2061 but abandoned in 2072 due to CRABE budget cuts in the early 2070s. It was reoccupied by the EDF when they arrived in 2098. Much to the consternation of the EDF, the station lies over a cold spot; there are no active vents or hydrothermal communities within 100 miles. Below Manannán lies a lifeless desert, and a gently sloping abyssal plain. The surface component of Manannán Station is described on p. DB49.

The EDF sea dock is a hemispherical structure anchored to the base of the ice shell. Since the base was originally designed for a smaller crew, the dock facility is not very large. It originally had only the capacity to launch one small manned submersible, and the EDF only has cryobots, ROV minisubs, and cybershells. The dock is extremely cluttered with supplies, boxes, parts, and robotic vehicles.

The EDF maintains a small network of SNS buoys on the barren sea floor below Manannán Station. The location of the Avatar base was well known, and the EDF's first activity on Europa (while still under the cover of XERG) was the creation of an SNS corridor extending toward the western end of the K-Z Channel.

Avatar was suspicious of the new group, and noticed its covert attempts to approach Genesis Station. More investigation revealed the true identity of XERG, and Avatar immediately dispatched its MAD forces to deal with them, hoping to destroy or cripple Manannán Station from space. While the surface installation was badly damaged, the submarine portion of the base was unharmed and the attack did little to dissuade the EDF from continuing its activities. Furthermore, the crash of the USV *Chesapeake Bay* (p. DB49) during the battle provided an unexpected bonus of arms and supplies to the EDF.

The ecoterrorists retaliated by launching cryobot carriers armed with Lamprey devourer nanobot hives (p. 122), targeting Avatar's facilities in the K-Z Channel. The attack succeeded, resulting in the complete destruction of two bases and the deaths of 80 Europans. The EDF announced its presence to TEN following the attack.

Since then, Avatar has tightened security along the K-Z Channel, as the EDF continues to send cryobots on automated patrols in and around the Channel. It programs them to target and destroy anything not of indigenous origin with their Lampreys – modified mussels, bacteria, Europans, oxygen crackers, bases . . . Each unit patrols for a couple of weeks and then returns to base, where the ecoterrorists download records of its kills. Recently, the EDF has sent some heavily armed cryobots on patrols near Mount Thera – recently strengthened Avatar defenses have destroyed most of them, but some have inflicted significant damage to the facilities there.

The EDF currently has a siege mentality. Its leadership – especially Torsten Rademacher – is growing more and more paranoid, particularly since Copernicus Jones escaped from captivity at Manannán. The less fanatical members are starting to worry that the leadership is becoming dangerously unstable, and see the E.U. negotiating mission as their last chance to get out of the situation alive. Some veteran EDF personnel are ex-members of Negative Growth, the terrorist organization responsible for the attempted bombing of China's Mars beanstalk. They fear that the E.U. mission will lead to their exposure, and that Chinese forces will arrive to destroy their base and kill them all, so they feel they have nothing to lose by performing more damaging attacks. Tensions at the base are very high, and could reach breaking point soon.

Distances on Europa

	Pwyll	*Manannán*	*Thera*	*Thrace*	*Conamara*	*Callanish*	*Tyre*	*Murias*	*K-Z*	*Greenberg*
Pwyll	0	698	1,211	1,323	606	998	2,233	2,938	958	515
Manannán	698	0	1,215	1,313	578	1,597	1,558	2,490	700	682
Thera Macula	1,211	1,215	0	114	1,679	1,902	1,448	1,889	531	714
Thrace Macula	1,323	1,313	114	0	1,791	1,964	1,384	1,776	618	828
Conamara Chaos	606	578	1,679	1,791	0	1,102	1,944	2,499	1,231	984
Callanish	998	1,597	1,902	1,964	1,102	0	2,779	1,951	1,921	1,436
Tyre	2,233	1,558	1,448	1,384	1,944	2,779	0	957	1,384	1,866
Murias Chaos	2,938	2,490	1,889	1,776	2,499	1,951	957	0	2,198	2,603
K-Z Channel (mid)	958	700	531	618	1,231	1,921	1,384	2,198	0	486
Greenberg Basin (mid)	515	682	714	828	984	1,436	1,866	2,603	486	0

Distances are in miles on the surface. To find distances between these locations at the base of the ice shell, multiply by 0.986. To find distances on the sea floor, multiply by 0.934.

Pwyll and CRABE (26°S, 271°W)

CRABE is the largest and oldest settlement on Europa, and has the most extensive research interests on the satellite. It was built in 2057 in the Pwyll impact crater, and expanded in 2092 as a result of increased funding. Like the other facilities on Europa, most of CRABE is under the ice. The complex can be divided into three parts: the upper section near the surface, the Consolmagno-Lewis base which is attached to the underside of the ice shell, and Chyba Station situated on the sea floor directly below it.

The upper section is a complex of rooms located a thousand feet below the surface of the ice. The elevator from the surface descends into a large airlock bay – when fully pressurized this opens into a large subterranean garage containing the surface vehicle and equipment storage facilities. Radiating out from the garage are several tunnels leading to laboratories, a medical bay, accommodation for up to 120 people (where most of the CRABE personnel live on a daily basis), food production and recycling facilities, and the main well shaft chamber which houses a second elevator shaft that leads down to the Consolmagno-Lewis base nearly thirteen miles below at the base of the ice shell. The second elevator shaft opens into a reception area at the bottom, from which visitors can access the base itself. CRABE personnel working in the Consolmagno-Lewis base refer to the central shaft as "the dumbwaiter," since it is used to transport food down to them from the upper section. The expanded accommodation, food-production, and recycling sections were built with the extra investment CRABE received in the early 2090s, allowing the base to sustain more people in more comfortable, less cramped surroundings.

The Consolmagno-Lewis base is a vertical dumbbell-shaped structure 80 feet across and three stories high, attached to the base of the ice shell. Half the uppermost level contains the old habitation section, now used for storage and to house scientists who need to stay at the underwater base to monitor their equipment. The other half contains the Science/Laboratory wing and the Technical wing, which is occupied by large computers that house the station's infomorphs (including Sinetär; see pp. DB126-127) and data analysis facilities.

The core of the dumbbell is 40 feet across, and houses the station's fusion reactor and engineering facilities. Conduits lead up and down into the ends of the dumbbell to provide power, heat, and light to the rest of the base.

Half of the lower dumbbell is taken up by hangars, which house the station's three *Asterius* mini-subs and various small aquatic cybershells and ROVs. The other half is divided between the CRABE Mission Control center and a new Vosper-Babbage facility installed in 2093, which contains extensive minifacturing workshops that produce and repair CRABE vehicles and robotics and maintain the base. In 2097, this facility completed the construction of the prototype *Zeus*-class Mobile Sea-Floor Explorer Rig, along with three state-of-the-art *Abyss*-class manned submersibles to accompany it. The *Zeus* was constructed in modules inside the station and assembled outside using cradles and supports, taking two years to complete. The *Zeus* and its crew of 10 are currently performing fieldwork on the sea floor along the deep Thomson Rift south of the Conamara Rise.

Chyba Station is a small CRABE facility located on the sea floor beneath the Consolmagno-Lewis base, near the southern end of the Thomson Rift System that extends northward toward the Conamara Rise. It provides more roomy accommodation and laboratory facilities for the *Zeus* crew, who will return here after their current fieldwork is completed, and serves as the shuttle terminus between the sea floor and the ice shell. It is also the nexus for the CRABE sea-floor SNS network.

Personnel: CRABE is a science base, studying the Europan biosphere and the surface geology. Most of the station's crew of 70 humans and 40 infomorphs are biologists from European universities and the International Exobiology Foundation. The rest of the scientific personnel are oceanographers, vulcanologists, and planetary geologists. There is also a small contingent of engineers from Vosper-Babbage, who moved in after the company provided sponsorship in return for a testbed for its heavy-duty submersible designs.

Tyre and Schenk Station (31.7°N, 147°W)

Tyre is a 93-mile-wide impact scar in the northern hemisphere, similar to but larger than Callanish (p. 69). A small CRABE research base called Schenk Station is located here. Schenk Station holds the distinction of being the most remote permanently staffed base on Europa – the nearest base is a small outpost located at Murias Chaos (p. 69) on the leading hemisphere, over 900 miles away. Schenk Station was established as one of a number of small CRABE outposts in the early 2090s, to study the surface geology of the area. In the past couple of years the base has expanded somewhat – its isolated location puts it beyond the scope of the War Under the Ice, so the station now serves as a refuge for a staff of nearly 20 scientists who want to escape from the tensions of the southern hemisphere.

In late 2098, CRABE decided to drill through the ice and establish a small outpost at the base of the ice shell below Tyre. The basic design of the station is similar to CRABE – a ring of galleries built near the top and the base of the ice shell, surrounding a reinforced central elevator shaft. Currently, the submarine part of Schenk Station is little more than a submarine dock extending from the ice shell.

Preliminary exploration of the sea floor has revealed that Tyre is located above a large plateau a mile above the sea-floor datum. The plateau contains some of the oldest rocks on Europa, dated at nearly two billion years old. The region appears to be a preserved chunk of ancient crust that has somehow escaped tectonic recycling. Although there are no hydrothermal vents in the area, there is still enough geological work to occupy the personnel at Schenk Station.

Conamara Chaos and Spaun Station (9.5°N, 273.3°W)

A small abandoned CRABE surface facility called Spaun Station is located among the ice rafts of Conamara Chaos. It was constructed in 2060 in order to study the geology of the Chaos, but was evacuated as a safety precaution in 2098 after the EDF launched its attacks on Avatar, due to its relative proximity to Manannán, less than 600 miles to the east. Sympathizers at CRABE informed the EDF of the location of the station, and in 2099 they gleefully plundered the base of the few supplies that were left there; little remains of the station now but an empty shell. The CRABE leadership is aware of the looting and is not happy about the situation. This was one of the first signs that the EDF had active sympathizers in CRABE – it is unlikely that the EDF could have located the station or known that it was abandoned without inside help from CRABE.

The Conamara Rise is the huge volcanic bulge on the sea floor that is the progenitor for the extensive chaos above. While its highest points penetrate the Hydropause, most of the Rise lies just below it, nearly 4 miles above the sea-floor datum. CRABE's prototype *Zeus* Mobile Sea-Floor Explorer rig is currently exploring the Thomson Rift zone that extends up to a mile below the sea-floor datum just south of the Rise. Although this is quite close to Manannán Station, CRABE feels that it is very unlikely that the EDF should chance upon it, because it is operating on its own, beyond any SNS networks, slowly following the deep rift northward from Chyba Station toward the Rise.

The Echo

The vast majority of evidence suggests that there is no indigenous life on Europa larger than the tiny vent worms, yet for the past 25 years there have been scattered reports of an object shadowing vehicles at the edge of sonar range. The object – referred to simply as "the Echo" – has been reported by CRABE researchers and Avatar convoys traveling through the Greenberg Basin. A few aquabots and cryobots from CRABE (and later Avatar too) have disappeared since the late 2070s in mysterious circumstances in the Basin; some people attribute these losses to the Echo. Since the War Under the Ice began, it has been difficult to separate such losses from those caused by armed EDF cryobots, but it is possible that the EDF has suffered unusual losses too.

Very little is known about the Echo; it is elusive and difficult to track, indicating some form of intelligence may be behind it. All that is known for certain is that it is about eight feet long and roughly cylindrical in shape. Current theories range from a hitherto unknown indigenous life form (deemed unlikely by CRABE and Avatar, but seized on by the EDF), to an errant aquabot or cryobot.

Greenberg Basin (Midpoint: 38°S, 238°W)

One of the most extensively studied areas on the Europan sea floor is the Greenberg Basin, a 600-mile-wide basin lying 170 miles to the east of CRABE. The base itself is located not far beyond the northwest corner of the basin, which contains two sizeable vent fields and many extinct hotspots and volcanic shield fields. This has given CRABE personnel plenty to study.

Thera Macula and Genesis Station (47.7°S, 180.9°W)

Genesis Station – the Avatar Klusterkorp facility located at Thera Macula – is located above an ancient volcanic hotspot, believed to have formed the chaos terrain, within which the station is located, approximately a million years ago. The volcano itself – Mount Thera – is still active and there is ongoing hydrothermal activity around the edifice. To the east lies the Thrace Rise, a large volcanic bulge that was the progenitor of the more extensive Thrace Macula chaos. The Thrace Rise is believed to be extinct, as the most recent flows around it are tens of thousands of years old and there are no active vents nearby.

Prior to the War Under the Ice, the surface component of the Avatar base was little more than a few access shafts and a maintenance shack. Recently however, the EDF has launched several attacks that have forced Avatar to radically improve base defenses. Hidden laser turrets cover the approaches to the base, and the MAD forces that have recently arrived to reinforce the base are installing new missile (AKV) turrets (see p. DB47).

The MAD garrison is housed in insulated tunnels and rooms melted into ice near the surface. Twenty combat bioroids are stationed at the surface garrison. Two MAD *Nestor Makhno* SPVs are also stationed at the Jupiter-Europa L2 Lagrange point nearly 7,600 miles above Europa's surface, from which they can monitor the anti-Jovian hemisphere of the satellite.

Genesis Station: Genesis Station itself is a marvel of bioengineering. It is a huge organic structure attached to the base of the ice shell underneath Thera Macula. It looks like a cross between an anemone and a plant, with roots extending deep into the ice shell above it to anchor the facility. It gets its energy from the fusion reactor built into its core. Submarine docks, residential blocks, and science facilities hang off the branches of the structure like decorations from a Christmas tree. Genesis Station is home to 50 human Avatar scientists and 30 sapient infomorphs. Avatar has moved Ten MAD soldiers specializing in underwater piloting (along with some armed subfighters) to Genesis Station to serve as rapid response teams in case of a direct assault on the base. A torus located around the base of the structure serves as the surface elevator access point. This torus contains guarded reception facilities and a docking bay for the submarine bus that shuttles visitors between the inhabited modules.

Avatar operates three sea-floor facilities at vents around Mount Thera, and four along the Kargel-Zolotov Channel. In 2098, the EDF destroyed two more facilities on the western end of the rift. All these facilities are populated by Europan bioroids – 40 are housed at each of the Theran vents, and 20 are located at each of the K-Z Rift bases.

Base Commander Judith Sigurdsson has been in charge of the facility since it was established in 2079. She has weathered many of the political changes that have occurred on Europa, and is a hardened and stubborn woman. She has maintained a sense of dogged persistence among the crew of Genesis Station, and refuses to allow the EDF to wear her down or get in the way of Avatar's work. She has lost many friends at CRABE because of the Europa Project but is universally admired by the staff of Genesis Station. She is determined to see the Europa Project succeed, and is almost ready to advance it the next stage – *parahuman* Europans.

However, recent events have put Avatar's projects on hold. Sigurdsson's contacts in the Gypsy Angels Collective (p. DB88) have heard rumors that the Chinese have mobilized a *Xingzhai*-class SDV (p. SSS35) to

Europan Parahumans and Bioroids

The current Europan bioroids are more fishlike than human, and are obviously engineered beings unable to sustain a population without technology. They are, however, but the second phase of Avatar's plans for the pantropic colonization of Europa; the first involved microbes and animals. Phase III is scheduled to commence within the next year – Europan parahumans. The existence of these parahumans is one of Avatar's most closely guarded secrets, and word has not passed beyond the walls of Genesis Station. Although EDF leaders suspect that this will happen eventually, if they discover that the project is advanced enough to start almost immediately, it could push the current tense situation over the edge.

Europans can survive pressures in the Tropocean from 1,360 atm. down to 1,600 atm. There are not enough chemicals in the Mesocean for their symbiotic bacteria to survive, and there is certainly not enough oxygen – though this is actually a problem at any significant distance from an oxygen cracker and a hydrothermal vent.

deal with the EDF once and for all, and she has taken the unusual step of spreading these rumors to CRABE, and via them to the EDF. She is hoping that the E.U. and Chinese forces *en route* to Europa will remove the problem of the EDF once and for all, but she is playing a dangerous game – the EDF is now more desperate than ever as a result of the rumors and the events of the past year, and more likely to mount a desperate last-ditch attack on Genesis Station.

Kargel-Zolotov Channel (Midpoint: 25°S, 208°W)

The K-Z Channel is a 370-mile-long rift that extends westward from a point 430 miles northwest of Mount Thera. The rift is seven miles wide and three miles deep relative to the surrounding plateau on average; its deepest point lies 1.5 miles below the sea-floor datum. The rift traps hydrothermal fluids from vents and eruptive fissures that run along its floor, forming a basal sea with a salinity of nearly 30%. The Kargel-Zolotov Channel contains some uniquely adapted hypersaline vent biota and is extensively studied by Avatar bioengineers. Four small Europa Project test farms are located on the sea floor near the eastern end of the rift. Two more farms used to exist further west along the rift; they were destroyed by the EDF in the attack that signalled the start of the War Under The Ice in mid-2098. Much of the War has taken place in and around the Kargel-Zolotov Channel since then, as the EDF tries to eradicate the altered communities in the rift.

Thrace Macula and Thrace Rise (46.6°S, 171.2°W)

Thrace Macula is a large, relatively young chaos located just over 100 miles east of Thera. Large pockets of liquid brine were entrained in the rising ice plume that formed it, creating dark flow-like features around the chaos.

The sea-floor progenitor for the chaos is a large volcanic structure known as the Thrace Rise, most of which rises above the Hydropause. This volcanic bulge consists of a large central volcano (Mount Thrace) and a shallow rift that extends eastward toward Mount Thera. The rise is currently geothermally inactive. Seismic measurements indicate that Mounts Thrace and Thera are part of a volcanic hotspot chain similar to Hawaii on Earth, and that the hotspot is moving westward relative to the crust. The current center of activity lies at Mount Thera.

Avatar has sent research vessels to the Thrace Rise to study and collect the fossilized Europan microfauna located among the metalliferous sediments there.

Surface Outposts

Not all outposts on Europa lie on the sea floor or at the base of the ice shell – some just study the surface geology or observe features in space there.

Callanish and Taylor Station (16.0°S, 333.4°W)

An ESA Jupiter Monitoring observatory – Taylor Station – is located at Callanish. It was chosen for its location near the sub-Jovian point, which affords a good view of Jupiter and the surrounding space (for field and particle measurements). Callanish is an impact scar similar in appearance to Tyre, 62 miles in diameter, consisting of disrupted terrain and multiple concentric rings and scarps. There are no underwater facilities here.

Taylor Station was established in 2065 and is crewed by three dedicated LAIs named Neberu, Mushtarie, and Brhaspati (the Babylonian, Arabic, and Sanskrit names for Jupiter). They refine the raw data they gather and transmit the processed data to CRABE for analysis via a small ESA relay satellite in a 24-hour equatorial orbit (5,290 miles high) around Europa. If necessary, the station can transmit its data directly to Earth or Mars.

Murias Chaos and Murias Station (22.4°N, 83.9°W)

A small CRABE outpost studies the surface geology of Murias Chaos, an unusual mitten-shaped chaos that bulges above the surrounding terrain. Research is coordinated from Schenk Station at Tyre (see p. 67), and occupancy is temporary. Murias Station is the most remote location on Europa that is occupied by people, lying nearly 3,000 miles from Pwyll.

Ganymede

Following the revelation of The War Under the Ice, the European Union decided to commence work on a new scientific research base on Ganymede, under the direction of former CRABE Facilities Chief Giovanni Montaldo. The E.U. is setting up the base in the Gilgamesh impact basin, a 91-mile-diameter crater located at 62°S, 124°W. Gilgamesh is similar to Valhalla on Callisto but much smaller in scale, and was formed when a large asteroid or comet smashed into Ganymede's thick ice shell.

The goal of this base is to penetrate the ice shell and investigate any life forms in the ocean below. Preliminary heat flow measurements made on the surface in 2057 suggested that the bottom of Ganymede's 500-mile-deep ocean was volcanically active, to a much greater extent than Europa. This raised the possibility of yet another extraterrestrial ecosystem, assuming it could survive the phenomenal pressures at the sea floor.

Furthermore, Ganymede's ecosystem would not be contaminated by Avatar's experiments, which would allow scientists to continue their studies of virgin alien biospheres. The environment is also both physically and politically less hostile, and while the engineering problems remain significant (not least, building vehicles that can survive pressures of over 20,000 atm. at the sea floor), companies including GenTech Pacifica and Vosper-Babbage have already placed bids on engineering contracts to meet the challenge.

Contractors started work on Gilgamesh using cryobots imported from CRABE Station on Europa in mid-December 2099, and ice drilling is underway. Gilgamesh Base should be fully operational by 2103. So far neither Avatar nor the EDF have shown any interest in Ganymede, and scientists involved in the project at CRABE hope they never will.

Other Worlds, Other Oceans

Two other bodies in the solar system are known to have liquid layers:

Callisto: Seismic surveys and geophysical data have revealed an ocean 45 miles deep sandwiched between Callisto's 80-mile-thick water ice shell and a 30-mile layer of dense, high-pressure ice at its base. Below this is a mixture of ice and rock, with the rock proportion increasing down to the surface of a completely rocky core of radius 420 miles.

Enceladus: A water ice shell 60 miles thick overlies a 20-mile layer of liquid water and a 75-mile radius rock core. The rock surface appears to be volcanically inactive.

Neither moon's ocean has been explored, though attempts have been made to send cryobots through the ice shells. No life is believed to exist in either satellite, and both oceans are in the process of freezing out. See pp. DB50-52 and DB60 for more information on these moons.

Titan

Titan's a strange place to be. You look out of the window in Port Minos and you can see the cliffs of the valley, the tide coming in on the sea, the surface of the ponds shimmering in the gentle wind, and the orange sky and maybe the odd cloud really high up. It all looks kinda normal . . . until you remember it's cryogenic out there, and that if you stepped outside without protection you'd freeze in an instant. I knew a guy that went nuts here – he forgot about the cold and decided that all he wanted to do was run around naked and frolic in the lakes. He didn't last more than a few seconds, of course. It happens from time to time, though the authorities try to cover it up. I guess this place can remind people too much of home . . .

– Madeleine Escobar, Port Minos dock worker

Titan is one of the most alien and challenging environments in which transhumanity has established an outpost. The only satellite with an appreciable atmosphere, Titan is an almost featureless orange globe, although in 2100 its southern hemisphere is a very slightly darker shade than the northern one. The atmosphere is so deep that the satellite was once thought to be larger than Ganymede, the largest moon in the solar system. In fact, Titan's visible atmosphere is nearly 200 miles deep, and the satellite's actual diameter is 3,220 miles. Beneath the atmosphere is a shell of water ice 90 miles thick. Titan has a very deep subsurface layer of water and ammonia stretching 450 miles beneath the ice shell. Below this is another 90 miles of dense, high-pressure ice, overlying a 980-mile radius rocky core. Titan does not have a metallic core or an intrinsic magnetic field; neither does it have an induced field, since its orbit is just outside Saturn's magnetosphere. The average ground temperature is -289°F and varies little across the surface; the minimum recorded temperature on Titan's surface is -296°F at the poles.

Atmosphere: Titan's atmosphere is composed of 93% nitrogen, with 5% methane, 1.8% argon, 0.2% hydrogen, and trace amounts of ethane, carbon monoxide, and hydrocarbon gases. There is no free oxygen, and only trace amounts of water vapor. The atmosphere is very deep; the top of the mesophere – where incoming meteors burn up – is 375 miles above Titan's surface. The top of the visible atmosphere is marked by a detached layer of hydrocarbon haze at 190 miles altitude. The main haze layer fills the stratosphere down to a height of 40 miles; below this the atmosphere is mostly clear. The haze absorbs the shorter wavelengths of light, allowing only the red end of the spectrum through, resulting in a dim orange light, as bright as a full moon on Earth (-5 Vision penalty), illuminating the surface. Methane exists throughout the atmosphere, with a maximum concentration at a height of 25 miles, where the temperature is lowest (-333°F). Methane clouds form at heights around 15 miles.

Weather: The climate on Titan is mostly dry. What little rain falls is very different to that on Earth. There are no low clouds or fogs on Titan; the only altitudes at which methane moisture can condense are between 12 and 16 miles. Rain clouds form quickly, dump methane rain in a short downpour, and then disappear rapidly. Raindrops form around a nucleus of ethane droplets or haze particles, growing up to half an inch in diameter. The methane usually evaporates in the lower troposphere on the four-hour journey to the ground, leaving only the cores around which the drops nucleated, called "rain ghosts." Around the Mayan Plateau, where the major settlements are located, small showers of rain ghosts occur every few weeks, although sometimes even the ghosts don't reach the ground. Snow and hail do not occur on Titan; temperatures are never low enough at rain-cloud-forming altitudes to freeze methane.

Once every 15 Earth years, around the spring and autumn equinoxes, a particularly large rainstorm covers about 10% of the satellite. These storms dump many feet of rain in a very short time, raising the humidity of the lower atmosphere so much that the methane actually makes it to the surface. Such downpours create short-lived methane floods that can erode river channels into the icy ground as they boil away into the atmosphere. The ethane that remains behind flows into the sea or collects in pools. The next storm is due sometime in 2100.

Winds on Titan are not very powerful at low altitudes, and are usually no stronger than moderate breezes at the surface. Higher up the wind blows predominantly westward, averaging up to 230 mph near the top of the stratosphere and gusting up to 450 mph.

The year 2100 is northern hemisphere spring on Titan; the summer solstice is due in 2103. There is currently more haze in the upper atmosphere in the southern hemisphere than the north, which causes that hemisphere to look darker when viewed from space.

Geography and Terrain: Titan's surface is made of bright water ice tainted by small amounts of ammonia. Small pools of liquid ethane and hydrocarbon sludge can be found all over the surface. Most of Titan's topography is subdued; an area of highlands and hills known collectively as the Mayan Plateau peaks only a mile above the surrounding terrain. Nearly 18% of Titan's surface – six million square miles – is covered by liquid ethane. The Minoan Sea, a large, shallow sea in Titan's western hemisphere, forms 90% of that. Eight large ethane lakes are located in the other hemisphere – six east of the Mayan Plateau, and two southeast of it.

There are about 2,000 craters on Titan, mostly 6 to 12 miles across. Smaller craters are rare, since most of the impactors that would have formed them burned up in the atmosphere. Larger craters are uncommon, ranging from 15 miles in diameter to the largest: a basin 90 miles in diameter east of the Minoan Sea. While more craters are located on the leading hemisphere, many are also located beneath the Minoan Sea, and crater rims poke above the liquid ethane near its shores. Most craters contain small pools of ethane or hydrocarbons; some of the larger craters contain ponds in their central pits and a ring of liquid near their rims, giving the appearance of a bullseye if seen from above.

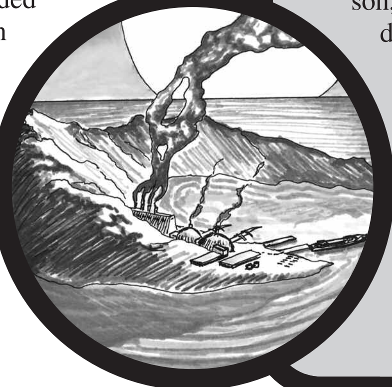
There are ice volcanoes on Titan, which erupt mixtures of ammonia and water that rises through cracks in the ice shell. This lava is a cold, partly frozen slush and is very viscous, forming wide domes similar to some volcanic features on Venus. Volcanic activity on Titan is never violent, though methane geysers do occur in rare circumstances.

The Minoan Sea

The Minoan Sea is a roughly diamond-shaped body of liquid ethane extending up to 60° latitude on both sides of the equator, with two of its apices located near the sub-Saturnian and anti-Saturnian points. It reaches a maximum depth of just over half a mile near its center. Because of the low density of the liquid ethane and the low gravity, the pressure at the sea floor in the deepest part of the sea is just under eight atmospheres. The sea-floor topography is smoother than the surface topography, and is mostly covered in thick layers of complex hydrocarbon sludge that has settled from the ocean above. Cryovolcanoes are located on the sea floor, erupting ammonia-rich water lava that freezes to form pillow formations under the liquid ethane.

The eccentricity of Titan's orbit around Saturn means the tidal bulge raised on the satellite oscillates between 3°E and 3°W over an orbit, changing by four yards in height as it does so. This causes considerable circulation and strong currents in the Minoan Sea within six degrees of the anti-Saturnian point, and that area has been named the Charybdis Sea as a result. The Nubia Chasma (also known as the Nubian Valley) on which Port Minos and Huygens City are located, is a linear fault zone 1,000 miles long, and the Minoan Sea fills much of this valley. Tides flow up and down the Chasma over the course of a Titanian day and are focused by the topography – high tide at Port Minos is 30 feet higher than low tide. As a result, the island of Labrys becomes about a mile smaller at high tide than at low tide, and Port Minos is located on the higher parts of the island. Huygens City is further inland and lies beyond the tidal range of the Minoan Sea. The cause of Titan's eccentricity is a mystery – the tides raised in the Minoan Sea and in the internal water shell should have circularized the orbit long ago.

A crescent-shaped island called Scylla is located in the eastern part of the sea, surrounding a large flooded crater basin. A hydrocarbon mining facility is located in this bay, extracting and processing the sludge that is concentrated in the topographic low of the basin. Other small islands and crater rims lie above the average sea level, particularly near the coastline.



LIVING ON THE MOONS

Gravity on the moons of Jupiter and Titan is lunar-like – between 0.1G and 0.2G, a range between microgravity and "low gravity." This *minigravity* range presents some problems to inhabitants. Normal walking is impractical, and running is impossible – the most efficient way to move around on foot is by bounding. Unlike microgravity, there is a definite down direction, though objects take five to seven times longer to fall than they would on Earth.

Bases are designed with distinct horizontal floors – the gravity is high enough to preclude three-dimensional beehive structures. Handholds and rails are often present on walls and ceilings to aid and control movement, but footholds are unnecessary.

Workers based on the Galilean satellites or Titan are usually provided with DNA Repair and Microgravity Biochemistry permanent nanomods (p. TS165) by their employers as perks of the job. The latter is required because minigravity still has adverse effects on bone structure and biochemistry. Employment contracts are always at least six Earth months long and can be several Earth years in length – after a year the employee is said to have paid off the nanomods. Biomods are rarely used, and Tennin are unnecessary in such environments.

Living on Titan

Buildings on Titan are pressurized to 1.5 atmospheres – the same as the ambient pressure outside. This makes construction and venturing outside simpler, although airlocks are still necessary to prevent contamination of breathable air with the external methane atmosphere.

Like any alien environment, life on a base on Titan can be stressful. Sometimes workers crack under the pressure, becoming victim to what is known as "The Titan Haze." One catalyst for the derangement is the vaguely Earth-like appearance of the external environment. Victims do all they can to get outside the base, wearing no protective clothing or oxygen supplies, and as a result they invariably die quickly in the cryogenic conditions. This method of death is referred to as a "Hazing." However, if the body is recovered soon enough, it is possible to produce a ghost of the person, and edit out their derangement – this has been done a few times in cases where the person had important knowledge or experience. It is rumored that some unscrupulous corporations on Titan sometimes do this to ensure that workers stay on for the entire length of their contracts. Some conspiracy theorists even believe that the ghosts are placed in cloned bioshells and their cryogenic deaths are edited from their memories completely, so that they carry on their working life blissfully unaware of their suicides.

4 ORGANIZATIONS

If man could find a way to work there in safety and relative comfort, he would at once possess the key to more than ten million square miles of seabed. He could tap the scientific secrets and mineral, animal, and vegetable wealth of those immense submerged plains.

– Edwin Link, ***Johnson-Sea-Link*** *research submersible designer, 1963*

We have entered a new age where the business of our corporation has evolved beyond simply producing a profit.

When people place their time and resources with GenTech Pacifica they have to know that we're working on making the company, and themselves, something far greater than the sum of the parts. GenTech Pacifica does not only invest in the future, we work to create the future. A future we will all have the privilege of seeing.

– Linda E. Panarelli, GenTech Chief Executive Officer, 2089

GenTech Pacifica Pty. Ltd.

GenTech Pacifica is the world's largest ocean technology corporation, involved with every aspect of underwater and sea-surface technology. Originally started as a small genetic engineering company by a group of Australian scientists in 2031, it has grown to become a transnational employing over 400,000 people, as well as a large number of infomorphs and uplifted animals. Its major offices are in Sydney and Seoul, but it has a presence in every Fifth Wave country, several less-developed nations, and most free city aquatic arcologies and underwater settlements. It also has a few labs in the Islandia space colony and one small L4 station of its own.

GenTech is known for its clashes with environmental and Preservationist groups, particularly Blue Shadow. It aggressively manipulates governments and the media to maintain its legal freedoms and its public image. It has been accused of crimes ranging from anti-competitive behavior and fraud through slavery of sapients to global pollution and criminal ecological manipulation, but none of the most serious charges have been prosecuted successfully, and no senior GenTech manager has ever been found guilty of wrongdoing.

Organization

When GenTech Pacifica began to turn a substantial profit from its early work in developing genemod fish and mollusks suitable for aquaculture, the idealistic researchers ceded control of the company's finances to a group of ambitious and foresighted executives. Under their direction, the company diversified and prospered.

Eight of the original 12 board members are still alive, and maintain an iron grip on the company. They have access to the best life-extension technology and none look likely to pass away soon. A ninth member, Daren Phuong, is publicly believed to have died in a transport accident in 2094. His comrades secretly arranged for a ghost upload, and Daren continued to work for GenTech, monitoring the Web for useful information. In 2097, he left a suicide note and apparently deleted himself.

Subordinate to the board of directors is a web of administrators selected for competence and loyalty – the most senior run GenTech's major operational divisions and projects. However, no person has unilateral power over such a large portion of the company; divisions are managed by triumvirates, each of which has at least one SAI that reports directly to the board. In this way, the board maintains ultimate control of company policy.

GenTech's divisions are Research and Development, Primary Production, Engineering, and Public Relations. Each is split into subdivisions referred to as *Projects*. Within a Project, various tasks are carried out under management groups, also consisting of at least one infomorph that reports directly to the board. At the task level, these direct reporters may be ghosts as well as SAIs. Very few people know that the Board maintains a direct link all the way down to specific tasks.

Activities

Research and Development

Gengineering: GenTech Pacifica's signature activities are genetic engineering and biotechnology research and development. It does basic genetic research and applies it to produce innovative parahuman, animal, and plant genemods. GenTech is famous for producing radical genemods, but for each Aquamorph there are dozens of minor germline modifications designed to make fish grow faster or lobsters taste better.

The Bioroid Project designs and produces new life forms from scratch, using existing creatures as templates and raw genetic material. The Uplift Project uses genetic, implant, drug, and psychological processes to raise the intelligence of certain sea species with the goal of producing sapience.

Climate Control: This Project concentrates on storm and seismic damage mitigation through the use of coastal wave buffers. Project leaders plan to launch oceanic heating laser satellites in the near future.

Primary Production

Aquaculture: Much of Earth's seafood is raised in controlled environments, and GenTech produces most of the technology used by the industry. Nearly all aquaculture farms buy at least some of their supplies from GenTech, from water filtration equipment to nutritionally balanced stock feed. GenTech also runs large farms of its own, supplying seafood to consumers in Oceania, eastern Asia, the Union of Alberta and British Columbia, Ecuador, and Chile.

The Space Aquaculture Project operates GenTech's orbital facilities, doing research into the unique problems of raising seafood in microgravity and places where every drop of water means excess mass to be carried around. The Fauxfish Project is researching the development of commercially viable vat-grown seafood meat. It has encountered several difficulties and has only recently begun to market product. Fauxfish remains expensive compared to aquacultured animals, and it doesn't seem to have quite the right taste or texture yet. At least, this is the story as the public knows it; see *GenTech Pacifica's Associations*, see below.

Sea-Floor Mining and Mineral Extraction: The Sea-Floor Mining Project manufactures underwater mining equipment and cybershells, and operates seabed mines in all the oceans and major seas. The Mineral Extraction Project uses processing plants to extract industrial chemicals and metals from seawater.

Engineering

Habitat Construction: This is a major Project with several large activities. Researchers develop new construction technologies and eco-engineers apply them to underwater and floating habitat designs. Construction crews assemble new habitats and perform expansions and renovations on existing ones under contract. With the growth in oceanic living, these activities generate a large component of GenTech's revenue.

Vehicles and Cybershells: The Submersible and Ship Projects design, test, and build aquatic vehicles in shipyards located in Australia, Korea, and Japan. Another Project develops and builds cybershells designed for aquatic use.

Power Generation: GenTech's Power Project produces oceanic power plants of all types (p. 113) for deployment around the world. It usually includes power systems in aquatic habitat contracts as well.

Public Relations

Media: GenTech's public relations division is a ruthless marketing and memetic engineering tool. The Media Project operates as a subsidiary company, producing entertainment and documentary InVids and slinkies with carefully designed messages supporting GenTech's activities. The popular children's InVid *Captain Salt and the Deep Rangers* presents heroes who use cutting-edge technology to accomplish goals and to defeat threats that embody philosophies antithetical to GenTech's own.

Memetics: The Memetics Project plans and executes long-term campaigns intended to produce favorable economic and legal conditions for company operations. An especially effective project discredited policies of the Australian government, effectively forcing it to grant free city status to Elandra in 2094 and ultimately contributing to the controlling party's loss of the next election.

Security: The Security Project is responsible for protecting GenTech's property and interests. It has access to the latest armor and weaponry, and tends toward a "shoot first, ask questions later" policy when protecting facilities from potential terrorist attacks. In some cases this is literally true, as Security has been known to create ghosts of killed terrorists for interrogation purposes. Security is also responsible for certain black operations involving industrial espionage and sabotage. Some people suspect the failures of rival companies to beat GenTech to market with a fauxfish product can be blamed on industrial sabotage.

GenTech Pacifica's Associations

Avatar Klusterkorp

GenTech is closely associated with Avatar Klusterkorp, though GenTech actively denies any link. The company has been helping Avatar with the Europa Project (p. DB47). GenTech collects and sequences genetic samples from terrestrial hydrothermal vent life forms and passes on the data to Avatar to use as templates for their modified microbes on Europa. There are rumors that modified organisms are tested at some isolated vent communities in the Pacific, and Blue Shadow is actively hunting out such testing grounds.

The Real Food Movement

This movement (p. 18) is secretly supported by GenTech's Memetics Project, and owes much of its organization and success to this. GenTech has far too much invested in aquaculture and fishing technologies to allow fauxfish to become commercially viable. Allowing quality fauxfish to become popular would ruin GenTech's stranglehold on seafood production technology, particularly with nanosocialist-backed companies ready to steal fauxfish genetic material and produce pirated versions. Having witnessed the downfall of land-based farming following the introduction of fauxflesh, GenTech began propagating the Real Food meme in much more subtle ways than the more overt engineering carried out by the Media Project.

Sakolpok Co. Ltd.

Sakolpok is one of the largest corporations within the TSA. It has interests and subsidiaries in aquatic vehicle and habitat construction, nanotechnology, oceanic mineral extraction, power systems, and aquaculture.

Originally based in Thailand, Sakolpok expanded into other nanosocialist countries as the political movement spread in the 2050s. It was a major supplier of naval and space hardware for TSA states in the build up to the Pacific War. These items were mostly naval vessels, spacecraft, and microbots, although some Sakolpok scientists were involved in the secret programs to develop nanovirus weapons (see p. FW16) and upgrading second-hand French AKVs to produce the *Kupu-Kupu* and *Rajasi*-class AKVs (pp. SSS47 and DB144).

At the end of the war, some of Sakolpok's management fled to its Jakarta office in Indonesia, leaving behind much of the company's infrastructure. The Indonesian government assisted the company in re-establishing itself because it still had factories throughout the TSA and represented a significant industrial base. The darker side of Sakolpok was left behind when the war ended, and its new management sought to reshape the company's image. They concentrated on civilian ocean technology and dropped the spacecraft construction division, which had been based in Thailand and could not be rebuilt easily.

Sakolpok has diverse facilities throughout the TSA, but little presence in other countries because of anti-nanosocialist trade sanctions. Apart from its contempt for international laws regarding intellectual property, Sakolpok is now a relatively benign company, with management and practices conforming to ethical, safety, and labor standards higher than the norm for TSA companies. It is thus one of the more desirable employers in the TSA.

Organization

Sakolpok is controlled by a strict hierarchy of managers led by a Chief Executive Officer. The current CEO is Setiawani Dharwiyanti, a bright and energetic woman who was elected to the position in 2093. Unlike her predecessor, she has adopted a hands-on approach to running the company, and receives regular briefings from her cadre of managers. Setiawani has increased the company's focus on civilian production and appears to be scaling back military contracts with a view to eliminating them.

Sakolpok's managers administer regional divisions based in each TSA nation. The largest regional operations are those in Indonesia, Malaysia, Bangladesh, and Peru. Each region engages in a slightly different mix of activities, depending on local technology and competition, though the emphasis remains on oceanic industry and nanotechnology.

Activities

Technology Sharing

This is the term Sakolpok uses to refer to the nanosocialist practice of copying ideas, research, and products created by others. Most regional offices have a large section constantly scanning the world media for new innovations, reverse-engineering rivals' products, and producing cheap copies of established designs. Sakolpok has a ready market for the fruits of this work because the TSA nations are so isolated from the world economy.

Anarchists and infosocialist sympathizers in non-TSA nations occasionally post pirated software, construction blueprints, and 3D printer programs to semi-secure Free Net data havens (see p. FW31) where Sakolpok and other nanosocialist companies can access them. The technology sharing sections must be vigilant for such information, because it is frequently deleted or the data haven shut down within hours by the various network law enforcement agencies of non-TSA states.

Construction

Sakolpok's major industry is the construction of ships, submarines, and aquatic habitats. Relatively little design work is done, with most vehicles being copies or minor modifications of successful models designed by other companies. There are shipyards in several TSA countries, producing commercial and private vessels. A few contracts for the TNI (Indonesian Navy, p. 81) remain to be completed, but other military production has ceased.

There are dozens of submarine habitats and hundreds of floating cities in the seas of the Malaysian and Indonesian archipelago, most constructed and maintained by Sakolpok. The Bangladeshi division is the major contractor for underwater habitats for the rapidly growing parahuman communities living offshore.

Nanotechnology

Despite losing many of its best nanotechnologists in the Pacific War, Sakolpok retains its position as a leading nanotech company in the TSA. This is the only division that does significant original research; therefore, it attracts grants from local nanosocialist governments. Sakolpok specializes in maintenance nanobots for its own products, so these are often aquatic-adapted. Innovative products from the research section include devices such as pearlwebs (p. 122) and Lateral Line nanosymbionts (p. 119). The nanotech section in Malaysia has also recently begun large scale copying of pirated mainstream consumer nanotech items.

Sakolpok's Associations

Bhuiyan Genetics

Sakolpok cooperates closely with Bhuiyan Genetics (p. 84) in Bangladesh's Bay of Bengal settlement project. The complementary skills of the companies make for an ideal partnership, tempered only by a friendly rivalry between engineers and scientists who strive to design and build products either with mechanical engineering or wet technology.

Manfasi

Following the Pacific War, PT Manfasi (p. FW57) has been Sakolpok's major competitor in the establishment of a new energy infrastructure for the Asian TSA states. While Sakolpok developed oceanic power sources, Manfasi concentrated on solar energy. Sakolpok now has the upper hand in the long battle, because its technology has been developed using readily available resources, whereas many of Manfasi's installations require hardware restricted by trade sanctions against the TSA. Although such items can be acquired, the ongoing expense has made solar power in the TSA uneconomical in the long term compared to the low running costs of oceanic power. Solar is still used for some specialized applications, but Manfasi's business has fallen dramatically and Sakolpok analysts are watching for any industrial sabotage sponsored by their rival.

Other Activities

Oceanic Mineral Extraction: Sakolpok builds and operates mineral extraction facilities in the shallow waters of the South China and Java seas and the Bay of Bengal. These produce industrial chemicals for the nearby TSA nations.

Power Systems: The industrial capacity of the TSA rests heavily on oceanic energy production because of helium-3 embargoes imposed by the United States and China. Sakolpok provides the expertise and infrastructure for some of the largest oceanic power projects on Earth. With almost all TSA nations in tropical regions, the emphasis is largely on OTEC systems (p. 30), but there are significant tidal and monsoonal storm surge power generators in the Gulf of Martaban near Rangoon, Burma, and along the Bangladeshi coast.

Aquaculture and Ecoscience: With 1.2 billion people to feed, and relatively little land area, the nations of the TSA rely heavily on fishing and aquaculture. The coastal shallows of most TSA states are dotted with fish and shellfish farms using equipment supplied by Sakolpok. The Peruvian regional office also runs a sophisticated ecoscience section, dedicated to study and preservation of the productive wild anchoveta and sardine fisheries in Peru's EEZ. The anchoveta fishery collapsed disastrously in the 1970s because of overfishing; it took nearly 100 years to recover and the Peruvian government is determined not to let a similar event occur again.

Blue Shadow

We're not terrorists, we're ***ecology advocates****. The rich and powerful have convinced the sheep of the world that the environment is doing great, when in reality they've broken the legs of Mother Nature and have given her crutches so she can hobble along. There may be less chemical pollution and fewer oil slicks these days, but do you think all those genemod fish and bacteria are just going to vanish or that they don't replace or outcompete natural species? Wishful thinking. The more we screw up the natural order the more we have to work to keep the whole ecology from flying apart – by introducing yet more technology. There's not much "natural" left in the oceans, but we're working on fixing that – one aquafarm and mining platform at a time.*

– "Mako," posting to the Web via an untraced Free Net server

Blue Shadow is the largest and best organized Preservationist radical group. It is dedicated to the protection of the ocean and the campaign against exploitation of sea creatures. Its stated policy is one of limited direct action – it engages in illegal activities up to property destruction but endeavors to minimize casualties. Blue Shadow's brand of Preservationism is moderated by a dose of pansapient rights – although its members believe that animals should not be uplifted and genemod creatures must not breed, they feel that existing sapients have the right to live out their lives. The breeding, use, and abuse of captive sapient creatures is thus a prime target for its operations.

Organization

Blue Shadow has unique problems of organization, being a large group requiring clear command chains, but with the requirement for secrecy and limited knowledge to protect against leaks and infiltration. Most members are organized into a centralized hierarchy, protected by cutouts, command encryption, and false fronts. Only the leaders and their immediate contacts know who really runs Blue Shadow. Operational teams are grouped into discrete cells with tightly controlled communications to the hierarchy. Cells generally handle their own recruiting; if they want extra resources, they can apply up the chain through dead letter drops (electronic or physical).

If a cell's cover is blown, Blue Shadow only loses a few operatives. Investigators who infiltrate the central hierarchy face the task of wading through chains of people, many of whom don't know exactly what they are doing. This prevents law enforcement from being able to pin serious charges on them and limits damage to the organization. Meanwhile, the internal security machine moves into action, eliminating the threat by legal action, memetics, or violence.

Blue Shadow has four divisions: Intelligence, Memetics, Operations, and Finance. Operations personnel carry out the organization's visible activities, but most Blue Shadow members have "office" jobs maintaining its large support structure. These divisions are not formalized – Intelligence personnel sometimes take part in actions mounted by Operations, and high-ranking members oversee work across several divisions.

Recruitment

Blue Shadow recruits people for jobs in Memetics or Finance initially. At this stage they are not aware they are working for Blue Shadow. Many people remain in this ignorant state their entire careers – this is particularly the case in Finance, where entire front organizations dedicated to raising revenue operate with only a few executives knowing where the profits go.

Senior memetics personnel discreetly compile psychological profiles of workers. Promising candidates are manipulated to increase their susceptibility to Blue Shadow doctrine. Some are abandoned at this stage as personality traits inconsistent with terrorist work come to light. After several months a candidate might find a pamphlet on his desk, or an anonymous e-mail message memetically designed to catch his attention. If he chooses to act on the contact, he will be taken into a cell and given tasks directly related to Blue Shadow activities.

Once a new recruit has proven himself, he may be reassigned to an area suiting his particular skills. Most members spend some time in Intelligence before moving on to Operations. Talented memetic engineers or administrators may remain in their original divisions, eventually rising to leadership positions.

Equipment

The day-to-day tasks of the Operations Division are acquiring, developing, and maintaining equipment. Blue Shadow operates a fleet of 11 ships, three cargo submarines, four helicopters, and numerous small boats. Additionally, there are personal surface scooters, submarine propulsion units, and diving gear. The large vehicles are legally registered and operated by front organizations, as either mainstream Preservationist, research, or commercial vessels. For the most part, they engage in legitimate activities. It is only a few times a year that they are seconded to terrorist missions.

Pan-Sentient Rights

Many activists who oppose animal farming in Fourth- and Fifth-Wave societies also oppose fishing and aquaculture. Cetanism, the Real Food Movement, the absence of economical fauxfish, and seafood's wet, scaly, uncharismatic nature have largely prevented campaigners from carrying public opinion with them. The pan-sentient rights meme (considering the interests of all sentient creatures, including nonsapients) is strongest in the E.U.; an extension of the 2081 farming ban to fish (but not crustaceans or mollusks) has been halted in its progress through the bureaucracy by strong resistance from Scandinavia, the Maritimes, and the seafood industry.

Blue Shadow recruits pan-sentient militants; those it cannot redirect to Preservationism are grouped with like minds in pan-sentient cells and fed information about common enemy targets. In 2099, a splinter group calling itself The Single Circle announced itself by capturing a GenTech Pacifica executive sub and forcing the occupants to downslink the death pangs of an aquacultured tuna (claimed to be "creatively" edited or downright faked by company lawyers).

Activities

Intelligence Gathering

Most of Blue Shadow's work is the gathering of information. The organization needs to know about potential targets for propaganda and terrorism, and what defenses it has to overcome in its operations. Typical intelligence personnel spend much of their time surfing the Web for leaked information and following it up, infiltrating corporate activities, or engaging in covert surveillance of operational sites. Surveillance of underwater bases is perhaps the most glamorous of these activities, but it is still mostly boring work, punctuated by moments of terror when discovery is likely. Collected intelligence is passed to the memetics division for propagation and to the operational division for planning.

Memetic Engineering

Many Blue Shadow members undertake the job of actively propagating Preservationist memes and cultivating new ones. The organization's memetic engineers specialize in the creation of subtle free memes (p. FW32) designed to sway public opinion in favor of radical Preservationism. Examples include alteration of

InVid entertainment programs so that criminal characters are parahumans while the heroes are baseline humans, or distortion of financial and news reports of ecohostile companies to undermine shareholder confidence.

The memetics division also creates public reports outlining collected evidence of illegal activities and animal and sapient rights abuses by target companies. While some reports are simply facts, many are engineered to emphasize the abuses, presenting them in ways calculated to promote public awareness and outrage.

Rescues

The most visible Blue Shadow operation is the rescuing and liberation of uplifted and sapient sea creatures. In fact, many people think this is all Blue Shadow does. Although these operations are risky and only a few are carried out each year, they are often spectacular and well-publicized. Several slinkies of raids, recorded by Blue Shadow personnel and highlighting cruelty to sapients and ruthlessness of defensive tactics, have been "leaked" to the Web.

A rescue is typically a lightning raid on an underwater facility. Perimeter detection equipment is neutralized, any guards incapacitated, and security and containment facilities breached. Often the "liberated" animals are frightened and disoriented and need to be coerced into leaving captivity. Previously liberated uplifts work with humans at the front lines to help convince the captives. Sometimes it is necessary to forcefully remove some animals. After being taken to safety and calmed down, most animals appreciate their release, or at least do not try to return to their captors, so Blue Shadow sees forced removal as a justifiable means.

Blue Shadow sterilizes rescued uplifts and genemods by nanoviral treatment (usually without their knowledge). Then they are either released or recruited into Blue Shadow.

Sabotage

Blue Shadow also sabotages ecohostile activities such as ocean floor mining, oil drilling, waste dumping, and new land development. Sabotage operations are designed for maximum disruption of activity, while trying to minimize casualties. Most are relatively subtle, such as burying caltrops in sediment that is to be sucked up for processing. The resulting mechanical failure of the mining machinery may not even be recognized as sabotage. Sometimes more militant methods are used, such as torpedoes, planted explosives, and bombjacking – teleoperating stolen cybershells or bioshells carrying explosives. Although these operations produce results, many of them are covered up by the victim organization, which is usually eager to avoid negative publicity.

Blue Shadow's Associations

Front Groups

Most of Blue Shadow's outside associations are through its various front groups. Many of these are legitimate businesses or non-profit organizations in their own right, with their only link to illegal activity being the surreptitious use of funds or equipment by Blue Shadow cells. These fronts are incredibly diverse, ranging from mainstream Preservationist groups, through scientific research institutes, to commercial enterprises. Through them, Blue Shadow has contacts throughout the social, scientific, and business communities. Most people never know when they deal with Blue Shadow, and nobody suspects just how far its tentacles reach.

Splinter Groups

An organization as large and decentralized as Blue Shadow is bound to splinter into competing factions, especially when the group as a whole is based on a moralistic ideology. Several high-ranking cell leaders have gone their own ways with their own interpretations of radical Preservationism, creating dozens of more-or-less independent activist groups. Some are more devoted to pan-sapient or non-sapient rights, while others are skewed to the militant Preservationist end of the spectrum. Irukandji (p. 86) is one of the largest and most dangerous splinter groups.

Daren Phuong

Unknown to GenTech Pacifica, the ghost of their ex-board member Daren Phuong (see p. 74) did not delete himself in 2097, but transmitted himself to a secure Blue Shadow computer. With his new perspective as an infomorph, Daren could no longer appreciate the physical comforts built up over 50 years of corporate greed and eventually converted to Christian hyperevolutionism (p. TS89). He vowed to erode the amoral edifice he had helped build, and sought out Blue Shadow contacts. They arranged a secure machine and encryption keys so he could transmit himself to a pre-arranged network address without being noticed.

Daren has provided information that has led to several successful raids on secret facilities, but Blue Shadow remains extremely cautious and has kept him isolated from the net in case he reports back to GenTech. Blue Shadow has made several xoxes of Daren; trying to hack them to create a trustworthy information source is a major ongoing project. Daren, sincere in his defection, is increasingly frustrated with his captivity and is on the verge of becoming psychotic.

Fund Raising

Blue Shadow's activities use considerable resources of materiel, manpower, and, ultimately, money. Its annual operating budget is between $300 and $400 million, varying from year to year depending on the success of fundraising activities.

More than half the budget comes from indirect donation. Blue Shadow operates several more mainstream Preservationist groups, research organizations, and even a religion (the Church of God's Image, p. 84) as fronts that simply funnel funds into its coffers. Some of these front groups also engage in merchandising and selling advertising space in publications to increase revenue.

Some donations are made directly to Blue Shadow, by people who agree with its methods. Most such donations are from wealthy eccentrics or people who participate in the group's terrorist activities. In general, such donations are made covertly enough to avoid the attention of law enforcement agencies.

The remainder of Blue Shadow's funding is raised by corporate subsidiaries that develop ecologically sound ocean technology, mostly stealth vehicles usable by the operations division, and InVid and slinky documentaries highlighting the beauty of the pristine sea.

MILITARY FORCES

MAJOR NAVIES

Although strategic thinking, and popular opinion, considers the control of space as the indicator of a first-rate military power, the fact is that the seas are still the cornerstone of human commerce and national authority. The seas remain the first line of battle for the world's major power blocs, and winning or losing control of the oceans can have disastrous consequences. However, conventional naval power, in the form of large fleets roaming the world's oceans, is an expensive luxury enjoyed by only a handful of major powers: China, India, Indonesia, Japan, and the United States. Other nations can only project power within a very limited area, such as their EEZ.

Small corporate navies and outright mercenaries fill the void left by the retreat of the large blue-water fleets and their national interests. These "neo-navies" fight using older vessels equipped with smatterings of recent technology, such as compact anti-missile lasers, advanced UCAVs, and bioroid crews.

China

People's Liberation Army Navy (PLAN): For decades the PLAN was the most important and influential section of the Chinese military, and directly controlled the entire military strategy of the nation. After the Pacific War this influence has waned drastically as its former subsidiary – the Space Forces – ascended in importance and recognition.

The PLAN's greatly reduced prestige within China, and infighting among the top Admirals over the role of the Space Forces, have slowed the fleet's reconstruction since the Pacific War. More problematic is the issue of recruiting high quality personnel; the PLAN has the reputation of being a haven for officers unqualified to serve with the Space Forces.

European Union

Most members of the E.U. lack a navy beyond small fleets of customs vessels, and some even lack that – they depend on arrangements with the United Kingdom or France. There is no effective coordinating body for maritime defense within the E.U., as the belief is that no force can threaten Europe from the ocean.

Marine Nationale (French Navy): The French Navy is the largest in Europe, and the most active outside of the Pacific. An entire fleet, including two submersible carriers and their supporting vessels, is based in French Polynesia. Fleet deployments are closely tied to national interests, and other E.U. members have made accusations that the French presence in the Pacific could draw them into a wider conflict in the region.

Royal Navy (RN): The United Kingdom's Royal Navy does not operate as widely as the Marine Nationale, but is less politically charged. It works extensively throughout the Atlantic, and is seen as an impartial mediator between the various national coast guards, corporate security fleets, and ocean habitats. The largest and most influential branch of the RN is the Submarine Service, which benefits from its very close relationship with the Space Service, including training exercises to refine anti-surveillance technologies and tactics.

Pacific Rim Alliance

Australian Naval Service (ANS): Australia's navy is small but competent, despite having obsolete hardware and commitments throughout the entire south Pacific. Except for the elite Mine Clearance Task Force, the fleet is Fourth Wave and depends on Japan to provide advanced cybershells and weapons.

Japanese Maritime Self-Defense Force (JMSDF): Japan maintains the largest and most advanced navy in the PRA. Its cutting-edge Fifth Wave navy emphasizes anti-submarine operations, with large numbers of long-duration AUVs and airborne sensor platforms. It cooperates very closely with the USN and ANS for regional defense, relying on their offensive power while the JMSDF keeps the sea-lanes open.

Transpacific Socialist Alliance

The TSA is an alliance of littoral nations – they rely on the seas for trade and all of their population centers are located on or near the oceans. The Chinese hit many of these cities hard during the Pacific War, from orbital and missile strikes and from the disruption of trade as the PLAN attacked the TSA fleets. Since the Pacific War, the TSA has had difficulties rebuilding to their former strength because of the damage done to their shipbuilding centers.

Marine de Guerra del Perú (Peruvian Navy): Peru has the only true navy in South America; Chile and Brazil have very capable brown water patrol forces but do not operate any open-ocean ships aside from a handful of coast guard rescue vessels. The Peruvian navy avoids politics, but has been campaigning for a more active role in the defense of the TSA after it sat out most of the Pacific War. The navy is lavishly fitted with Fifth Wave equipment, and the fleet operates the highest percentage of fusion-powered attack submarines in the world.

Tentara Nasional Indonesia (Indonesian Navy; TNI): The Indonesian Navy is the premier combat force within the TSA, and enjoys a great deal of worldwide respect for its capabilities after the impressive showing it gave during the Pacific War. In recent years the TNI has devoted a substantial percentage of its budget to mysterious secret research projects and expanding the Indonesian space forces in partnership with the Duncanites – most notably with the *Salahudin Samboja* (pp. SSS44-45).

Islamic Caliphate

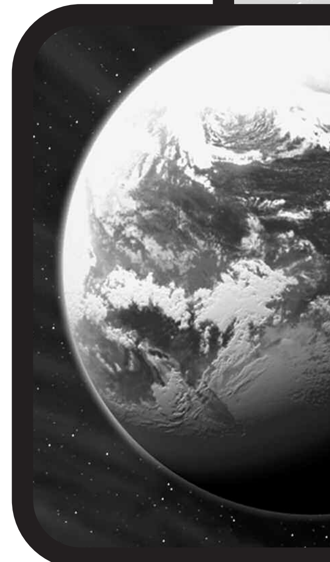
The Islamic Caliphate operates a single joint navy . . . in theory. In fact it is funded almost entirely by Saudi Arabia and Bahrain, with bioroid crews and officers drawn from families with political connections.

Royal Caliphate Naval Force (RCNF): Severe manpower shortages and poor training have handicapped the RCNF, which is otherwise supplied with the best ships money can buy – including two modern French arsenal submarines. For this reason the RCNF is not considered capable of operating far from home, despite its technical capability. The fleet's mission is simple: keep the Persian Gulf open for Caliphate shipping in the event of a conflict with Iran.

United States

Passed over to lead the nation into space, the United States Navy and Marine Corps has eroded in its size and political influence. Even so, they continue to work at acquiring a role in space – with the Navy deploying a detachment to Mars and the Marines slowly gaining support to establish a base on Titan (over the objections of the Army).

United States Navy (USN): The U.S. Navy maintains the second largest fleet in the world next to China, and the second most advanced after Japan – but it strikes a balance between the two. The USN keeps tight control of the United States' EEZ and carefully monitors activity on the continental shelf, especially in resource disputes involving U.S. corporations. In recent years it has flexed its political power to acquire a very public, if largely ceremonial, role on the oceans of Mars and Titan.



India

India dominates South-East Asia with its military might and economic power. The military takes great pains to stay out of politics, but the navy and air force are strongly conservative, while nanosocialist sympathizers dominate the army. If the nation tips further toward nanosocialism, the powerful military may split over politics.

Bhartiya Nausena (Indian Navy): The Indian navy is a mix of old and new, with many vessels constructed as far back as the 2020s and refitted over the years. Most of the older vessels serve as a reserve fleet that patrols exclusively within the EEZ as a visible force within sight of the numerous arcologies. The "first line" fleet is solidly Fourth Wave, but benefits greatly from advanced automation and strong support from the Indian aerospace forces.

Marine Units

Amphibious warfare is like special operations without any of the good parts – like decent equipment and a nice armpatch.

– Sergeant Juanita Rodriguez-Martello, USMC, 2085

Most nations with a coastline and competent military maintain some form of naval infantry, often regular army units who receive a few classes on naval terminology and how to disembark from landing craft. Dedicated marine units specialize in amphibious operations, often with an emphasis on deep raiding and commando missions.

Operational Environments

Green Water: Over the continental shelves, near archipelagos and coasts.
Blue Water: Open ocean.
Brown Water: Inshore estuaries and coastlines.
Red Water: Mars, or any planetary surface waters other than Earth.
Black Water: The various extraterrestrial under-ice oceans.

NONACOUSTIC SUBMARINE DETECTION

The traditional methods of detecting submarines – passive acoustics, active sonar, and magnetic anomaly detection (MAD) – are challenged by the rapid adoption of advanced acoustic signature reduction technologies and widespread use of composite materials in submarine construction. Even civilian vessels use technologies that challenge the most advanced sonar systems available to Fifth Wave powers.

Detection is further complicated by the littoral operating environment of many submarines. Shallow-water areas of the ocean are extremely noisy environments because of shipping and biological activity; combined with variations in ocean temperature, salinity, and interactions with the seabed, tracking and detection is almost impossible.

The most commonly used techniques to detect submersibles are *ladar*, *bioluminescence effects*, *wake detection*, and *heat emissions*. These do not require the sensor to be located in the water, and are usually most efficient when on aircraft.

Ladar: Multifrequency ladars can operate in the blue-green spectrum band with the best transmission properties through water. Maximum depth for most ladar units in coastal water is about 150 feet (see p. 52 for ladar Scan penalties), but the resolution and accuracy make it attractive for submarine detection.

Bioluminescence: The seas are filled with microscopic plankton that produce brief, faint flashes of light at random intervals or when stimulated. Billions of these organisms flashing after being stimulated by contact with a hull or wake can generate impressive light shows. Bioluminescence is greatest in warm, shallow waters, but varies strongly with biological activity, temperature, salinity, and depth. Depending on these factors, bioluminescence gives a Scan bonus of +1 to +4 to detect a vessel visually at night.

Wake: The wake of a submarine produces physical disturbances known as internal, near-field and far-field waves. As a passing submarine displaces water it generates internal waves, which cause a wave at the thermocline. This wave can work its way to the surface, appearing there as streaks. The near-field wave, known as a *Bernoulli Hump*, is a rise and dip in the surface of the ocean as the submarine displaces water. Far-field waves, called the *Kelvin wake*, form in a wedge behind the submarine.

The size of these waves depends on the submarine's size, speed, and depth. For example, a 650,000 cf submarine traveling at 25 mph, 90 feet underwater, generates a seven-inch Bernoulli hump. To detect these waves using radar or ladar, calculate a Scan modifier as (Size Modifier + Speed/Range Modifier -9), where the Speed/Range modifier uses the submarine's depth as the range and *subtracts* the speed rather than adding to it, to a minimum of 2 yards.

These waves can sometimes be detected with radar or ladar, even from orbit, as they are regularly shaped phenomena that stand out from the surrounding environment. Wind-driven waves mask these man-made waves however, and the submarine can only be detected when it is operating near the surface.

Heat: The motion of a submarine and waste heat from its machinery and power plant slightly heat the surrounding water. This warm water may rise to the surface, creating a wake with a temperature contrast. Detection is usually possible only when the submarine is operating at very shallow depths, but in isothermal waters (such as the Arctic Ocean) the heated water columns can rise from great depths. Infrared sensors can detect a heat wake as if detecting the submarine with a -1 Scan penalty per 10 feet of depth.

British Royal Marines: The 3 Commando Brigade Royal Marines and supporting units are the amphibious "force in readiness" for England. Royal Marine missions include providing security detachments for British warships and facilities (space and surface) and conducting amphibious strikes to support Royal Navy operations. The Royal Marines specialty is orbital fire support, which even the lowliest officer is trained to utilize and given the authority to call upon to support his operations. Royal Marines rely heavily on battlesuits for their infantry, but make extensive use of high-end Japanese and German cyberswarms and miniature UAVs. They cooperate closely with the United States, and personnel participate in an exchange program that some think is a way for the U.S. Navy and Marines to get around restrictions on their role in space. The Special Boat Service (SBS) defends British sea platforms and colonies, emphasizing antiterrorism (particularly ecoterrorism) and facility raids. Experienced SBS operators are allowed to volunteer for Commachio Group or transfer into British covert operations units.

Jiefanjun Haijun Luzhan Dui (Chinese PLAN Marines): The PLAN Marines have a limited terrestrial role since the PLA began providing amphibiously trained infantry units under naval command and the PLAN Space Forces were expanded. The two remaining marine divisions not under Space Forces command are stretched thin training PLA units guarding critical aerospace and naval facilities. They remain a formidable Fourth Wave military force, emphasizing the large-scale offensive amphibious operations that have largely fallen out of favor with other marine forces. The secretive "special reconnaissance commando" companies commanded directly by the fleet admirals are famous for their success in countering and eliminating TSA naval special operations teams during the Pacific War.

Morskaya Pekhota (Russian Naval Infantry): The Russian Marines' reputation for tenacity, skill, and professionalism sets them apart from the mediocre *spetsgruppa* (special forces) units of the Russian Army. The Marines are the Russian government's preferred rapid-reaction strike force, receiving the best equipment and maintaining their own combat air support and transportation detachments (administrative support is done by the navy). Russian Marines are volunteer sailors from the Navy, although operations often fall outside of navy command. The Russian Marines have recently been expanded to a full division, leading some navy admirals to joke that by 2120 the Marines will have more personnel than the entire navy! A *Spetsnialnogo naznacheniya* (naval special forces) company, known as *Delfin* ("Dolphin"), works closely with Russian foreign intelligence; they receive training in underwater operations, sabotage, intelligence gathering, and assassination.

United States Marine Corps (USMC): Despite several close calls with dissolution, the USMC has survived through the support of former Marines in government positions and reintegration with the Navy. In addition to maintaining two brigade-sized combined-arms Marine Expeditionary Strike Teams, the Marines provide physical security for the Navy and provide guards for all U.S. embassies under State Department command. The Marine Corps is primarily Fourth Wave, but uses even more AIs per individual than the USAF, and was an early adopter of cyberswarms at the individual level. The Marines rely heavily on infomorphs at all levels and have a very liberal attitude (compared to the other U.S. services) on how much responsibility and freedom they are allowed. Marine Recon Commandos specialize in signals intelligence and field surveillance, and often work with field agents from the CIA and NTIC on operations.

Other Organizations

Many types of organization have an interest in the seas, from resource companies to research groups, and from idealists to criminals. A few representatives of each type of group are described below.

Corporations

Agua Negra S.A.

This Argentine mining giant is the largest resource company in South America. Agua Negra specializes in ocean floor mining and extraction of minerals from seawater, but also has conventional mining interests on the South American continent. It operates deep-sea cybershells that collect manganese nodules from the South-East Pacific and Argentine basins, and perform sulfur and metal extraction near hydrothermal vents. These activities are supported by several new islands, the largest of which is Isla Santa Fe Córdoba, some 600 miles southeast of Buenos Aires. The subsidiary company Agua Negra Profunda S.A. runs Santa Fe Córdoba and two other floating islands in the South Atlantic.

Recently Agua Negra has begun operating shallow sea-floor mines on the continental shelf around the Antarctic Peninsula, supported by centralized underwater habitats with parahuman and uplifted animal workers originally supplied by GenTech Pacifica. Chile has lodged formal protests against the Antarctic activity, claiming it violates the Revised Antarctic Treaty (p. FW25), but is hesitant to take further action because of more pressing military issues on its northern borders and the current good relationship between the United States and Argentina. Blue Shadow activists are convinced Agua Negra's activities are disrupting the Antarctic Peninsula ecosystem, as well as employing gengineered sapients. Unlike the government of Chile, this group has no qualms about taking action against the company's bases.

Atlantec Inc.

Atlantec is a U.S. based bioengineering company with a strongly ecoproactive philosophy. It produces animal-based bioroids designed to stabilize ecosystems and clean the environment of pollution. The two main approaches used by Atlantec are: producing artificial species to replace ecologically important species which are being depleted or lost; and creating new life forms which can actively process and restore some part of the damaged environment. Most replacement projects involve unglamorous species such as corals, mollusks, fish, and plants. Environment processor bioroids are more notable, including the recently developed leviathan filterers (p. 123).

Atlantec also has a small division engaged in archaeobiology. Its greatest success to date has been the reintroduction of the Florida panther, which originally became extinct in 2031. Although not as important to the company's main goals, this division generates most of Atlantec's publicity and fosters the donations that make up a significant portion of its revenue.

Bhuiyan Genetics Ltd.

Bhuiyan is the largest company in the rapidly growing gengineering industry in Bangladesh. It made its fortune when it was commissioned by the Bangladeshi government in 2077 to produce parahuman designs for its initiative to populate the waters of the Bay of Bengal (see p. FW69). It won the contract because it had recently acquired pirated genetic blueprints for GenTech Pacifica's Aquamorph parahumans. Bhuiyan has since produced several variants, other water-adapted parahumans of its own design, and a series of biomods and nanoviruses for adapting humans to aquatic life. With the nanosocialist subsidies for research and profits from production of designs, Bhuiyan has built an aquatic gengineering company more influential than GenTech Pacifica within the TSA.

Although Bhuiyan's strength lies in human and parahuman gengineering, it is rapidly expanding into the fields of animal and plant engineering. It has adopted some pirated food fish designs from non-TSA companies and is tweaking genes to develop species more suited to the Indian Ocean. Its greatest non-human success to date is a productive red alga that has been adapted to thrive in the low-light zone between 300 and 600 feet deep, opening thousands of square miles of the Bay of Bengal to intensive biomass production.

Mbungwe Engineering (Pty.) Ltd.

A South African ecoengineering and biotech company, Mbungwe Engineering acts as a consultant to many projects within Africa and off its shores. The highest profile projects concern wildlife management in the large terrestrial preserves of Kenya and Tanzania, and ecological consulting for the Olympus Project (p. FW50). Mbungwe's most important ecoengineering activities, however, are in the areas of coastal stabilization, storm mitigation, arcology design, fishery management, and artificial reef habitat construction.

The biotech arm of Mbungwe is active in archaeobiology, genetic preservation, and gengineering of ecologically important species. Mbungwe has secretly been developing minestars (p. 124) as a method of collecting ore-rich manganese nodules from the deep seabed. Its recently formed sea-floor mining division carried out the first minestar operation in 2096, and it has quietly been using processing ships to collect the fruits of their work ever since. A single operation scatters a million minestars, about 30% of which are collected over the next few weeks, yielding approximately 750 tons of high grade ore.

Shimada Umiya

The culturally conservative population of Japan remains one of the highest consumers of seafood per capita. Shimada Umiya is one of several large fishing and aquaculture companies supplying this huge demand. The Japanese government strictly regulates catching fish from wild populations to prevent overfishing. Shimada adopted Fifth Wave fishery management technology early, giving it an unsurpassable lead in the modern seafood industry.

Most of the people employed by Shimada work in ecoscience and eco-engineering activities, studying and managing marine ecosystems. A construction division creates large artificial reefs in the shallows off Japan's coast and along the Ryukyu island chain, which are seeded with rapid-growing gengineered plankton and iron-rich mineral supplements. These reefs house large fish communities and form a major source of Shimada's catch. The company uses pearlwebs and cybershells extensively to herd and catch mature fish.

Victoria Shipping Ltd.

This is a cargo shipping company based in Victoria, in the Union of Alberta and British Columbia. It operates a fleet of 54 cargo vessels and several support vessels with over 5,000 tons displacement. The ships are controlled by infomorphs, either SAIs or ghosts of former captains who enjoy the nautical life. They ply the waters of the Pacific Ocean, shipping goods between Alberta, British Columbia, and other major nations of the PRA, especially Japan and Korea. A few ships operate on routes through the Panama Canal to Buenos Aires or via the Arctic Ocean to ports in Europe.

Victoria Shipping also services floating arcologies and underwater settlements in the North Pacific region, using cargo submarines to reach submerged habitats. It has established its own arcology a few miles off Vancouver Island, in which it is selling real estate to raise revenue for a planned expansion into commercial arcology construction and management.

International Nongovernmental Organizations

Church of God's Image

This is a high-profile televangelist religion based on the tenets that those created in God's image (i.e. baseline humans) can be saved while other sapients (parahumans, uplifted animals, and infomorphs) are abominations. These beliefs appeal to many religious Preservationists and the church has a broad, if not very deep, following. Its main activities appear to be delivering pulpit-bashing sermons and soliciting donations.

In reality, the church is a front operated by Blue Shadow for two purposes. The first is to spread the Preservationist meme, while the second is to raise cash for its operations. On both accounts the church has proved successful beyond expectation. If anything, it may be too successful, because it is beginning to attract interest from economic authorities who are wondering just how much money it makes and where it goes.

Global Ocean Institute (GOI)

The GOI is a scientific research organization made up of oceanographers, ecologists, climatologists, and members of associated fields from around the world. It acts as a loose administrative body and a dissemination agency for matters of ocean science. A few executive positions are filled by members of the oceanographic community by election, and a committee sits to discuss and arrange liaisons with national governments on matters of scientific and ecological importance. The GOI also holds a few conferences each year, attended in person by hundreds of participants and remotely by thousands more.

Mars Oceanographic Group (MOG)

The Mars Oceanographic Institute is a professional academic society. Any scientist with an interest in Mars oceanography is most likely a member. The 1,500 members of MOG study the dynamics and structure of the new Martian oceans. Mainly, they organize scientific meetings and encourage the dissemination of Martian oceanography research. Members don't have any real duties, apart from the few elected heads of various committees that decide policy such as eventual sea level, temperature, and salinity targets. The MOG is also overseeing a Mars University research project, which involves seeding areas of the Borealis and Hellas Seas (and ice sheets) with modified Black Plague algae (see p. ITW35) in an attempt to reduce the reflectivity of the planet and prevent temperatures from dropping so much in winter. Large black algal mats are currently growing in Chryse Bay north of the mouth of the Marineris Sea, though it is too early to say whether they are having the desired effect or not. MOG members (known informally as "moglodytes") gather to discuss progress and future strategy at a conference held throughout the first week of Virgo every year at the University of Mars. Although the MOG has limited funding (mainly membership dues), the fact that it represents the collective wisdom of the Martian oceanographic community through its elected committee heads means it has a strong influence on overall terraforming policy.

Those whom God has made in His holy image are destined for salvation. Those whom man has corrupted are destined for damnation. This is the word of the Lord.

– Traditional benediction,
Church of God's Image

Servare Historiam

This is a group of professional and amateur archaeologists and historians dedicated to the preservation of archaeological and historical sites. Servare Historiam supports scientifically-conducted archaeological research, but campaigns against the unnecessary disturbance of sites. With virtual presence and slinkies, it argues, there is no need for the removal of artifacts to museums. The practice it decries most, however, is the recovery of historical artifacts by treasure hunters, and subsequent sales to private collectors.

With the majority of known archaeological sites on land already plundered for museum pieces or private collections, Servare Historiam concentrates on the protection of underwater sites, most of which have only become accessible in the past 100 years. It seeks to protect shipwrecks and coastal sites submerged by rising sea levels.

Marine Archaeology

Until the 21st century, almost all archaeology was done on dry land. It was only with the invention of small submersibles designed for scientific work in the 1960s that historic shipwrecks could easily be studied, and it did not become routine until after remote operated vehicles appeared in the 1990s. As robotic vehicles evolved into cybershells, more researchers gained access to the wealth of archaeological material hidden beneath the waves.

Over the centuries, hundreds of thousands of ships have sunk. Those which plied ancient trade routes contain valuable clues to unraveling the history of human civilization, including ship construction techniques, cargo types, and trade quantities. More recent wrecks shed light on historical expeditions, military actions, and commercial shipping. A few, such as the wreck of the *Titanic*, fascinate the public and continue to be explored by virtual presence as *in situ* museums.

Shipwrecks are not the only archaeological sites underwater. Since the last ice age ended around 10,000 B.C., rising sea levels have submerged 10 million square miles of land, inundating countless Neolithic, Bronze Age, and Iron Age sites. Some areas, such as the Black Sea, hide coastal settlements from as late as 1000 A.D. Anoxic water conditions or burial in sediment can preserve such sites better than those on land.

Finding submerged archaeological sites involves long, exhaustive searches, but once found they are eagerly studied by professionals and the public alike. Groups such as Servare Historiam campaign to protect them, while more mercenary ones like Choses Merveilleuses (p. 86) seek to exploit them. A significant find can trigger interest and activity from many corners.

Weathersense

Weathersense is a well-regarded mainstream eco-proactivist group dedicated to monitoring Earth's climate and campaigning for initiatives designed to halt and reverse climate change. It is a strong supporter of the effort to restore the ozone layer to preindustrial levels and wants a similar program to reverse the global warming and sea level rises of the past 150 years. This has been proposed by a few national governments, but the Fifth Wave nations most able to undertake such a task are reluctant to commit the enormous levels of expenditure necessary to achieve significant results. Unlike the immediate physical dangers of the ozone crisis of the 2070s (p. FW21), the threats of global warming are longer term and not obvious enough to cause outcry among leaders looking no further than the next term of office.

The group is particularly concerned about the possibility of runaway methane hydrate release (p. 25). Most members are opposed to the artificial manipulation of weather phenomena by atmospheric-warming laser satellites, because this injects further energy into the already overactive global climate system. OTEC power generation (p. 30) is another area of concern.

Many leading ecoscientists and meteorologists are active members of Weathersense. They give speeches and produce educational InVids to deliver the message that the world's weather will continue to worsen unless something is done to counteract the changes already cascading through the climate system. The group's philosophy is one of peaceful protest and political lobbying. There are no known associations between Weathersense and more militant Preservationist groups, but many agencies harbor suspicions.

CRIMINAL AND TERRORIST GROUPS

The Boreal Pirates

Mars is already one of the most interesting and dangerous places in the solar system. So what does a disenchanted youth do to seek excitement and rebel against society? He runs away to join the Boreal Pirates!

The Pirates are actually a number of loosely organized gangs who, for the most part, fight amongst themselves as a sort of unbridled historical recreation society. Members hail from both the Chinese and U.S. settlements. They seek to relive the heydays of piracy on Earth in the 17th century, except with more modern equipment. Occasionally they attack ships plying their way across remote parts of the Borealis Sea, using small hydrofoils and jetbikes. Their main objective in such attacks is the theft of luxury goods and recreational drugs – they try not to inflict casualties, lest they prompt a concerted effort to eliminate them. Many of the Pirates have wealthy parents, so the local authorities are reluctant to deal with them too harshly, and often profit in under-the-table deals when one of the rich-brat scions goes a little too far.

The Boreal Pirates should be played straight in most ***Transhuman Space*** campaigns. In campaigns with a silly or satirical bent, however, they are likely to adopt pirate slang ("Arr! Shiver me timbers!") and the captains are bound to have a cybernetic leg and a gengineered sentient parrot.

Choses Merveilleuses

This black market enterprise has a very select clientele. Choses Merveilleuses specializes in acquiring archaeological artifacts, items of historical interest, and treasures unknown or thought lost. It sells these items for small fortunes to private collectors, who pay a premium for absolute discretion. Although it is a small operation, a large amount of cash flows through its coffers, and Choses can exercise considerable influence in the archaeological and treasure-hunting communities.

Choses does not operate artifact recovery expeditions itself. It hires freelancers for active fieldwork, and sends agents to work on or negotiate with other expeditions. Agents are skilled psychologists and memeticists, who determine the best approach for acquiring choice items, either by buying, stealing, or blackmail. Freelance treasure-hunters mostly work on underwater sites, away from easy detection, but some terrestrial expeditions in developing nations have been commissioned – and rumors abound that NASA's Mars Polar Lander probe, lost in 1999, has found its way into a private collection . . .

Irukandji

Irukandji is a recently-formed militant Blue Shadow splinter group dedicated to the eradication of all marine life upgrading – and, especially, intelligence-enhancing – projects and military applications. Named after a tiny but deadly jellyfish, the name fits the group's *modus operandi* of striking quickly and with lethal force. Unlike Blue Shadow, Irukandji terrorists use any means at their disposal and have no qualms about loss of sapient life. They sabotage gengineering laboratories, research vessels, scientific meetings, and any operations making use of genemod species such as aquaculture, sea-floor mining, and submarine and coastal habitat development. They also target Fifth Wave naval vessels and shore installations, whether they are involved with gengineering or not. Bombjacking bioshells and puppeteered uplifts (such as War-Dops) is a particularly favored terror tactic, though they will bombjack cybershells too. Operations are designed to kill genemod species, bioroids, and bioshells, and those who develop or use them, rather than simply disrupting activities. See more about Irukandji on p. 38.

Rackham Gang

The "Rackham Gang" is the nickname of a well-organized piracy group operating in the Celebes Sea region around the islands of the Philippines, Indonesia, and Sarawak and Sabah. A lot of PRA cargo traffic passes through this region, especially ships loaded with expensive cybershells and electronics, making it a rich hunting ground. The gang operates modern biphibian hydrofoil craft from bases hidden among the more remote islands of the archipelagos. They remain submerged near their bases to avoid satellite detection. PRA patrols managed to find one base in 2097, and the amount of high-tech gear stored there was staggering. The Rackham Gang has continued their attacks at an average rate of one cargo ship every four months, so the gang obviously suffered little from this loss. Cargo shipping and military analysts speculate that they are backed by Indonesia and Thailand, but the TSA denies this and accuses China of conducting a privateering operation.

The favored tactic of the Rackham Gang is to surface in several biphibians a few miles away from an unmanned cargo vessel – to avoid raising suspicions as close sonar contacts – then close and board as quickly as possible. Security experts jam or destroy communications and any automated defense systems, allowing cargo subs to surface nearby and receive transferred goods. The booty is then fenced through smuggling channels throughout the world.

Campaigns and Adventures

The settings in ***Under Pressure*** can be used to bring variety to a ***Transhuman Space*** campaign with a broad scope, or as the focus of an entire campaign. Many of the campaign themes in the ***Transhuman Space*** core book and ***Transhuman Space: Fifth Wave*** can be explored in aquatic environments. In addition, several new and unique possibilities are available.

Living Undersea

The most primal adventure theme is survival. Underwater is a hostile environment, with difficulties at least as great as survival in space. The exotic scenery can be used as a backdrop to a campaign, or it can become an integral component of an adventure plot. GMs should play up the otherworldly nature of life under the sea – there are unique hazards to be faced, and danger is close if anything goes wrong.

An undersea campaign can be built around simply making a living. A group of dwellers in Elandra might be involved in anything from arcology politics, to inspecting deep mining facilities, to foiling industrial espionage or terrorism. Encounters with cetanist tourists or strident Atlanteans will add color and spice.

Places like Elandra and Ondala are connected to the Web, so media junkies and memehackers can indulge in their activities with abandon. Agitators might seek the safety of remote settlements and pursue political or criminal operations through the Free Net to avoid being traced. And some places, such as the Dhamchos Thupten Khusu Monastery, are totally isolated from outside communication for weeks at a time, providing perfect locations for mysteries, covert activities, or old-fashioned, locked-in-a-box horror.

Taking a Stand

From Preservationists to ecoproactivists, thousands of people are adopting causes and fighting for them. Adventurers could be members of Blue Shadow, planning and executing raids on underwater settlements or corporate facilities. This will be a life of excitement and danger – perfect fodder for gaming. Players may enjoy exploring the moral ambiguities of using violence as a tool to fight what are seen as greater injustices. For a game of intrigue, one or more activists might become aware that Blue Shadow has targeted them as potential recruits. Alternatively, law enforcement agents might be given the job of infiltrating such a group.

Political activity can also lead to adventures. A group of people supporting nanarchy or universalism might help others to establish drift habitats, lobby for independence or legal recognition, or help fend off unwelcome attention and hostility from governments and corporations. This can be achieved in many ways, from negotiation and memetics to direct action, depending on the style of the campaign.

Corporate Projects

Company employees are often assigned a wide range of tasks. Simple jobs like working on cargo subs or establishing a new sea-floor outpost could lead to unexpected difficulties or conflict. Operating in deep-sea facilities, or surface habitats in extreme weather, can add environmental challenges to any task.

A party of troubleshooters might work for a company, from a giant like GenTech Pacifica to a small aquaculture firm, either full-time or as freelancers. They could investigate and stamp out cases of industrial espionage, memetic propaganda against their employer, sabotage, and terrorism. Secret projects need protection from activists – and in some cases the law – and someone will need to step in to save the researchers, or perform a cover-up operation, if something goes disastrously wrong.

On the other side of the coin, governments or international bodies such as the World Trade Organization frequently want to investigate companies for illegal activity, and bring transgressors to justice. Agents may be sent to underwater facilities or corporate islands to determine the truth about rumors of ecological destruction or poor working conditions. Such agents face a deceptive or hostile reception from the company.

In the Navy

Only a fool believes the role of navies is over. With 90% of Earth's population either in the oceans or less than 40 miles from shore, they are more important now than ever before. The Pacific War proved the power of orbital superiority – and also its inability to counter submersible weapons or impact the small, tactical surface engagements that typified the conflict. Naval conflict in the Fifth Wave is fast and decisive, and in the harshest combat environment in the world. Under the waves, stealth submarines still cruise so close that they occasionally ram each other accidentally, and incidents of piracy and ecoterrorism rise by the day.

A navy crew can be called to service to perform almost any mission, from humanitarian assistance to disaster relief, and the next day find themselves playing cat-and-mouse with an armed pirate attack submarine. The PLAN and U.S. Navy still conduct worldwide tours to show the flag, including sailing to ports in unfriendly waters. In many places the major navies are the only law, and a passing warship on international waters may be the only justice for thousands of miles – under the ancient conventions of the sea, the word of a navy captain is still final.

Europa in Turmoil

The only certainty on Europa is that nothing is certain any more.

– Dr M. Marron, CRABE personal log, December 2099

A campaign focusing on the War Under the Ice provides many opportunities for roleplaying. With spacecraft from the European Union and possibly China on the way to Europa, tensions are reaching the breaking point on the satellite. A campaign would most likely focus on the growing turmoil within and between the three groups on Europa.

Last Stand: The leaders of the Europa Defense Force have a lot on their mind. How much has Amy Wilson told the European Union about the organization? Is the French SDV really bringing a negotiating team, or is it a cover for a commando unit? Is there really a *Xingzhai* SDV on the way, after the head of Torsten Rademacher? Some recruits in the EDF are starting to wonder if their cause really is worth dying for, and may attempt a coup in order to force a surrender and avoid bloodshed. The option of underwater escape is no longer available since Jones and Wilson made off with the EDF's only manned minisub, so a rebellion is looking like an increasingly attractive option to some of the less fanatical members. However, Rademacher and other hardline members are not willing to sit and wait for destruction, and are prepared to take drastic measures to cause some major damage to their enemies – and their increasing paranoia will make it harder for any coup attempts to succeed. There are even rumors at Manannán that the EDF has a nuclear weapon in storage, ready to be used as a last resort . . .

Lying in Wait: Avatar is sensing an opportunity. With a garrison of MAD combat bioroids and two SDVs in orbit, it is willing to collaborate with the forces from Earth once they arrive. Some personnel would be happy to see the EDF completely annihilated, while others think it is more prudent to tighten up Avatar's defenses and see what happens. A campaign centered on Genesis Station could include fending off increasingly ferocious attacks on the facilities in the Kargel-Zolotov Channel. The EDF may even attempt to bring the fight directly to Genesis Station in desperation.

Mutiny at CRABE: Even at CRABE, the situation is tense. Should a concerted attack occur at Manannán Station, the EDF sympathizers at CRABE may be forced to decide where their loyalties really lie, and some may openly side with the terrorists. If they were to somehow wrest control of CRABE from the current leadership, they may offer support to EDF personnel and an escape route should they be forced from Manannán. Characters at CRABE could already be on either side of the fence, or be forced to choose sides if the situation flares up.

The Hammer Falls: Alternatively, characters may be outsiders: part of the negotiation team on the French SDV, or soldiers on the Chinese SDV. They will have to judge the situation on Europa carefully, whether they come offering an olive branch to the EDF or bringing its destruction.

And the situation may turn violent at any time . . .

5 CHARACTERS

"Well, it's about time you regained consciousness, Ms. Desmet," clicked the Irukandji leader. "I know our method of removing your infomorph was a bit . . . crude . . . but I expected a bit more resilience from a famous human such as yourself." The terrorist's placid face betrayed no human emotion, but his black eyes burned with malice. She was in a moon-pool room, empty except for a few crates and a small tray holding the bloody dive knife that they had used to cut the implant from her jaw.

There were more clicks and the CeTalker placed in front of her spoke again with its improbable British accent. The dolphin had his mouth open, a clear sign of aggression.

"I thought you might want to see this, considering that you helped make it all possible." A display flickered to life above her. It was a TEN broadcast, live from the scene of some newsworthy atrocity. She already knew what it was but she couldn't turn away.

". . . least 80 fatalities have been confirmed by Applied Genentech officials, many of them young uplifted cetaceans undergoing socialization training in the facility's crèches. Dozens more are missing and presumed dead in the tragedy." The dolphin made a squeak of indignation.

*"They call it a **tragedy**!" He shook his head in anger. "This is but the beginning! And we owe it all to you and Applied Genentech. Their newest AIs have a few unintended features our agents saw fit to insert into the final code. All we needed was for the company to throw some chum into the water carrying an AI with our modifications. Now we have access to their deepest, darkest secrets, all thanks to you. They showed some initiative when they decided to send the company's best troubleshooter to track me down. But did you expect me to be as simple to catch as a Doolittle?" He did a roll to show his pleasure.*

Through gritted teeth she whispered, "You would kill your own kind, Coak?" He stopped his roll and faced her, squeaking outrage.

"My kind? What do you know of it, human? Engineered from birth to be little more than an organic tool for your species, our brains "upgraded" to be more like yours. Even my name was assigned, along with my model number. Does it surprise you that your new toys don't show appreciation for their fate? You created us in your image, human. Despair and revenge are emotions we now understand all too well." Coak closed his mouth, and his all-too-human eyes locked on hers.

"But I know what I once was, I have memories from before I was modified into a freak. I'm one of a kind, you know, a state of the art example of uplift technology." Coak clicked derisively and rolled over to show the scars that crisscrossed his belly. "This body is just a shell. Even my brain is more mechanical than organic. Others like me were being designed for the U.S. Navy, quickly produced organic weapons. Ironic that their little war machine has decided to fight ***them****.*

"Even some of your fellow humans appreciate my plight. Irukandji will use the data you and your AI provide to strike a fatal blow to Genentech and their uplift projects." He gave a self-satisfied chirp and slapped his fins on the water.

She was beginning to feel light-headed from the blood loss but pride stiffened her back. "I'll never tell you anything, Coak," she gasped.

"Once my associates arrive we will make a personality emulation of your mind. After a little tweaking, your shadows will be more than happy to tell us everything they know about the company's operations and plans." He turned away as the translator finished his words. "If it's any consolation, we promise to delete them after we're through."

The bastard was ***definitely*** *smiling.*

CHARACTER TYPES

The oceans of Earth are home to millions of individuals, many of whom have adapted to their environment in strange new ways. Many of the character types found in ***Transhuman Space*** and ***Fifth Wave*** are also living in the oceans – although Spacers and Mangliu are few and far between. The following sections outline some common character types and suggested advantages, disadvantages, and skills.

Activist

"Yeah, we're protesting Metazyne's dumping of genemod fish in Lake Victoria. We're ronin with a conscience, protecting those less fortunate from the depredations of the transnats and their own corrupt governments who trade short-term profit for long-term disaster. They claim this is an "economic development assistance program" and we're depriving people of food and livelihood – typical corporate doubletalk. Now please step away so people can see my sign. I have four more hours of protesting before I catch a suborbital to Baku to cut a ribbon at the Caspian Sea Recovery Zone."

Maybe you're a bored dilettante looking for something to occupy your time and impress your socialite friends, or maybe you're an executive at a prosperous biotech firm looking to change the world for the better. The incredible standard of living in the hyperdeveloped nations and the ease of working from anywhere means you can devote your free time to traveling around the world, globe-hopping on behalf of your chosen cause.

Advantages: Ally Group, Charisma, Contacts, Independent Income, Status, Wealth.

Disadvantages: Code of Honor, Duty, Obsession, Overconfidence, Pacifism, Workaholic.

Skills: Diplomacy, Economics, Fast-Talk, Law, Memetics, Politics, and possibly scientific and professional skills related to the cause.

Biotech: The individual resources and sensibilities of activists prohibit any broad generalizations. Most human activists are affluent enough to be genefixed (p. TS67).

Coast Guard

"No sir, I can't say I've ever heard of the Free City of New Haven. No, I'm afraid our country doesn't recognize your territorial claims and thus your boarding of that tanker yesterday was piracy. No, we don't care that your Free City is recognized by the TSA. Keep your voice down, sir, or I will have you sedated. You will be assigned a legal adviser infomorph who will explain your rights while you are in custody. No, you will not be given reparations for the cargo sub we sunk, and we have already arranged for military assets to be in the area if your "country" tests our patience again."

Keeping the peace in your nation's waters is your job, one that is more important every year. Thousands of people are streaming to the seas to look for a new life or escape their old one. You're there to make sure things don't turn into a lawless mess, and that the corporations and settlers don't get the idea that they can flaunt your nation's sovereignty or try its patience.

You've assisted local police forces at a nearby arcoblock, investigated a murder aboard an underwater mining platform, and sunk opposing coast guard vessels from a Freedom Ship that got the impression they could set up a fish farm in your waters. You've been up and down the coast, putting out fires above and below the waves. Things can get a bit wild, but there is never a dull moment out here on the frontier of Earth civilization.

Advantages: Alertness, Contacts, Fit, Intuition, Legal Enforcement Powers, Military Rank.

Disadvantages: Bully, Callous, Duty, Honesty, Intolerance, Overconfidence.

Skills: Criminology, Detect Lies, Electronics Operation (Sensors), Guns, Law, Powerboat, Professional Skill (Law Enforcement), Sailor, Scuba, Stealth, Streetwise.

Biotech: Many coast guards welcome bioroids and parahumans already adapted to the ocean environment. Aquamorphs are especially valued for boarding operations and rescues at sea. Individuals often invest in minor biomods that will be useful on their jobs.

Ecoengineer

"My last job was on an OrcaTech aquafarm outside Tangaroa. They had a problem with some parasitic worms that one of their competitors or some ecoterrorist group had planted. Turned out they were being introduced by cyberswarms disguised as maintenance units – they even ID'd friendly to the local AI controllers. The parasites themselves proved a bit more trouble; the first generation had injected some proteus nanoviruses into the pharm jellies and we had to destroy three crops and restart from fresh genestock. I can still smell burnt ChocoPotato™ . . ."

You've gotten your hands dirty redesigning the arcology's waste treatment system and configuring a cyberswarm network to fight that carnivorous algae that appeared off Los Angeles; your job is one adventure in engineering after another. Technically you're an "environmental planning and operations technician," but most people just call you an ecoengineer. Your skills are in massive demand; a month ago you assisted architects working on the Tangaroa expansion to minimize its impact on ocean currents and fish migration, and a small Swedish arcoblock that has been the target of ecoterrorists just contracted you to do an inspection. Better pack an assault rifle this trip.

Advantages: Contacts (former employers), Reputation, Wealth (including levels of Multimillionaire).

Disadvantages: Enemy (Rival corporations and ecoterrorist groups), Overconfidence, Workaholic.

Skills: Aquaculture, Ecology, Engineer (Nanotechnology, Materials Fabrication), Geology, Hydrology, Oceanography. Administration and Research may be useful.

Biotech: Ecoengineers looking for field work and exposure consider survival-related biomods a prerequisite on their resumes. Myelin replacement nanovirus (p. 118), brain boosters (p. TS165), permanent respirocytes (p. TS165), and liver upgrades (p. TS162) are very popular.

Ecoterrorist

"It's unfortunate when civilians get caught in our operations, and I won't even try to scan an excuse past you. I don't sleep well at night, friend. I've done some terrible, shameful things and the only thing that keeps me going is that there is a light at the end of the tunnel when mankind's war against nature will end. I remember what I've seen in the labs that the transnats hide from the light of scrutiny, creations so sickening we don't even use them for our memetic campaigns. Their crimes are against life itself."

You're fighting mad over the development and exploitation of the world's oceans. Maybe you've become disillusioned with memetic campaigns or political action, or you've become infected by a toxic meme spread by fringe Decelerationist groups (p. DB26) or radical Preservationists. Whatever the case, you're now willing to use violence to bring about change, whether you're a pacifist who refuses to harm anything living and will settle for destroying aquatic cyberswarms or a hardcore radical who can justify even the most bloodthirsty actions as being for the greater good. When Blue Shadow contacts you about a plan to blow an OTEC facility near Franklin City, or your Irukandji cell members happily kill "freakish" uplifted cetaceans, what will you do? There's no going back; the corporations and governments you've crossed in the past have your number – and even if you're dead they can make you talk . . .

Advantages: Ally Group, Combat Reflexes, Contacts, Independent Income, Patron, Strong Will, Zeroed.

Disadvantages: Enemy, Fanaticism, Paranoia, Reputation, Secret.

Skills: Guns, Scuba, Tactics, Teaching, Underwater Demolition. Memetics and Politics are important for those working on public relations and propaganda.

Biotech: Combat-related biomods tend to attract unwanted attention in many areas and are avoided by all but a minority. However, a boosted heart (p. TS161) and retinal enhancement (p. TS162) are still handy in a fight and do not arouse suspicion with authorities.

Marine Scientist

"It's a race against time to study the remaining natural ocean life before it's all swallowed up by genemod species or edited into the latest source for exotic biochemicals. It's a thankless job, it's not as sexy as giving a fish a tiger tail or whatever the latest craze demands and you won't be making money by selling data on carp mating habits. But we're the ones on the front lines, banking Nature as "progress" turns the Earth's oceans into a giant stage-managed theme park."

The study of Earth's oceans is more important than ever. With millions now living in giant arcologies or underwater habitats, knowledge of the sea isn't just an academic luxury. Depending on your interests, you may study the remaining natural species before they are all displaced, try to solve the problems of global warming and climate change, or work on a new generation of food fish. There are plenty of opportunities to be found; from mining companies hoping to find a new source of exploitable wealth to rich Preservationist patrons privately funding genebanking, the money is there. If you are political, the fringe Preservationists are always looking for skilled biochemists, and you hear the Green Duncanites are having some interesting problems with their Europan parahumans. Better hurry; your colleagues are looking at the same jobs and you don't want to be stuck as botboss to some analysis AIs in a stuffy lab.

Advantages: Ally Group (Programmable), Contacts, Reputation, Tenure.

Disadvantages: Loner, Odious Personal Habits, Overconfidence, Workaholic.

Skills: Aquaculture, Biochemistry, Ecology, Electronics Operation (Medical), Genetics (Genetic Engineering), Hydrology, Oceanography, Zoology. Administration, Politics, and Scuba will be useful in many situations.

Biotech: As for the Ecoengineer (p. 91), but with more emphasis on modifications useful for laboratory work. Those that can afford it purchase a brain booster (p. TS165) and regular treatments of mnemotropics often continue after their initial education.

Meteorologist

"The media call this the age of "heavy weather," but they don't know the half of it. More people live in storm zones than ever before – on the shores and in floating arcologies. One good hurricane and you'll have a humanitarian crisis of epic proportions. My human colleagues assist environmental management AIs such as myself in making sure the storms stay within tolerable safety limits. But even with massively parallel quantum computers we still work with uncertainty and primitive weather control technology. And there's no worldwide organization to answer to. We try to cooperate with other nations, but no one wants a hurricane formed in their backyard just because it will mean less severe storms next year."

You work with technology that was science fiction just a decade ago, and you still have trouble preventing or predicting the next hurricane. You have tools that let you mitigate or even control the movement of weather systems, but without international cooperation it's a chaotic game of tug of war. Even so, lives are on the line and your early warning or strategic use of orbital lasers to heat just the right air mass may mean you prevent hundreds of deaths and billions of dollars in property damage. When you're wrong, people die. Now you see why most "weather masters" are AIs.

Advantages: Alertness, Intuition, Mathematical Ability, Visualization.

Disadvantages: Attentive, Obsession, Workaholic.

Skills: Computer Operation, Ecology, Hydrology, Mathematics, Meteorology, Physics, Research.

Biotech: None. Most meteorologists are artificial intelligences.

Navy Officer

"Space may be a frontier, but it's not the only one, and certainly not the final one. The oceans of Earth are teeming with over a hundred million people, and more wealth travels over the seas than through space. Our nation still needs to show the flag around the world and keep the peace, not to mention making sure the arcologies and floating cities sitting off territorial waters don't abuse our hospitality. You can't do that sitting in orbit."

You may have less freedom of action than a captain of an SDV out in the Deep Beyond, and your admiral may be fond of micromanaging your every move, but you'll get more real-world operational experience and the opportunity to lead, rather than simply manage, those under your command. The naval forces of the world may be but a shadow of their former selves in terms of numbers of ships, but you know more than anyone how deceptive that is. You've devoured the textbooks and run the Pacific War simulations from both sides – and won. When the next war comes you won't be sitting in a space coffin two months away from any fighting; you'll be right at ground zero making a difference.

Advantages: Fit, Military Rank 3+, Patron, Security Clearance.

Disadvantages: Bloodlust, Code of Honor, Duty, Fanaticism, Intolerance, Overconfidence, Secret.

Skills: Administration, Electronics Operation (Sensors), Guns, Leadership, Savoir-Faire (Military), Shiphandling, Tactics.

Biotech: Combat biomods are unusual as they are rarely useful in command positions. Many officers invest in brain boosters (p. TS165), finding them much more of an asset in their professional and academic advancement than a bio-booster.

Salvage Operator

"I made my fortune off the bounty of the sea, son. More specifically, the bounty that man has left in the sea. Ha! I've recovered radiologically clean steel from World War II submarines, and cleaned up hulks for both the TSA and PLAN after the Pacific War. My biggest job? Two years ago I pirated a few artifacts from the ***Bismarck*** *for sale on the antiquities black market. Yeah, that was me. Made a tiny fortune once I dodged the assassins the trustees sent! I've seen a lot of interesting things, but I can't say I'm sad to retire. I won't miss being haunted by the bones of the dead or constantly being on alert for an ambush or double-cross by crews even greedier and rougher than me."*

You're a combination grave robber and garbage man – combing the oceans for hulks that are worth the effort of recovering for recyclable materials or artifacts. Most specialize in a specific type of work, such as recovering radioactive waste for sale to governments and ecological institutions that pay top dollar for removing it from the environment, or "liberating" artifacts from historical sites protected by trustees and corporations. The best salvagers get contract work recovering sunken ships and dismantling old mining facilities. The mediocre make do with occasional finds of archaeological significance and the bulk sale of cheap metals.

Advantages: Ally Group, Strong Will.

Disadvantages: Enemy, Greed, Paranoia, Reputation (Antiquities thief), Workaholic.

Skills: Exoskeleton, History, Law, Merchant, Powerboat, Research, Sailor, Scrounging, Scuba, Seamanship.

Biotech: Anything goes. Even legitimate salvors often have an implant or three that stretches legality in at least one nation.

Settler

"Our homesteader group was pretty lucky; we managed to latch on to one of those old cruise ships that were sold off when the arcos and freedom ships got hot. What did we pay? Ha! We just walked in and sailed it out of the port before it could be broken up for scrap. Well, sailed is the wrong word – we bought some tugs and towed it out. Illegal as hell, but we made sure that it would have cost the company more to get it back than to just let us go. Now we're like Robinson Crusoe with robots."

You've had enough of the landlubber life, for whatever reason. You might disagree with every government on the planet and want to get away from external control. Maybe you want to escape the bustle of Fifth Wave life and return to where it all began, or perhaps your job came with a relocation package to a corporate island in the North Pacific. Either way, you have some tough challenges ahead, from raising enough to eat, to dealing with those pesky military commanders who insist your legal settlement is anything but. You'll need to defend yourself from the sharks, and the people who act like them, either through political action and leadership, or force of arms.

Advantages: Ally Group, Charisma, Claim to Hospitality (Atlantean Society), Strong Will.

Disadvantages: Enemy, Intolerance, Laziness, Reputation (bad PNC).

Skills: Aquaculture, Guns, Law, Leadership, Mechanic, Powerboat, Scrounging, Scuba. Drifters can use Navigation and Shiphandling.

Biotech: The only truly common piece of bioware is the liver upgrade (p. TS162). Aquatic parahuman modifications are increasingly popular for settler children.

Special Forces

"You get cynical working in special ops these days. Appeals to nationalism and some inherent superiority are hard to swallow when most of your teammates are either bred or built for the job and your operations end up being strictly for the benefit of whatever transnat is the flavor-of-the-week with the politicians. That's why I work for EDI – you're still a puppet but at least the pay is good and you know the score."

Defining what constitutes an "elite" in 2100 is harder than ever – augmented reality training, AI assistance, and smaller military forces have resulted in even line infantry units handling missions and roles that were once the exclusive domain of special operations forces. Naval special-forces units of Fourth and Fifth Wave nations handle the niche missions (such as the U.S. Navy SEAL detachments on Mars and Titan) or in jobs that require very close operational control and mission. Most special operations units are composed largely of bioroids or infomorphs – even the European Union has a significant number of citizen bioroids and AIs in their units – as the retention rate for parahuman and human personnel is astoundingly low.

Advantages: Alertness, Combat Reflexes, Military Rank, Security Clearance, Strong Will, Very Fit.

Disadvantages: Bloodlust, Extremely Hazardous Duty, Fanaticism, Sense of Duty.

Skills: Battlesuit, Guns, Gunnery, Savoir-Faire (Military), Tactics.

Biotech: Bio-boosters (p. TS161), no-shock glands (p. TS162), and neural augmentation (p. BIO73) are common even for forces that are otherwise Third Wave. Bioroids built for the special forces often possess cutting-edge modifications such as perflubron blood (p. 118).

Nonhuman Characters

Parahuman and Bioroid Templates

The ocean provides a strong stimulus for the development of parahuman species adapted to its various environments. Parahuman germlines begin as bioroid models, many of which are still in developmental phases. Some specialized applications require bioroids not even remotely based on humans.

Arctic Aquamorph — *71 points*

Attribute Modifiers: ST +1 [10]; HT +2 [20].
Advantages: Amphibious [10]; Disease-Resistant [5]; Nictating Membrane 1 [10]; Oxygen Storage [14]; Pressure Support 1 [5]; Temperature Tolerance 2 (Comfort zone between 1°F and 80°F) [2].
Disadvantages: Overweight [-5].
Features: Very thick mottled or black skin; webbed fingers and toes.
Date: 2078. ***Cost:*** $176,000.

This is a cold-adapted version of GenTech Pacifica's popular Aquamorph line (p. TS116) that is widely used in both hemispheres – the company is considering a variant adapted for Mars but so far demand is small. Arctic aquamorphs are distinguished from their temperate cousins by their huskier build and relatively short limbs; their bulk out of the water is seen as a minor hindrance but not a design flaw. Their ability to maintain a high body temperature works almost too well – they are very uncomfortable in any environment above 60°F and can suffer heatstroke above 80°F.

Snow Viper: This GenTech bioroid is more animalistic in appearance, with a squat body and a feral grace. They have a more efficient method of regulating their body heat at high temperatures and do not suffer ill effects like the arctic aquamorphs. Increase Temperature Tolerance to 3 (Comfort zone between 1°F and 96°F), and add Bioroid Body [0], Combat Reflexes [15], Hyper-Reflexes [15], Overconfidence [-10], Short Arms [-10], and Ugly [-10]. *72 points* ($216,000; 2097).

Gillmorph — *375 points*

Attribute Modifiers: ST +30 (ST above 20 is Natural, -40%) [149], DX +1 [10]; IQ -1 [-10]; HT +3 [30].
Advantages: 360-Degree Vision [25]; Acute Hearing +2 [4]; Alertness +2 [10]; Bioroid Body [0]; DR 1 [3]; Enhanced Move (Swimming) 1 [10]; Extra Arms 6 (No Physical Attack; Bad Grip, -10%) [27]; Extra Encumbrance [5]; Extra Hit Points +8 [40]; Immunity to Disease [10]; Independently Focusable Eyes 5 [75]; Injury Tolerance (No Neck) [5]; Nictating Membrane 1 [10]; Oxygen Storage [14]; Pressure Support 2 [10]; Sharp Teeth [5]; Sonar Vision (Nearsighted, -25%; Underwater only, -30%) [12]; Temperature Tolerance 1 [1]; Ultrasonic Speech [25].
Disadvantages: Aquatic [-40]; Inconvenient Size [-10]; Legless [-35]; Stuttering [-10].
Date: 2098. ***Cost:*** $1,750,000.

The gillmorph is a Biotech Euphrates bioroid based on work done by Atlantec and Duncanite contractors for a failed "paracetacean" project in the 2050s. Slightly smaller and sleeker than orcas, but with similar coloration and outline, gillmorphs differ from killer whales in a number of ways. Most noticeably, their ventral side has six flexible tentacles and two human-like arms. The arms can be stored behind muscular flaps and the tentacles contract by up to 30% when not being used. They have four pairs of eyes spaced around their anterior end, although in practice only one pair is used at a time; heavy lids shutter unused eyes. Gillmorphs average 15 feet in length and over a ton in mass.

Gillmorph Bioshell: Gillmorphs are frequently used as bioshells. Add Bioshell Template [41] and remove the IQ penalty and Alertness. Note that Immunity to Disease only adds 7 points to the limited form present in Bioshell Template, reducing the total cost by 3 points. *413 points* (2098; $1,785,000).

Nemo — *89 points*

Attribute Modifiers: ST +1 [10]; HT +2 [20].
Advantages: Amphibious [10]; Bioroid Body [0]; Disease-Resistant [5]; Enhanced Move (Swimming) 1/2 [5]; Extra Fatigue +1 [3]; Immunity to Poison (Only gas narcosis, -75%) [4]; Nictating Membrane 1 [10]; Oxygen Storage [14]; Pressure Support 1 [5]; Resistant to Poison (Dissolved gases, -75%) [2]; Temperature Tolerance 1 (Comfort zone between 33°F and 100°F) [1].
Features: Smooth mottled gray or black skin; webbed fingers and toes; unaffected by SAD.
Date: 2082. ***Cost:*** $135,000.

The Nemo bioroid is an advanced form of Aquamorph (p. TS116). Perflubron fluid is used instead of blood and radical nerve tissue re-engineering has altered cerebral myelin, granting resistance to the bends and nitrogen narcosis. Nemos can hold their breaths for periods similar to a dolphin (see *Oxygen Storage*, p. 103), or use nitrox breathing gear for operations as deep as 600 feet with no ill effects or need for decompression. GenTech Pacifica's Bioroid Project is investing heavily in turning the Nemo adaptations into a parahuman germline.

Purushagor *50 points*

Advantages: Amphibious [10]; Enhanced Move (Swimming) 2 [20]; Immunity to Disease [10]; Nictating Membrane 1 [10]; Night Vision [10]; Oxygen Storage [14]; Pressure Support 2 [10]; Temperature Tolerance 1 [1].

Disadvantages: Legless [-35].

Features: Taboo Traits (Genetic Defects); unaffected by SAD.

Date: 2087. ***Cost:*** $176,000.

Bhuiyan Genetics' Purushagor is a radical parahuman design that replaces the legs with a fishlike lower body and tail. Purushagor are virtually unknown outside the TSA, but are common in Bangladeshi aquatic habitats, and some have found their way into settlements off Burma and in the South China Sea. They do not require any special environmental controls on the surface, but will be uncomfortable in cold environments and require some sort of exoskeleton to be fully mobile – their tail is strong enough to stand up on, but they can only move by hopping, or crawling like a seal.

Seawolf Series Bioroid *112 points*

Attribute Modifiers: ST +1 [10]; DX +2 [20]; HT +1 [10].

Advantages: Acute Taste and Smell +2 [4]; Acute Vision +1 [2]; Amphibious [10]; Bioroid Body [0]; Combat Reflexes [15]; Disease-Resistant [5]; Enhanced Move (Swimming) 1/2 [5]; Fit [5]; Night Vision [10]; Oxygen Storage [14]; Pressure Support 2 [10]; Temperature Tolerance 2 (Comfort zone between 1°F and 78°F) [2]; Versatile [5].

Disadvantages: Unattractive [-5]; Unnatural Feature (Few facial features) [-5]; Workaholic [-5].

Features: Rubbery black skin with very light fur; webbed fingers; unaffected by SAD.

Date: 2085. ***Cost:*** $200,000.

The basic Aquamorph design (p. TS116) has its origin in GenTech Pacifica military bioroids used by the U.S. and Chinese navies in the 2070s. The company has remained on the cutting edge of the field, using its experience first to develop the Aquamorph, and then a new generation of aquatic combat bioroids for the U.S. Navy. The Seawolf shares many basic features with the Aquamorph and Sea Shepherd, differing mainly in appearance; the Seawolf has only a vestigial nose, small pointed ears, and very fine fur.

CYBERSHELLS AND BIOSHELLS

As Jacques Cousteau used to say, the ideal means of deep-sea transport would allow us to move "like an angel." Our minds can now go it alone, leaving the body behind. What could be more angelic than that?

– Robert D. Ballard, ***The Eternal Darkness***

Amphibious RATS *820 points*

Attribute Modifiers: ST +2 [20]; DX +1 [10]; HT +2 [20].

Advantages: 3D Spatial Sense [10]; Absolute Direction (Uses GPS, -20%) [4]; Acute Hearing +3 [6]; Amphibious [10]; Chameleon 2 [14]; Doesn't Breathe [20]; DR 60 (Laminate, +33%) [240]; Enhanced Move (Swimming) 3 [30]; Extra Hit Points +5 [25]; Extra Legs (4 legs) [5]; Full Coordination 1 [50]; Infravision [15]; Machine Body [37]; Nictating Membrane 1 [10]; PD 4 [100]; Polarized Eyes [5]; Pressure Support 2 [10]; Radar Sense (Low-res ladar; 6 miles) [56]; Radio Speech (Laser and radio, +40%) [35]; Silence 2 [10]; Sonar Vision (Enhanced, +20%; Underwater only, -30%) [23]; Weaponry (Recoilless Rifle and Assault Pod, LC 0 + LC 1) [110].

Disadvantages: Dependency (Maintenance; occasional, weekly) [-20]; Mistaken Identity [-5]; No Sense of Smell/Taste [-5]; Short Arms [-10]; Social Stigma (Barbarian) [-15].

Features: Complexity 6-8 compact microframe computer.

Date: 2090. ***Cost:*** $525,000 + computer.

The Darwin-Sogo Type 91 *Samebito* ("shark-man") is a robotic armored tactical system (RATS, p. TS124). It is widely used by several Fifth Wave navies for amphibious operations. The design is a sleek shark shape in the water, with the two rear legs locking together and extending smart fins to act as a fluke while the arms and legs retract flush with the body. They are capable of underwater combat operations but are no match for dedicated combat platforms; they rely on stealth to approach their target – often crawling slowly along the bottom. 310 lbs., 8' long.

Baikal Cryobot *464 points*

Attribute Modifiers: ST +4 [45]; HT +3 [30].
Advantages: 360-Degree Vision (Eyestalks, -20%) [20]; DR 30 [90]; Enhanced Move (Swimming) 1 [10]; Extra Flexibility [10]; Extra Hit Points +5 [25]; Machine Body [37]; Microscopic Vision 10 [40]; Move Through Ice (Tunnel left behind, 40%; Takes extra time, 256 times as long, -80%) [6]; PD 4 [100]; Radiation Tolerance 1,000 [41]; Radio Speech (Laser, +40%; No radio, -40%) [25]; Sonar Vision (Replaces normal vision) [0]; Vacuum Support [40].
Disadvantages: Aquatic [-40]; Mistaken Identity [-5]; Social Stigma (Valuable Property) [-10].
Features: Complexity 6-8 microframe computer.
Date: 2050. ***Cost:*** $350,000 + computer.

Vosper-Babbage's *Baikal* is a typical first-generation cryobot, designed to penetrate and study thick ice sheets and explore the waters below. It resembles a larger version of the mushroom-shaped *Vostok* cryobot (p. TS122). The hemispherical head is four feet wide, and houses hydrojet thrusters and the radiothermal unit that melts the ice. The central cylindrical post is four feet long and two feet wide, ending in a hemispherical "braincase" housing the AI and other electronics. The *Baikal* is a more rugged design than the later *Vostok*, and does not require constant maintenance.

The *Baikal* has three evenly spaced arms, but only two end in manipulators. The third is a sensory appendage capable of scanning all around the cybershell. It cannot support its full weight on these arms – once in the water, it is only capable of swimming with its hydrojets.

Early Europan explorers would set up a *Baikal* on the surface, tethered to a transmitter station with a commline (p. 120). The cryobot unspooled the line as it melted through the ice; as the ice froze behind it, the cable was held fast. Once below the ice shell (after 12 days of tunneling), the *Baikal* would detach from the commline and go exploring. It would return to the cable periodically and send the data it had gathered to scientists via the transmitter on the surface. Some old *Baikal* cable sites are still used by *Vostoks* and other vehicles in 2100. CRABE used several *Baikals* before the design was retired from production in 2080, and still has five operational units. 2,500 lbs., 7' tall.

Calamarine *281 points*

Attribute Modifiers: ST +5 [60]; DX +3 [30]; HT +2 [20].
Advantages: Bioshell Template (Animal) [51]; Chameleon +2 [14]; Constriction Attack [15]; DR 2 [6]; Enhanced Move (Swimming) 1/2 [5]; Extra Arms (8 extra arms, 2 with reach 2) [100]; Extra Flexibility [10]; Extra Hit Points +3 [15]; Gills [0]; Night Vision [10]; Peripheral Vision [15]; Pressure Support 1 [5]; Sharp Teeth [5]; Smoke (Ink; Only in water, -30%) [11], Super Swimming 2 (Limited endurance; 2 seconds, -20%: Takes recharge; 5 seconds, -10%) [14].
Disadvantages: Aquatic [-40], Bad Grip [-10]; Cold-Blooded [-5]; Inconvenient Size [-10]; Invertebrate [-20]; No Depth Perception [-10], Social Stigma (Valuable Property) [-10].
Features: Complexity 6-8 microframe computer.
Date: 2092. ***Cost:*** $120,000 + computer.

GenTech Pacifica's *Dosidicus demelloii*, commonly known as a calamarine, is a bioshell based on a Humboldt squid. A calamarine's computer usually runs a dedicated NAI to handle the complex control of the squid's propulsion, chameleon, and tentacle systems at the direction of the controlling infomorph. GenTech uses most calamarines in construction, mining, and aquaculture operations. The U.S. and Australian navies each operate a small calamarine squad, using them as maintenance and patrol shells – if necessary they can hold torpedo launchers. The ANS has begun replacing its calamarine control infomorphs with the ghosts of Octosap IIs, which can control all of the systems instinctively without requiring a NAI assistant. Irukandji has recently acquired a few calamarines through unknown means and used them to attack Agua Negra's ocean floor mining operations near the Antarctic Peninsula. 230 lbs., 12' long.

Cyberdolphin — *186 points*

Attribute Modifiers: ST +5 [60]; HT +2 [20].
Advantages: 3D Spatial Sense [10]; Doesn't Breathe [20]; DR 5 [15]; Enhanced Move (Swimming; Nuisance Effect: Cannot use arms, -10%) 2 [18]; Extra Hit Points +1 [5]; Flesh Pockets (2 lbs.; robotic, -60%) [2]; Machine Body [37]; Modified Arm DX (Both arms) +2 [16]; PD 1 [25]; Radio Speech [25]; Sonar Vision (Underwater only, -30%) [18]; Ultrasonic Speech [25].
Disadvantages: Aquatic [-40], Bad Sight [-10]; Dependency (Maintenance; common, monthly) [-5]; Disturbing Voice [-10]; Limited Endurance (5 hours) [-10]; Mistaken Identity [-5]; Modified Arm ST (Both arms) -5 [-20]; Social Stigma (Valuable Property) [-10].
Features: Complexity 5-7 small computer or Complexity 6-8 microframe computer.
Date: 2070. ***Cost:*** $98,000 + computer.

The Sagawa-Llinás cyberdolphin is a common marine cybershell used worldwide for a variety of roles. It resembles a small dolphin from a distance, but is obviously artificial up close, even with its biomorphic coating. It is natural enough that wildlife is not spooked by its presence and it is in danger of attack by some large predators. Two retractable manipulator arms extend for detailed work and a small cargo compartment can hold tools or personal effects. Sagawa-Llinás markets several variants of the design, including one for use on Mars. It is not rated to dive below six atmospheres and has a crush pressure (see p. 51) of 12 atm. 200 lbs., 6' long.

Idmon Explorer Aquabot — *149 points*

Attribute Modifiers: ST -6 [-50], HT +1 [10].
Advantages: DR 10 [30]; Enhanced Move (Swimming) 2 [20]; Machine Body [37]; Microscopic Vision 10 [40]; PD 2 [50]; Radiation Tolerance 10 [14]; Radio Speech (Laser, +40%; No radio, -40%) [25]; Sonar Vision [25]; Telescopic Vision 3 [18]; Vacuum Support [40].
Disadvantages: Aquatic [-40]; Dependency (Maintenance; common, monthly) [-5]; Mistaken Identity [-5]; No Manipulators [-50], Social Stigma (Valuable Property) [-10].
Features: Complexity 5-7 small computer.
Date: 2055. ***Cost:*** $80,000 + computer.

The *Idmon* Explorer is produced by Elwyncorp, a small company based in Southampton, England. It is a simple design – essentially a camera with fins and a propulsion system that can be sent to observe and explore the ocean depths and report back. It is commonly used for submarine exploration on Earth, Mars, and Europa.

An *Idmon* is teardrop-shaped, three feet long and one foot wide, with a transparent hemisphere containing forward-facing visual sensors at the wider end. Chemical sensors are on the body behind the hemisphere. The thinner rear is truncated near the tip, ending in a hydrojet housing, surrounded by four stabilizer fins and rudders. 180 lbs., 3' long.

ROV Option: Although the *Idmon* can be controlled by an infomorph as a cybershell, it is often adapted for use as a Remotely Operated Vehicle (ROV), controlled via a tether from a manned submersible or a surface ship. Simply add a commline (p. 120).

Spionfisch — *-16 points*

Attribute Modifiers: HT +2 [20].
Advantages: Bioshell Template (Animal) [51]; DR 1 [3]; Enhanced Move (Swimming) 1 [10]; Gills [0]; Pressure Support 1 [5].
Disadvantages: Aquatic [-40]; Cold-Blooded [-5]; No Depth Perception [-10], No Manipulators [-50].
Features: Complexity 5-7 small compact computer.
Date: 2086. ***Cost:*** $17,000 + computer.

Fish are ubiquitous in the seas. Few people will pay attention to one extra. Neumann Lebentechnologie AG designed the Spionfisch to take advantage of this as an inconspicuous surveillance bioshell. Spionfische are based on several species, ranging from two-foot bonito to 10-foot tuna. Smaller fish are less conspicuous, but sometimes get eaten by predators. Spionfische normally house NAIs or LAIs – few sapients enjoy controlling a prey animal. Ordered to observe and record underwater activities, they can be extremely effective. People familiar with fish biology may notice the atypical behavior of a Spionfisch carrying out surveillance (roll vs. Zoology). The template represents a five-foot-long Spionfisch.

Bonito: For a small Spionfisch, add: ST -6 [-50]; Reduced Hit Points -6 [-30]. *-96 points* (2086; $35,000).

Tuna: For a large Spionfisch, add: ST +8 (No Manipulators, -40%) [54]; Extra Hit Points +8 [40]; and an additional level of Enhanced Move (Swimming) [10]. *88 points* (2087; $45,000).

Warshark — *207 points*

Attribute Modifiers: ST +16 (No Fine Manipulators, -40%) [93]; DX +3 [30]; HT +2 [20].

Advantages: Bioshell Template (Animal) [51]; Enhanced Move (Swimming) 1 [10]; Extra Hit Points +15 [75]; Faz Sense (In water, not air, +0%) [10]; Field Sense (No Absolute Direction, -50%) [5]; Independently Focusable Eyes [15]; Injury Tolerance (No Neck) [5]; Night Vision [10]; Peripheral Vision [15]; Pressure Support 2 [10]; Scales [3]; Sharp Teeth [5]; Subsonic Hearing [5]; Ultrasonic Speech [25].

Disadvantages: Aquatic [-40]; Cold-blooded [-5]; Inconvenient Size [-10]; Increased Life Support 2 [-20]; No Manipulators [-50]; Short Lifespan 4 [-40]; Social Stigma (Barbarian) [-15].

Features: Complexity 5-7 small computer or Complexity 6-8 microframe computer; small sonarcomm; short-range radio.

Date: 2082. ***Cost:*** $65,000 + computer.

"Communing with whales." Who'd have thought that there'd be so many hippies still around? "Enhanced cetacean troops." And in the Navy, too, pouring all this money into some parvenu group of squeaky mammals. How can you explore the ocean when you have to come up to breathe as soon as you've found something interesting? Can't they see that the ancient, bloody, primeval king of the ocean, the shark, is the perfect vehicle? It found the ideal form 300 million years ago; it breathes the sea; it **is** *the sea. How I wish . . .*

– Dr Eddy Bryant,
later Head of Warshark Development,
TSA Bioweapons Directorate;
private journals, 2074

TSA bioweapons researchers appreciate the utility of enhanced marine animals in aquatic warfare, but don't understand western sentimentality toward mammals in general and cetaceans in particular. Air-breathers must surface regularly to breathe, at intervals that can be tactically inconvenient, limiting their operating depths. Also, uplifting dolphins to a level of sapience useful for war-dops is difficult, time-consuming, and expensive. Far faster development cycles can be achieved using marine animals as bioshells; in particular, the shark, a fast-maturing apex predator with impressive natural armament and fully adapted to the undersea environment.

Although there are bioroid warshark designs in service in the TSA armed forces, bioshells are more common, the most favored being the blue and tiger in the aquatic infantry role, with smaller species being used for reconnaissance and espionage.

This template represents a blue shark bioshell, 12 feet long, with minimal cybernetic enhancements: a sonarcomm and radio for underwater and surface communication. Many feature hardpoints attached to the shark's cartilaginous skeleton for carrying minitorp launchers, supercavitating cannon, and extra sensors.

Cetapod — *683 points*

Attribute Modifiers: ST +990 (No Fine Manipulators, -40%; ST above 50 is Natural, -40%) [230]; HT +4 [45].

Advantages: Bioshell Template (Animal) [51]; DR 10 [30]; Enhanced Move (Swimming) 1 1/2 [15]; Extra Hit Points +50 [250]; Independently Focusable Eyes [15]; Injury Tolerance (No Neck) [5]; Nictating Membrane 1 [10]; Oxygen Storage [14]; PD 4 [100]; Peripheral Vision [15]; Pressure Support 2 [10]; Sharp Teeth [5]; Subsonic Speech [20]; Temperature Tolerance 1 [1].

Disadvantages: Aquatic [-40]; Bad Sight [-10]; Inconvenient Size [-10]; No Manipulators [-50]; No Sense of Smell or Taste (Can taste, -50%) [-3]; Short Lifespan 1 [-10]; Social Stigma (Valuable Property) [-10].

Features: Poor color vision. Complexity 7-8 microframe computer.

Date: 2068. ***Cost:*** $1,350,000 + computer.

Cetanists (p. 16) who wish to commune with whales use Cetapod bioshells. These are humpback whale clones, with their brains modified to be decerebrate in utero (or exowomb), before they can develop awareness. Cetapods actually predate human bioshells, since the computer to run the digital mind does not need be as small. There are only a few dozen Cetapods in existence, almost all owned by companies that rent them out. Most infomorphs only use them on a per-day basis, as the experience can be disconcerting. Even cetanists who spend most of their time in a dolphin shell usually spend only a week or two in a Cetapod as a novel vacation.

Taniwha: The Taniwha is a custom bioshell created from a killer whale. They are used by military forces and some terrorist groups. Generally, Taniwha are simply converted from an adult orca, since those who use them are not particular about destroying an animal with a prior existence. Increase HT to +5 [60] and Short Lifespan to 2 [-20]; reduce ST to +45 (No Fine Manipulators, -40%; ST above 20 is Natural, -40%), DR to 5 [15], Extra Hit Points to +10 [50], and PD to 1 [25]; add Sonar Vision (Nearsighted, -25%; underwater only, -30%) [12] and Ultrasonic Speech [25]; and remove Subsonic Speech. *271 points* (2071; $500,000 + computer).

ANIMAL TEMPLATES

Cetaceans *Varies*

Advantages: Acute Hearing +4 [8]; Alertness +4 [20]; Enhanced Move (Swimming) 1 [10]; Independently Focusable Eyes [15]; Injury Tolerance (No Neck) [5]; Nictating Membrane 1 [10]; Oxygen Storage [14]; Peripheral Vision [15]; Pressure Support 2 [10]; Sonar Vision (Nearsighted, -25%; underwater only, -30%) [12]; Temperature Tolerance 1 [1]; Ultrasonic Speech [25].

Disadvantages: Aquatic [-40]; Bestial [-10]; Distractible [-1]; Dull [-1]; Innumerate [-5]; Mute [-25]; No Manipulators [-50]; No Sense of Smell or Taste (Can taste, -50%) [-3]; Short Lifespan 2 [-20]; Social Stigma (Wild Animal) [-10].

Features: Poor color vision.

Cetaceans are highly specialized marine mammals ranging in size from three-foot long Hector's dolphins to massive blue whales that can stretch over 100 feet. Most are gregarious creatures with well-developed social systems, but their intelligence is often overstated – at least as measured by humans. All have streamlined bodies, tails with horizontal fins called flukes, flippers (actually modified forelimbs), and a nostril on the top of the body forming a blowhole. Many have a dorsal fin, which aids stability. The two major suborders of cetaceans are the *Odontoceti* (toothed whales) and *Mysticeti* (baleen whales). The template above applies primarily to toothed whales.

Bottlenose Dolphin (Tursiops truncatus): These dolphins are found worldwide in temperate and tropical waters. They range from eight to 15 feet in length and weigh between 450 and 1,000 lbs. Coastal bottlenose dolphins tend to be smaller; those native to offshore habitats are on the larger end of the scale. Males are slightly longer and substantially heavier than females. Most dolphins are gray-green or gray-brown in color, darker on the back fading to a pale belly.

To the basic cetacean template add: ST +6 (No Fine Manipulators, -40%) [42]; DX +3 [30]; IQ -4 [-30]; HT +1 [10]; Extra Hit Points +5 [25]; and Chummy [-5]. *52 points*.

Augmented Dolphin: These are bottlenose dolphins with an implanted VI and translator NAI (see *Cetacean Uplift*, p. 100). Physically they are no different to unaugmented dolphins, but the opportunity to interact with humans and learn abstract concepts noticeably enhances their intelligence.

To the basic cetacean template add: ST +6 (No Fine Manipulators, -40%) [42]; DX +3 [30]; IQ -3 [-20]; HT +1 [10]; Extra Hit Points +5 [25]; and Chummy [-5]; and replace Mute with Mute (Mitigated by computer interpreter, -60%) [-10]. *82 points*.

Harbor Porpoise (Phocoena phocoena): These common porpoises live in cold coastal habitats throughout the northern hemisphere. Although often confused with dolphins, they tend to be smaller – averaging four feet long and weighing from 90 to 150 lbs. Females are slightly larger than males. These porpoises are stouter than dolphins, lack a pronounced snout, feature small, triangular dorsal fins, and have differently shaped teeth, but their main differences are in social behavior. They are dark blue or gray on the back with a white underbelly; albinos have become more common since the 20th century.

To the basic cetacean template add: ST +3 (No Fine Manipulators, -40%) [18]; DX +1 [10]; IQ -4 [-30]; HT +1 [10]; and Extra Hit Points +2 [10]. Also add three *additional* levels of Short Lifespan [-30]. *-32 points*.

Orca (Orcinus orca): Also known as "killer whales," orcas are the largest members of the dolphin family (*Delphinidae*) and are found all over the world, although they tend to stay in colder waters such as the Arctic. They have been observed in fresh-water rivers at times. Orca females are smaller than males, averaging 18 feet in length and weighing from one to four tons, compared to 20 feet and four to six tons for males. Orcas are distinctively colored: black on their backs and white on their stomachs, with a white swath behind the dorsal fin. The fin can be up to six feet high in males and is as distinctive as a fingerprint; about one in four orcas have bent or curved fins. A white "eyespot" is located just above and behind the real eye.

To the template above add: ST +45 (No Fine Manipulators, -40%; ST above 20 is Natural, -40%) [86]; DX +2 [20]; IQ –4 [-30]; HT +5 [60]; Congenial [-1]; DR 1 [3]; Extra Hit Points +10 [50]; Inconvenient Size [-10]; and Sharp Teeth [5]. Add a half-level to Enhanced Move (Swimming) [5]. *168 points*.

Humpback Whale (Megaptera novaeangliae): Humpback whales are a member of the rorqual family that includes blue and minke whales, within the *Mysticeti*. They feed by filtering krill, small fish, and other organisms out of the water through baleen plates. Humpbacks average 40 feet in length when fully grown and weigh between 25 and 40 tons. Males are slightly smaller than females. Individuals can be identified by unique patterns on their dorsal fins and flukes. Humpbacks are not particularly sleek creatures, with a rounded body that narrows toward the tail, whose flukes can be up to 18 feet wide. The flippers are very long, averaging 25% of body length. Coloration is typically black on the dorsal side and a mottled black and white on the ventral.

Modify the cetacean template by removing Sonar Vision and Ultrasonic Speech and reducing Short Lifespan to one level. Add: ST +990 (No Fine Manipulators, -40%; ST above 50 is Natural, -40%) [230]; IQ –4 [-30]; HT +4 [45]; Congenial [-1]; DR 10 [30]; Extra Hit Points +50 [250]; Inconvenient Size [-10]; Passive Defense 4 [100]; and Subsonic Speech [20]. *587 points*.

Dolphin Sapience and Psychology

Wild dolphins are creatures with a degree of self-awareness – they have thought processes at a similar level of sophistication to a four-year-old human child or an adult chimpanzee. Even in 2100 there is a wide range of opinions about how smart dolphins actually are. The only thing anyone knows for certain is that they are quite clever and always a source of both surprise and disappointment. If they possess some special insight into the nature of the universe or are in touch with nature at a mystic level, they certainly are not letting anyone know about it.

According to the Adjusted Sapience Index Test (p. TS91), dolphins qualify as "borderline-sapient." This is a simplification, of course, and largely measures how close a creature is to human levels of intelligence rather than an abstract statement about how "smart" they are.

Although as aware as a human child in general terms, dolphins have a unique psychology that makes interacting with them difficult. They have an alien intelligence well adapted to a completely different environment. They are non-materialistic – they enjoy playing with "toys" such as bits of flotsam, but abandon them easily. Some dolphins will steal toys from others, but not out of desiring wealth or possessions. They will usually accede to simple orders, but do not respond to threats or violence; if threatened they simply cower. Dolphins have no concept of freedom – captives never attempt escape and freely return if released. Strange or new things frighten them, and they are reluctant to explore unfamiliar terrain. They are highly susceptible to claustrophobia and require constant social stimulation to remain healthy. They have little concept of empathy outside of their species – dolphins will torture other animals (even porpoises and seals) to death in their play – but this is not done out of bloodlust or a desire for murder. Male dolphins occasionally force intercourse with unwilling females. Dolphins are also notoriously lecherous.

Many humans tend to ignore the darker side of dolphin psychology in their dealings – possibly because these aspects are unsettlingly familiar or they have difficulty not anthropomorphizing these actions and moralizing. Unfortunately, dolphins are not harmless, smiling friends of humanity who simply lack the ability to tell us all of their wonderful secrets of living in harmony and peace. They are wild animals, and when under stress can and *do* attack humans. Even trained dolphins can be unpredictable and violent, ramming humans, raking them with their teeth, or pulling them underwater.

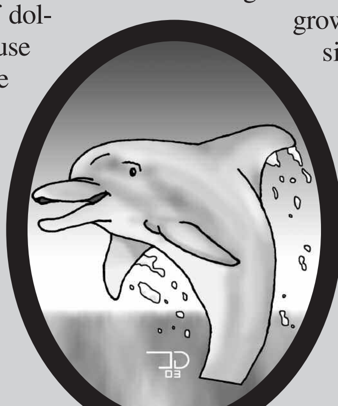
Cetacean Uplift

It is possible to implant a VI and "nanny/translator" NAI into an otherwise unmodified dolphin, allowing it to communicate and interact with humans. This technology is in its infancy and subject to extensive debate – there is still much to know about how baseline dolphins perceive and organize their world. It has proven to be extremely useful in training and interacting, and augmented dolphins have shown an amazing capacity for adaptation and improvisation with these tools, especially those implanted when very young. This technique is not as controversial as uplifting dolphins to full sapience but is also not as remarkable in effectiveness.

Applied Ocean Technology was the first company to have any success using gengineering techniques to produce dolphins with increased intelligence. Throughout the 2040s and '50s several corporations were applying techniques similar to those used in the development of the K-10 A Postcanine (p. TS118) to dolphins. (This was a sequence that led, through further refinements of the process applied to humans, to the Metanoia-series human upgrade, p. TS116.) Nootropic treatments and surgical procedures produced dolphins with greater cognitive capacity, but they were virtually unable to function as independent living creatures. The breakthrough came with the Doolittle germline in 2059 – a viable species of significantly enhanced dolphins.

Corporations continued their research into cetaceans, with GenTech Pacifica making fitful advances in recent years under the direction of Flynn Martin (p. 109). Applied Ocean Technology maintains the lead in dolphin uplifts however, with rumors of a new germline to supersede the successful Delphís (p. 101).

Where GenTech has been more successful is with the enhancement of larger cetaceans. The cerebral cortex of whales can be increased in thickness and complexity of folding, which boosts processing capability without the intricacy of neural modification needed in smaller brains. GenTech has produced a modified humpback whale germline with this treatment, and those grown to adulthood display intriguing signs of modified behavior and socialization, which some researchers claim represents enhanced abstract reasoning ability. So far, however, communication attempts with the boosted whales have been fruitless, so if they *are* thinking advanced thoughts, they may be so alien that humans cannot yet understand them.



Doolittle Dolphin *65 points*

Attribute Modifiers: ST +8 (No Manipulators, -40%) [54]; DX +3 [30]; IQ -2 [-15]; HT +1 [10].

Advantages: Acute Hearing +4 [8]; Alertness +2 [10]; Enhanced Move (Swimming) 1 [10]; Extra Hit Points +2 [10]; Independently Focusable Eyes [15]; Injury Tolerance (No Neck) [5]; Nictating Membrane 1 [10]; Oxygen Storage [14]; Peripheral Vision [15]; Pressure Support 2 [10]; Sonar Vision (Near-sighted, -25%; underwater only, -30%) [12]; Temperature Tolerance 1 [1]; Ultrasonic Speech [25].

Disadvantages: Aquatic [-40]; Distractible [-1]; Hidebound [-5]; Innumerate [-5]; Mute (Mitigated by computer interpreter, -60%) [-10]; No Manipulators [-50]; No Sense of Smell or Taste (Can taste, -50%) [-3]; Semi-Literacy [-5]; Short Lifespan 2 [-20]; Social Stigma (Valuable Property) [-10]; Stress Atavism (Severe, uncommon) [-10].

Date: 2059. ***Cost:*** $80,000.

The Doolittle dolphin was the first stable germline resulting from Applied Ocean Technology's cetacean uplift program (see *Cetacean Uplift*, p. 100). The Doolittle removed the need for bionic and chemical augmentation, at the expense of mental stability and alertness. Although considered a success by most, the uplift process proved far from perfect – the gross structural changes to the dolphin's brain resulted in near-human intelligence at the expense of instinct. Doolittles lack many basic behaviors of baseline dolphins and require assistance to live natural lives (they are incapable of the "half-sleep" of dolphins, for example, and cannot rest underwater or they will drown in their sleep). They do not understand dolphin speech, but their brains are capable of processing human-style conceptual strings and forming meaningful sentences with them. With a translator that can interpret the ultrasonic part of their speech they can communicate easily with humans.

Doolittles are still the most common cetacean uplift, with some 15,000 around the world. Most live and work with humans, but a few have tried to return to nature – most die or return after a few months. Although legally classed as uplifted animals they have extremely powerful and vocal lobbies working for them; it is extremely rare for Doolittles to be mistreated without consequences.

Although not included in the template, substantial minorities of Doolittles experience severe personality disorders shortly after reaching maturity. The most common symptoms are combinations of Bestial, Bully, Manic-Depressive, Low Empathy, Obdurate, Paranoia, and Slave Mentality. These often manifest after an episode of stress atavism.

Delphís: A refinement of the Doolittle dolphin germline, the Delphís (from Greek, plural Delphí) has further enhanced intelligence and fewer psychological limitations. Delphí can suffer the same personality disorders as Doolittles, but this is rare. There are 2,000 adult Delphí in existence, with a second generation still reaching maturity. To the Doolittle template: increase IQ to -1 [-10], decrease Alertness to +1 [5], remove Hidebound, Innumerate, and Semi-Literacy, and change Stress Atavism to (Moderate, rare) [-4]. *86 points* ($122,000; 2084).

UPLIFT

Science fiction author David Brin coined the term "uplift" in his 1980 novel *Sundiver* (see ***GURPS Uplift*** for the official roleplaying adaptation of this novel and its sequels). Strictly speaking, *uplift* refers to the process of modifying animal species to make them sapient, but in the ***Transhuman Space*** setting it has also become common slang usage to refer to members of uplifted species as "uplifts."

Octosap *22 points*

Attribute Modifiers: ST -1 [-10]; DX +4 [45]; IQ -5 [-40]; HT +2 [20].

Advantages: Alertness +7 [35]; Ambidexterity [10]; Chameleon +2 [14]; Constriction Attack [15]; DR 1 [3]; Enhanced Move (Swimming) 1/2 [5]; Extra Arms 6 [60]; Extra Flexibility [10]; Gills [0]; Injury Tolerance (No Neck) [5]; Peripheral Vision [15]; Pressure Support 1 [5]; Sharp Teeth [5]; Smoke (Ink; Only in water, -30%) [11].

Disadvantages: Aquatic [-40]; Bad Grip [-10]; Bad Sight [-10]; Cold-Blooded [-5]; Color Blindness [-10]; Edgy [-5]; Hidebound [-5]; Innumerate [-5]; Invertebrate [-20]; Mute (Mitigated by computer interpreter, -60%) [-10]; Reduced Hit Points -2 [-10]; Short Lifespan 4 [-40]; Social Stigma (Valuable Property) [-10]; Stress Atavism (Mild, uncommon) [-6].

Date: 2072. ***Cost:*** $21,000.

GenTech Pacifica's uplift program made a significant breakthrough with the augmentation of cephalopod intelligence, resulting in the Octosap. Based on the giant Pacific octopus, *Enteroctopus dofleini*, one could easily be mistaken for a natural animal. The changes are enhanced intelligence, the ability to operate safely at greater depths (up to 600 feet), a significantly longer lifespan, and unintended stress atavism. Octosaps rarely live past 20 years of age, and grow steadily throughout their lives. A mature 10-year old weighs 160 lbs., with an armspan of 10 feet. Octosaps are seldom found in human settlements any more – they have been superseded by the Octosap II and are discouraged from reproducing. Exogenesis' Astropus (p. TS118) is based on this germline, radically adapted to survive in zero G and require less living space.

CEPHALOPOD PSYCHOLOGY

Octopuses are naturally curious. Investigative behavior helps them learn quickly, which is useful because natural octopuses only live a handful of years at most. They explore and like to take things apart to see how they work and if the components can be used in other ways. Typically they experiment with different ways of getting a task done, using the practical approach rather than thinking things through to arrive at a solution first. They are pragmatic and will use whatever works in a given situation, whether or not a better solution might exist. For these reasons, Octosap workers make good practical mechanics and builders, but poor engineers and planners.

Octopuses are solitary creatures. This tendency remains in Octosaps – most get along with other species but become competitive and aggressively territorial with members of their own species, while some are complete Loners (p. CI91). Overlying these general habits, octopuses display individual personalities, ranging from shy to excessively tactile to destructively curious. One common trait is unpredictability. Octosaps can be diligent workers one day, easily distracted the next, and frequently engage in bizarre activities such as disassembling and reassembling items for no reason, refusing simple requests, or breaking off social contact for a few days. Humans never quite know where they stand with an Octosap companion.

Octopuses are not left- or right-armed – they use whatever arm is most convenient for a task with equal dexterity. They also use directed water jets to push and manipulate loose objects, with excellent control.

Octosap II: This is a second generation Octosap germline produced by GenTech for applications requiring greater intelligence and autonomy. The rate of growth has been slowed down considerably. The longer education times and nootropic treatments result in further enhanced intelligence. Octosap IIs can live 40 years or more. Increase the Octosap's IQ to -2 [15] and DR to 2 [6]; reduce Alertness to +4 [20] and Short Lifespan to 2 [-20]. *55 points* ($35,000; 2081).

War-Dop — 54 points

Attribute Modifiers: ST +3 (No Manipulators, -40%) [18]; DX +3 [30]; IQ -2 [-15]; HT +1 [10].

Advantages: 3D Spatial Sense [10]; Acute Hearing +4 [8]; Bioelectric Shock [10]; Enhanced Move (Swimming) 2 [20]; Extra Hit Points +2 [10]; Field Sense [10]; Independently Focusable Eyes [15]; Injury Tolerance (No Neck) [5]; Nictating Membrane 1 [10]; Oxygen Storage [14]; Peripheral Vision [15]; Pressure Support 2 [10]; Sonar Vision (Superior signal discrimination, +20%) [30]; Temperature Tolerance 1 [1]; Ultrasonic Speech [25].

Disadvantages: Aquatic [-40]; Chummy [-5]; Distractible [-1]; Dull [-1]; Mute (Mitigated by computer interpreter, -60%) [-10]; No Manipulators [-50]; No Sense of Smell or Taste (Can taste, -50%) [-3]; Short Lifespan 5 [-50]; Social Stigma (Valuable Property) [-10]; Stress Atavism (Mild, common) [-12].

Features: Complexity 4-7 tiny compact computer with puppeteer implant. Rubbery gray skin.

Date: 2055. ***Cost:*** $170,000.

The War-Dop "D-model" was one of the first successful animal intelligence upgrades; the techniques pioneered in their development led directly to the Doolittle uplifts and the U.S. Navy's Cetacean Enhancement Program (CEP). The original uplifts were heavily modified harbor porpoises who underwent extensive neurological modification and cybernetic enhancement to boost their natural intelligence. Their implants created an unusual signature that could be detected by EM field scanners, betraying their location (+2 bonus to detect using Field Sense or MAD). They average five feet in length and weigh up to 250 lbs.

E-Model: The latest generation of War-Dops is based on new technology, building on the Delphís uplift germline (p. 101). Fewer cybernetics are required to turn the Delphís into an even more effective combat tool than the D-model. There are only a few Es in existence, most with the U.S. Navy. One notable individual, rescued in a Blue Shadow raid, is now the major threat to the CEP (see *Coak*, p. 110).

To the D-model template: increase ST to +8 (No Manipulators, -40%) [54], Extra Hit Points to +5 [25], reduce Short Lifespan to 2 [-20], remove the IQ penalty and Dull. *151 points* ($320,000, 2085).

ADVANTAGES, DISADVANTAGES, AND SKILLS

The world under the waves can be as alien as any asteroid. The following sections outline some differences and special cases for an aquatic campaign in ***Transhuman Space***.

Advantages

Absolute Direction *see p. B19*

Migrating sea creatures have an uncanny navigational sense to guide them to their destination. However, this ability is crude compared to the full Absolute Direction advantage and is a 0-point feature.

Acute Taste and Smell *see p. B19*

Non-aquatic characters or Aquatic characters in their non-native environment lose all benefit from Acute Taste and Smell.

Acute Vision *see p. B19*

Non-aquatic characters or Aquatic characters in their non-native environment gain only half their Acute Vision bonus (round down).

Bioshell Template *see p. TS126*

Bioshell Template includes Bioroid Body [0] (p. TS131). However, animal bioroids do not possess Social Stigma (Minority Group) [-10], so the net cost of Bioshell Template (Animal) is 51 points, not 41.

Breath-Holding *see p. CI21*

This advantage assumes more efficient lungs and increased oxygen storage in the blood, as well as additional lung volume. Up to two levels of this advantage are available; beyond that see *Oxygen Storage*.

Claim to Hospitality *see p. CI21*

Members of the Atlantean Society (p. 16) possess a Claim to Hospitality worth 5 points.

Gills *see p. CI56*

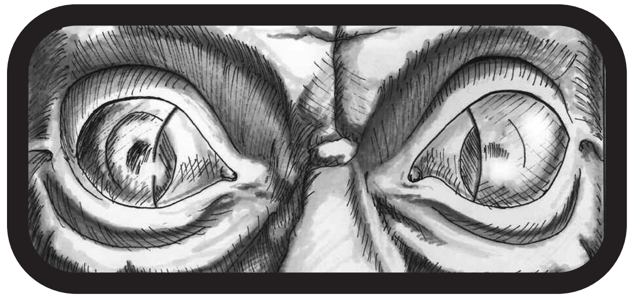
For gills to be effective, there must be significant dissolved oxygen in the water. This is not the case for the oceans of Mars and the satellites of the Deep Beyond, and some places on Earth (such as below 600 feet in the Black Sea), where Gills are useless.

Immunity to Poison *see p. CI58*

The following special limitation is available: Only gas narcosis, -75% (4 points if this is the only poison immunity you have). You have no myelin in your brain tissue. This means you are immune to the effects of narcosis caused by nitrogen and other gases at high pressures. Other poisons affect you normally. The Nerve Boosters nanosymbionts (p. TS165) replace myelin throughout the entire body. There is a variant available ($145,000) that grants both Immunity to Poison (Only gas narcosis, -75%) and the effect listed on p. TS165.

Nictating Membrane *see p. CI62*

This advantage eliminates the Vision penalty for characters seeing in their non-native environment without goggles (see *Senses*, p. 52).



Oxygen Storage *see p. CI62*

You have features in common with marine mammals like cetaceans and pinnipeds. This includes the ability to store a significant quantity of oxygen in the hemoglobin in your blood or myoglobin in your muscles. Your muscles can operate anaerobically for extended periods. When diving, air is not kept in your lungs; they are evacuated and allowed to collapse under pressure (which often involves a flexible ribcage) – this reduces buoyancy and prevents problems from absorbing high-pressure gases. Efficient blood routing keeps your vital organs supplied with oxygen and helps you stay warm.

These features allow you to stay underwater for extended durations before surfacing to breathe. Multiply the amount of time you can hold your breath (as determined on p. B91) by 90. You get no bonus for hyperventilation and this does not combine with Breath Holding or Breath Control. You must breathe normally for at least 10 seconds for every minute you were under water to correct oxygen debt. Diving again more quickly than this means you do not get a time multiplier and must start over the next time you surface.

This means a HT 10 character with Oxygen Storage can hold his breath for 60 minutes with moderate exertion. A dolphin with HT 12 can stay submerged for 18 minutes at heavy exertion – exertion is assumed to be heavy during dives. A humpback whale (HT 14) can dive for 21 minutes.

Characters with Oxygen Storage are immune to the bends, nitrogen narcosis, oxygen toxicity (see *Breathing*, p. 48), and aseptic bone necrosis (p. 51) when diving without an external compressed air supply, and may dive and ascend as fast as they can swim. If such characters breathe pressurized gas, they are affected by these problems like any other air-breather.

Oxygen Storage is functionally Doesn't Breathe (p. CI53) with the limitation Limited Duration (-30%), for a net cost of 14 points. Other limitations are possible: 30-minute Oxygen Storage gives a multiplier of 45 to breath-holding time (-40%, 12 points); 2-hour Oxygen Storage gives a multiplier of 180 (-20%, 16 points).

Pressure Support *see p. CI63*

This advantage keeps you from suffering harmful effects from pressure levels higher than your native pressure. Aquatic creatures do not necessarily need this advantage, but they may suffer if they leave their narrow "layer" of the seas.

Characters without Pressure Support can often withstand high pressures for short periods of time, if compressed slowly and suitable precautions against secondary dangers are taken (see *Breathing*, p. 48). However, living for long periods at pressure will cause them physiological problems – from stressed cardiovascular systems to muscle and bone degeneration. Pressure Support will prevent these problems and allow a full, healthy life under high pressures.

Pressure Support grants immunity to the damage caused by crushing pressure (p. 51). It also prevents the bends, oxygen toxicity, and gas narcosis (p. 50), and maladies brought on by the stress of repeated pressure changes such as bone necrosis. It does not provide immunity to sudden or localized changes of pressure (such as a hull breach or explosive shockwaves).

The 5-point version of Pressure Support allows safe operations in pressures up to 10 times native pressure, and the 10-point version protects characters at up to 100 times native pressure. The 15-point version is not available in ***Transhuman Space***.

Radar Sense *see p. CI63*

Instead of radar, this can represent a ladar system. It is treated as a standard ladar (p. 144) with the listed range (in hexes for imaging, in miles for low-res).

Special enhancement: If this sense uses actual radar it may be *low-probability intercept* for +10%. If switched to LPI mode at the beginning of a turn, the range is halved but any radar detectors can only detect it in operation at 1.5 times the (halved) range.

Special enhancement: If the low-res mode can be used for *targeting,* add +25%.

Radio Speech *see p. TS130*

The *Laser* enhancement has a blue-green mode for underwater communication. Treat as a normal blue-green laser communicator with a base range of 50 miles.

Resistant to Poison *see p. CI29*

The following special limitation is available: Only dissolved gases, -75% (2 points if this is the only poison resistance you have). You have adaptations that reduce the amount of pressurized gas that dissolves in your body tissues. This provides resistance to the bends, nitrogen narcosis, and high pressure nervous syndrome. At pressures below 20 atm., you are immune to these conditions; at pressures greater than 20 atm., you are affected as though the pressure were 20 atm. lower. You have no special resistance to normal poisons such as cyanide gas. Although this is presented as a limitation, the full Resistant to Poison advantage does not normally include this form of resistance to dissolved gases.

Resistant to Poison (Only dissolved gases, -75%) is distinct from Immunity to Poison (Only gas narcosis, -75%) in that it provides partial resistance to all forms of problems caused by dissolved gases, whereas the latter provides complete immunity only to gas narcosis. The two advantages overlap somewhat and can be taken together for 5 points (instead of 6).

Sonar Vision *see p. CI66*

You have the ability to produce sound waves that bounce off nearby objects and the ability to receive the echoes; by analyzing the echoes you can construct an image of your environment. This may involve special organs such as the oil-filled melon of dolphins or enlarged nasal cavities and ears of bats.

Sonar Vision is normally limited to a 120° arc in front of you; the addition of the Peripheral Vision advantage means you can scan 180° to the front. Large features can be discriminated clearly to 2,400 feet in water and 300 feet in air, with resolution increasing the closer the object is. You have Color Blindness (p. B28) while using Sonar Vision but do not suffer any darkness penalties.

Sonar Vision is not as detailed as medical ultrasound. In water, layering effects will also adversely affect resolution (see *Submarine Acoustics*, p. 24). In ***Transhuman Space*** you do not receive bonuses to Diagnosis or Holdout from using Sonar Vision, but thin-hulled hollow objects (no more than DR 3) can be distinguished from solid objects when within IQ yards.

Sonar Vision can be blinded by explosions and other loud multifrequency sound sources (for 20-HT seconds after the sound ends) or interfered with by strong sonar signals (a -1 to -5 penalty depending on intensity). Bubble walls and other techniques that disrupt sonar will appear as "blank spots" or jumbled terrain.

Special enhancement: You have superior signal discrimination and recover quickly from sudden noises blinding you. The longest you remain blinded or stunned by loud noises is 2 seconds. This does not help you recover from stunning caused by explosive concussion. Cf. Polarized Eyes (p. CI63). +20%.

Special limitation: You are Nearsighted (p. B27) when using your sonar and can only distinguish detail within 10 yards. -25%.

Disadvantages

Aquatic *see p. CI101*

Aquatic characters suffer no penalties using skills underwater, but suffer a -2 penalty to DX-based skills when out of water (see p. CI101). Additionally, for all templates in this book, Aquatic includes the zero-point feature Amphibious (No Move on land) [0], which allows aquatic-adapted beings to swim at their normal Move rate without needing Swimming skill (p. CI49).

Cannot Swim *see p. CI101*

For a species, this is a 0-point feature. For individuals of species normally capable of swimming, this is a -1-point Incompetence (p. CI91).

Increased Life Support *see. p. CI102*

Increased Life Support levels for food requirements are one level for up to twice as much food as a human, two levels for three *or more* times as much. The cost of water tanks and purification equipment for aquatic creatures in life support situations is included in the Aquatic disadvantage, and does not need to be bought as Increased Life Support.

Reputation *see p. B17*

A PNC (p. 17) is almost universally a negative Reputation with law enforcement organizations (a "large class" of people). Frequency of Recognition is "occasionally," such as when applying for a visa or being processed for a crime. Nations with stringent PNC requirements will be worth Reputation -1 [0] while those known as criminal havens will be Reputation -4 [-3].

Enhancements and Limitations

Not Underwater *-10%*

This is an Accessibility limitation (p. CI110). It may only be applied to advantages or disadvantages that normally work above and below water.

Only Underwater *-30%*

This is an Accessibility limitation (p. CI110). It may only be applied to advantages or disadvantages that normally work above and below water.

Skills

Botany/TL *see. p. B60*

A botanist may optionally specialize in Botany (Marine). This covers nutrient distribution, phytoplankton, algae, sea grasses, etc.

Breath Control *see. p. B48*

This skill is Esoteric in ***Transhuman Space***. Dedicated free divers and some martial artists (such as Zhua, see p. ITW92) will possess and teach this skill.

Crossbow *see p. B50*

The use of spear guns is a familiarity within this skill. Crossbow users will be at -4 to use a spear gun, and vice versa, until familiarity is gained (see p. B43).

Ecology/TL *see p. B60*

An ecologist may optionally specialize in the same terrain types as the Survival skill.

Geology/TL *see p. B61*

A geologist may optionally specialize in Geology (Marine). This covers submarine plate tectonics, mid-ocean rifting, hydrothermal vents, and submarine volcanoes, rocks, mineral deposits, and crustal formations.

Languages *see p. B54*

Baseline and augmented dolphins have a simple language that can be used to communicate basic physical and emotional data. This is a M/E language for dolphins, commonly called Dolphinspeak. The enhanced brains of Doolittle and Delphís uplifts enable them to learn a M/A language (called Tursin, from the Latin for "dolphin") capable of conveying abstract information. Uplifts can learn Dolphinspeak, but it is M/H for them because they lack optimized interpretive neural structures, and most never bother. Uplifts can also understand human language (treat as M/VH skills), but lack the vocal capabilities to speak them. Humans can learn a few of the obvious signals of the dolphin languages, but cannot effectively understand or speak the full language because much of its structure is beyond human hearing. CeTalker software (p. 119) can translate between either of the dolphin languages and any human languages in its programming.

Powerboat *see p. B69*

This is the skill used to operate small submersibles controlled by a single person. Each type of submersible is a familiarity (see p. B43). For large submersibles, use Shiphandling (Submersible).

Scuba *see p. B48*

This skill covers all underwater breathing apparatus systems – specifically rebreathers. Other breathing systems are treated as familiarities of this skill. Scuba is also used to control small powered devices used to supply additional thrust to a diver, such as finsocks, squidpacks, and divetorps (p. 117), with a -2 familiarity penalty. (Aquatic-adapted characters, who will not possess Scuba skill, use Endurance Swimming to control these devices.)

Shiphandling *see p. CI161*

The required specialization "Submersible" is used to direct the operation of large submersibles.

Sports *see p. B49*

Common water sports include water-skiing (defaults to Skiing at -4 or DX-6), surfing (defaults to DX-6), and water polo (defaults to Swimming -4 or DX-5). Many sports are familiarities of other skills, such as wind-sailing (Boating) and platform diving (Acrobatics).

Survival *see p. B57*

Aquatic survival includes an understanding of tides, currents, and winds, knowledge of simple water distillation methods, how to locate or catch food in that region, and how to avoid hazards such as venomous fish, sharks, and stinging jellyfish.

In addition to the specialties listed on p. B57, the following are applicable to the various "terrains" of the oceans and waterways: Bank, Deep Ocean Vent, Fresh-Water Lake, Open Ocean, Reef, River/Stream, Salt-Water Sea, Tropical Lagoon.

Zoology/TL *see. p. B62*

A zoologist may optionally specialize in Zoology (Marine). This covers zooplankton, invertebrate species, fish, marine reptiles, cetaceans, etc.

New Skills

Aquaculture (Mental/Average) *Defaults to IQ-5*

This is the skill of managing aquatic ecosystems and harvesting their output, including plankton, algae, and fish. It corresponds to Fishing as Agronomy corresponds to Survival.

Endurance Swimming (Physical/Average) *No default*

Available only to aquatic-adapted races, this skill is the aquatic analog of Hiking (p. CI152). It is based on HT, not DX. Roll vs. Endurance Swimming before each half-day's travel; on a successful roll, increase distance traveled by 20%. If a group is traveling together, they must all succeed on the Endurance Swimming roll to gain this benefit. This skill can also be used to control personal powered thrust devices such as squidpacks (p. 117) and divetorps (p. 117).

Oceanography/TL (Mental/Hard) Defaults to IQ-6 or Physics-6

This is the study of the fluid dynamics and thermodynamics of oceans. It covers water properties such as density, pressure, temperature, solutes, and fluid flow (currents, tides, waves). A professional oceanographer may also have skills such as Botany (Marine), Ecology, Geology (Marine), Hydrology, Meteorology, or Zoology (Marine).

Speed Swimming (Physical/Hard) *No default*

Available only to Amphibious or aquatic-adapted races, this skill is the aquatic analog of Running (p. B48). It is based on HT, not DX. Divide your skill level by 8 (don't round down) and add the result to your Speed to calculate your Move in water. Dodge is unaffected.

PEOPLE

Hiroko Shimada *270 points*

Ghost of a human female, born 2077, uploaded 2096. Age 22. Most commonly encountered in a Clockwork Souls Custom Cyberdoll (p. TS122), black African female, apparent age 20; 5' 6", 138 lbs. "Dyed" blonde hair, brown eyes.

ST 14 [0]; **DX** 10 [0]; **IQ** 12 [20]; **HT** 12/15 [0].
Speed 5.50; Move 5.
Dodge 5; Parry 7.

Advantages: Charisma +1 [5]; Comfortable Wealth [10]; Contacts (Cetanists; skill 12, 9 or less, somewhat reliable) [1]; Cyberdoll (Clockwork Souls Custom) [182]; Ghost Mind Emulation [17]; Independent Income [5].

Disadvantages: Disowned [-5]; Impulsiveness [-10].

Quirks: Cetanist; Dislikes ghost upload cults; Eats regularly despite not needing to; Pretends to be a natural human; Uncomfortable about transferring bodies. [-5]

Skills: Animal Handling-12 [4]; Area Knowledge (Cape Town)-12 [1]; Area Knowledge (Elandra)-11 [1/2]; Axe/Mace-8 [1/2]; Botany (Marine)-9/15 [1]; Brawling-11 [2]; Calligraphy-8 [1/2]; Carousing-13 [4]; Fast-Talk-12 [2]; First Aid-12 [1]; Hydrology-12 [2]; Knife-11 [2]; Navigation-13 [1]; Savoir-Faire-11 [1/2]; Scuba-13 [4]; Streetwise-14 [6]; Survival (Open Ocean)-13 [4]; Survival (Urban)-12 [2]; Swimming-13 [8]; Zoology (Marine)-10/16 [2].

Languages: English-12 [2]; Japanese (native)-12 [0].

Hiroko Shimada is the granddaughter of Tsutomu Shimada, the head of Japan's Shimada Umiya fishing company. Spoiled as a child, she grew rebellious and spent increasing amounts of time immersed in the Web and interacting with infomorphs rather than people. She became involved with various Japanese cults practicing and promoting ghost uploading. A week before her 19th birthday, Shimada impulsively ran away from home and visited a professional ghost upload facility in Sapporo. With access to a large inheritance, she bought the best care for her uploading process and was beamed to a new cyberdoll body in South Africa.

For the next two years Shimada struggled to come to terms with what she'd done to herself. Although she liked her new cyberdoll body, she wasn't comfortable with the idea of leaving it either for another body or to exist as a "pure" infomorph on the Web. She went through bouts of depression and lived day-to-day, out of touch with her family, who presumed she was dead. Seeking some form of spiritual comfort, she was befriended by a cetanist, who convinced her that she needed to get in touch with nature through interactions with dolphins.

Shimada traveled to Elandra in her cyberdoll body and hired a dolphin shell from a cetanist bioshell rental company. She overcame her fears about transferring to another body and, after some training in the use of a dolphin shell, spent the next few weeks interacting with wild dolphins. The experience was an epiphany for her, allowing her to regain a sense of purpose and confidence to face her existence as a ghost. She contacted her parents, who took some time to be convinced that the African woman talking to them was their daughter.

A year later, at the beginning of 2100, it is Shimada's parents who are having difficulties understanding and accepting what their daughter has done. Tsutomu Shimada has disinherited her, but her parents are more sympathetic and have helped her get casual work controlling deep-sea cybershells designed for biological research near Elandra – a job at which she has proved talented. This has boosted Shimada's self-esteem, and she is now considerably more stable than at any time in the past few years, with a wide circle of new friends. She spends most of her time in Elandra, acting like a human, with occasional forays in dolphin or whale bioshells, and occasional assignments in a research cybershell. Although becoming used to switching bodies, she still finds the process unnerving.

Shimada makes a useful Contact or Ally – she is fairly well-known and liked in the Elandra community, and has contacts with cetanist groups worldwide and within the biological sciences. She resents the Japanese ghost-upload cults and may be able to give investigators leads on some of these groups. It's also possible that she could get into trouble in one of her aquatic shells and require rescuing. She may suffer an emotional crisis if her parents decide to visit Elandra in person, and Tsutomu Shimada might take more drastic action against what he sees as a travesty of his granddaughter.

Rahul Sangupta *100 points*

Male Aquamorph, born 2076. Age 23; 6' 2", 184 lbs. Gray skin, no hair, gray eyes.

ST 12 [10]; **DX** 12 [10]; **IQ** 13 [30]; **HT** 11 [0].
Speed 5.75; Move 5.
Dodge 5; Parry 5.

Features: Smooth gray, mottled, or black skin [0]; Webbed fingers and toes [0].

Advantages: Aquamorph [65]; High Pain Threshold [10].

Disadvantages: Charitable [-15]; Enemy (IndiGene; medium group, 6 or less) [-10]; Secret (Wants to undermine Blue Shadow) [-30]; Sterile [-3].

Quirks: Avoids medical doctors and procedures; Believes moray eels are harmless and misunderstood; Militant pan-sapient rights believer; Outspoken about political beliefs on the web; Wants to have children. [-5]

Skills: Camouflage-13 [1]; Computer Hacking-13 [8]; Computer Operation-14 [2]; Demolition-12 [1]; Escape-12 [4]; Fast-Talk-14 [2]; Knife-13 [2]; Mechanic (Marine Vessel)-14 [4]; Memetics-11 [2]; Politics-12 [1/2]; Research-11 [1/2]; Sailor-12 [1]; Scrounging-13 [1]; Sleight of Hand-10 [1]; Survival (Bank)-13 [2]; Survival (Open Ocean)-12 [1]; Survival (Reef)-13 [2]; Underwater Demolition-13 [2].

Languages: English-12 [1]; Hindi (native)-13 [0].

Rahul Sangupta is a first-generation Aquamorph, born to a human surrogate mother in Chennai. The local company IndiGene Ltd. had licensed GenTech Pacifica's design for local production and hired cheap surrogates rather than buy exowombs. IndiGene took the newborn Sangupta and raised him with a group of other Aquamorphs. They were studied closely and regularly subjected to intense medical examinations. From their early teens, they were given work helping to develop an underwater settlement off the coast near Chennai.

Although allowed only limited contact with the web and the outside world, Sangupta slowly realized his Aquamorph "family" members were being held as prisoners, denied the freedom to travel and seek their fortunes in the wider world. He developed a talent for accessing web content that was supposed to be restricted, and learned that his species had been artificially created and just how unusual his upbringing was. He tried to escape but was tracked down by an implant he didn't know about and punished cruelly.

Searching for a way out of his situation, Sangupta posted information to an obscure pan-sapient rights website, hoping someone with the power to help would see it, while at the same time trying to avoid the attention of IndiGene. Blue Shadow, who had already been investigating IndiGene, used the information he provided to plan a raid on the Chennai facility. The terrorist group struck in 2097, blowing up much of the new construction and freeing Sangupta and several of his friends.

Grateful and wishing to help parahumans and uplifts in a similar situation, Sangupta joined Blue Shadow and helped them plan and carry out other raids over the next two years. Recently, however, he has become disenchanted with Blue Shadow's methods and increasingly resentful of the fact that he was sterilized without his knowledge when freed. He believes fervently in the group's cause, but is increasingly disturbed by its destructive and fearful tactics. For the moment, he continues to work with Blue Shadow, since he is not sure if he can stop doing so and escape retribution. If someone offers him a way out, so that he can fight for pan-sapient rights in a more peaceful way, and even undermine Blue Shadow without fear of retaliation, he would jump at the opportunity.

Sangupta would make an interesting Ally for fellow parahuman or uplifted Blue Shadow members, who might also be of two minds about their "rescues." He would also be a useful Contact for investigators attempting to infiltrate or shut down Blue Shadow. He could be encountered on a raid, where he might suddenly switch sides in the middle of a battle, or via his political activity on the web. He currently lives on a Blue Shadow ship disguised and operated as a scientific research vessel, so he could be found in any ocean.

Flynn Martin *343 points*

Male human, born 2046. Age 53; 5' 10", 171 lbs. Balding brown hair, brown eyes.

ST 11 [10]; **DX** 10 [0]; **IQ** 15 [60]; **HT** 11 [10].
Speed 5.25; Move 5.
Dodge 5.

Advantages: Ally Group (Programmed) (Infomorphs, small group of 150-point characters, 15 or less) [120]; Appearance (Attractive) [5]; Contacts (Biotech researchers; skill 12, 15 or less, usually reliable) [6]; Genefixed Human [0]; Mathematical Ability [10]; Patron (GenTech Pacifica; 12 or less, Equipment: Expensive, +10) [70]; Security Clearance 3 (GenTech Pacifica) [15]; Status 2 [5]*; Wealthy [20].

* Includes 1 free level from Wealthy.

Disadvantages: Duty (to GenTech Pacifica, 6 or less) [-2]; Enemy (Blue Shadow, 6 or less) [-15]; Greed [-15]; Intolerance (Dolphins) [-5]; Reputation -4 (Ruthless uplift researcher; recognized by small class, 10 or less) [-3].

Quirks: Can't comprehend why Blue Shadow hates him; Prefers working to leisure activities; Shows people his travel photos; Uses antique film cameras to take travel photos everywhere he goes. [-4]

Skills: Administration-14 [1]; Animal Handling-13 [1]; Area Knowledge (Elandra)-14 [1/2]; Biochemistry-17 [16]; Chemistry-14 [2]; Computer Operation-14 [1/2]; Ecology (Open Ocean)-12/18 [1]; Genetics (Genetic Engineering)-17 [16]; Leadership-14 [1]; Mathematics-15 [1/2]; Oceanography-14 [2]; Photography-13 [1/2]; Physics-12 [1/2]; Physiology-13 [2]; Politics-13 [1/2]; Research-16 [4]; Savoir-Faire-17 [0]; Scuba-13 [1/2]; Swimming-11 [2]; Veterinary-13 [1]; Writing-14 [1]; Zoology (Marine)-13/19 [2].

Languages: English (native)-15 [0]; Japanese-13 [1/2].

Dr. Flynn Martin is the Senior Research Scientist of GenTech Pacifica's Uplift Project (p. 74). As such, he is one of the three people in charge of GenTech's Research and Development division, along with Kaysey Patrick of the Bioroid Project and the SAI Zumfleer, who is currently directing climate control research. The trio makes broad policy decisions on the direction of GenTech's research, under guidance from the board of directors. Unknown to Martin and Patrick, Zumfleer is in constant contact with the board and takes orders directly from them without question.

Dr. Martin joined GenTech Pacifica in 2073, straight out of his Ph.D. program in genetic engineering at James Cook University in Townsville, Australia, where his thesis work was developing gene sequences for high temperature adaptation in coral species. His success in this field led to the development of several important corals over the next few years, which were used to replenish tropical Pacific reef systems ravaged by global warming. As provided in his employment contract, the patents for these corals were issued in the name of the company, and although Dr. Martin was well compensated he never realized how much money he'd made for GenTech.

His unquestioning loyalty and clear brilliance in gengineering led Dr. Martin through a rapid rise and assignment to the Uplift Project, where he produced significant enhancements for the Octosap II. He went on to work on dolphin uplift, but did not find it as interesting as invertebrate work. Dr. Martin cut corners on the research and came up with genemods that enhanced dolphin intelligence but at the cost of undesirable secondary traits. His indifference and cruelty to the dolphin specimens became legendary within GenTech, and by 2093 Dr. Martin had become Blue Shadow's "most wanted" biotechnologist.

Today, Dr. Martin is administrative head of the dolphin uplift program, but he has returned to cephalopods for his own work – attempting to uplift squid species. He encourages free experimentation and less-than-ethical practices on dolphin research subjects – which suits the GenTech board because it produces results. He is aware that his life is in danger from militant Preservationists, but can't understand why they object to his work. He lives in Elandra and commutes to Australia a few times a year under heavy guard. Blue Shadow tries to track his movements, but is frequently unaware of them.

Dr. Martin is just the sort of person the GenTech board wants as a senior administrator: loyal, hard working, ruthless. He has no loved ones who could be used as leverage against him, but interacts with many research colleagues and rivals on the web. He could be a useful Contact for individuals dealing with the biotech industry, probably via the web rather than in person. Personal interaction with Dr. Martin is more likely to come in the form of attempting to assassinate him, or protect him from such attempts. He would also be a valuable prize for Blue Shadow if captured alive.

Coak — *350 points*

Male dolphin, born 2085. Age 14; 10' 5" long, 612 lbs. Smooth, dark gray-green skin, shading to white on belly, which is covered in faint surgery scars.

ST 18 [0]; **DX** 13 [0]; **IQ** 12 [20]; **HT** 11/16 [0].
Speed 6.00; Move 13 (Swimming).
Dodge 7.

Advantages: Allies (Four 250-point characters, 9 or less) [80]; Ally Group (Irukandji, Large group of 100-point characters, 12 or less) [80]; Combat Reflexes [15]; Strong Will +2 [8]; War-Dop (E-model) [141].

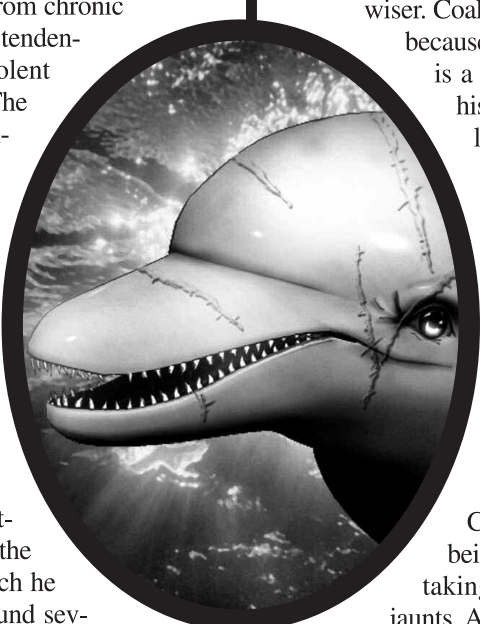
Disadvantages: Bad Temper [-10]; Enemy (Major law enforcement agencies, Formidable group, 6 or less) [-20]; Fanaticism (Gengineering and uplift of animals must be stopped) [-15]; Odious Personal Habit (Gloating) [-5]; Sadism [-15]; Stubbornness [-5].

Quirks: Overconfident of Irukandji's resources; Points out ironic situations; Proud; Shows off surgery scars; Swims rather than taking vehicles if possible. [-5]

Skills: Acting-13 [4]; Administration-11 [1]; History-10 [1]; Interrogation-14 [4]; Intimidation-15 [8]; Leadership-18 [12]; Memetics-14 [16]; Strategy-17 [14]; Survival (Open Ocean)-13 [4]; Survival (Reef)-12 [2]; Tactics-12 [4]; Zoology-10 [1].

Languages: Tursin (native)-12 [0].

The U.S. Navy's Cetacean Enhancement Program suffered a major setback in 2092 when Blue Shadow raided their Pearl Harbor research facility, rescuing two E-model War-Dops before their final conditioning. Blue Shadow deactivated their puppeteer implants, sterilized them, and tried to deprogram them to live a reasonably normal life. One of the Es suffered from chronic stress atavism and developed bestial tendencies, becoming uncontrollably violent until finally released to the wild. The other turned out to be even more intelligent than GenTech or the CEP could possibly have hoped . . .



Coak, as he was named by the CEP, took to the Preservationist philosophy and eagerly agreed to join Blue Shadow. Following a couple of low-key assignments in which he was observed discreetly for loyalty and effectiveness, Coak was welcomed as a full and trustworthy member of the terrorist group. He immediately began cultivating contacts reaching far beyond the small cell of fellow members to which he was supposed to have access. He found several people who were increasingly frustrated with Blue Shadow's policy of minimizing loss of sapient life, feeling that it restricted the effectiveness of their operations.

Early in 2096, Coak activated his plans and left Blue Shadow, along with several of his contacts. Four months later, a spectacular explosion destroyed a Biotech Euphrates gengineering laboratory ship in the Mediterranean. A document claiming responsibility was circulated on the web, signed with the name of a new terrorist group: Irukandji.

Coak is probably the most intelligent dolphin in the solar system, and also the most bitter and vindictive. He resents the treatments and surgery used to turn him into a machine of war, he despises the research and the ideas which produced his very body, he is pained by the sheer indignity of the way in which animals have been used as tools by humans. He has researched widely and been disgusted to find that humans have *always* treated animals as lesser beings.

The tremendous fury in Coak's soul is tempered by the knowledge that he alone among the animal world is uniquely placed to exact revenge. Although only moderately bright by human standards, he retains an animal cunning and is a strategist *par excellence*. Irukandji boasts excellent scientists, technicians, memetic engineers, and field operatives amongst its scant hundred members. They are all fanatically loyal to Coak and do their best to further his goals and plans. This network has access to stolen equipment and funds from Blue Shadow – indeed, many of Coak's followers still pose as Blue Shadow members – so they are surprisingly well-equipped.

Irukandji is run from a prefabricated underwater habitat that can be carried and placed anywhere in the world's oceans by a carrier ship. It has been moved several times by infiltrated Blue Shadow cells that remain none the wiser. Coak prefers to swim under his own power, because this gives him time to pretend that he is a wild baseline dolphin, and to think up his schemes. Since he resembles a baseline to all but close inspection, he can pass unnoticed in many places where humans would look suspicious.

Coak is an obvious Enemy for many types of characters, including biotech researchers, corporate troubleshooters, law enforcement agents, and naval personnel. It would be difficult to use him as a Patron or Contact except in a game where the PCs are themselves militant terrorists. Other characters could meet Coak briefly, perhaps even without being aware of it, in the field when he is taking one of his intelligence-gathering jaunts. Anyone who runs into him and becomes aware of his identity would be in line for a huge reward if he could be captured.

6 AQUATIC TECHNOLOGY

Ridley glided along a wall that appeared to have escaped the Irukandji attack unscathed. Some of the buildings had been completely destroyed – ruptured hulls allowing the sea to spill in, killing those inside. Others were critically damaged and had been tended to swiftly. The living walls of the habitats were marked with the telltale sonar beacons from the emergency response crews and fluorescent dyes released by the maintstars that crawled over every surface. Divers, cybershells, and Octosaps swarmed around the largest buildings and the water was thick with sonar transmissions. Almost everyone was armed; Irukandji was infamous for booby traps and surprise attacks after they lured out maintenance crews.

He spotted a dye marker and turned to investigate, controlling his squidpack with practiced ease. A crack the width of his finger gaped in the structure. The flexible metal jacket within was intact, but the limestone covering was scarred and needed repair if it was to maintain maximum strength. He transmitted a sonarcoder burst with the damage assessment to the control center and went to work.

Ridley pulled a roll of fine copper mesh from a pouch and bent it into shape. He pushed it into the crack, attached an energy cell, and let chemistry get to work. Chemistry could only go so far, however, so he took a spray canister and released small clouds of velox growth hormone onto the coral on either side of the gap. Within a few days the coral would grow over the wound, sealing it as though it had never existed.

Habitats

Construction Material

Acropora Velox: The gengineered coral polyps that produce aquacrete (see box) include a "terminator" gene sequence that renders them unable to reproduce sexually and kills them if they do not receive regular doses of a particular hormone. They can reproduce by budding, and do so rapidly when in rapid growth mode. Polyps are available for a nominal fee. The control hormones are the real expense, and must be purchased from GenTech Pacifica. Life-sustaining hormone is $50 per dose; a dose keeps 10 sf of coral alive for a week in fast growth mode or a year in slow growth mode. Hormones to switch growth modes are $20 per dose each, affecting the same area of coral. Each dose is 0.01 gal. and 0.1 lb.

Aquacrete Hardening Polymer: Used to fill the pores in aquacrete, creating a stronger composite material. $2 and 3 lbs. per 10 sf per inch of thickness.

Bubble Fencing: Semi-porous pipes connected to an air supply, these release a fine wall of bubbles that form an effective fence against fish. Frequently used to pen aquacultured fish, bubble walls also completely block sonar. Requires a surface compressor (p. 116) or compressed air supply. $50 and 20 lbs. per 100'.

Seacrete Mesh: A precision metal mesh used for shaping structures to be constructed from seacrete (see box). Seacrete mesh comes in two grades: *fine* for small areas and repair jobs, and *coarse* for new walls and buildings. Coarse mesh isn't strong enough to be structural; it requires a stiff framework to tether the edges if covering an area greater than 10 square feet. Fine mesh is $1 and 0.1 lb. per sf; course mesh is $3 and 0.4 lb. per sf.

Prefabricated Habitats

Although technology like aquacrete has made it easier to construct buildings underwater, most contractors still use prefabricated modules that can be hauled out to sea and assembled on site. To design a habitat, select components from the list below and add up the volumes, costs, and power requirements, then add enough power generation to cover the total requirement. Multiple modules of the same type can be combined to form larger examples of the same structure: e.g. 10 Basic Quarters combined makes a communal bunkroom for 10 people. Note that if food and water production is inadequate, supplies will need to be imported.

General maintenance on habitats costs $0.10 per cf per year.

Seacrete and Aquacrete

Seacrete is an underwater construction material produced by a technique invented by Wolf Hilbertz in 1976. An electric current passing through a wire frame causes chemical reactions in seawater, resulting in the deposition of calcium carbonate – limestone – on the framework. It accretes at a rate of 0.02 inches of thickness per day. Under ideal conditions, a kWh of energy produces 2 lbs. of seacrete, but each kW of power requires 500 sf of mesh on which to grow the limestone. (This implies an even accumulation of 0.01 inches per day, but seacrete is lumpy and semi-porous.)

In practice, seacrete is useful only for laying down a foundation structure, since the rate of accretion drops as the mesh electrodes are covered. Its main advantage over conventional construction is that the mesh can be produced in any shape, creating structures impossible to cast in concrete.

Aquacrete is the popular name for the limestone deposits left by a rapidly growing gengineered coral known as *Acropora velox*. Based on one of the fastest-growing natural coral species, a colony of *A. velox* can deposit a layer of structurally sound limestone 0.2 inches thick per day. This rate of accretion requires water rich in dissolved calcium and carbon dioxide as well as organic nutrients, so growing *A. velox* colonies are irrigated with fresh seawater circulated by impeller pumps. Aquacrete is commonly grown on a foundation shape of seacrete.

Several varieties of *A. velox* have been developed and are used for applications requiring different growth patterns. Although the limestone is strong, it is not solid, and contains small chambers and channels that can be colonized by other creatures to form a living structure, or filled with an organopolymer for extra strength. Once a structure has reached the requisite strength, a synthetic hormone released into the water switches the coral into a slow-growth mode, in which it adds less than an inch of material per year. Maintenance on aquacrete structures can be carried out either conventionally or with a supply of various hormones to influence growth rate.

Structures made of living aquacrete have DR 4 and require 10 points of damage per inch of thickness to be breached; polymer-strengthened aquacrete can take 18 points of damage per inch before failing. A wall of aquacrete used as cover provides DR 40 per inch of thickness to whatever it is protecting. A yard of aquacrete has a radiation PF of 64 (see p. TS60).

Living Space

Basic Quarters: Cramped cabin-style accommodation for a single person. Usually combined in pairs or multiples to house two or more people. Includes external corridor space for linking to other quarters. $1,500, 350 cf.

Roomy Quarters: More spacious accommodation for one person. $5,000, 600 cf.

Studio: Living space about the size of a hotel room. $12,000, 1,400 cf.

Apartment: Enough space for a person to live comfortably with personal possessions and extra space for entertaining guests, etc. Family apartments use multiple modules. $30,000, 3,500 cf.

Environmental Control: Air conditioning, heating, and lighting system to keep inhabitants comfortable indefinitely. If the system is overloaded, carbon dioxide will build up to dangerous levels. $5,000 plus $500 per person, 10 cf plus 10 cf per person, 10 kW per person.

Industrial Space

Factory: Usually a minifacturing plant, although large versions can be dedicated factories for producing specific equipment. Use statistics for *Large Printer*, *Optimized Printer*, *Modular Robofac*, or *Biofac* on p. TS153.

Food Production: Fauxflesh vats, hydroponic gardens, or aquaculture facilities. Each module can support one person indefinitely (i.e., produces one man-day of food per day), but fauxflesh vats and hydroponic gardens require 1 kW and $2 of raw materials per day. Aquaculture costs money to set up, but its volume can be outside the habitat, and it has no ongoing costs. $2,000, 1,000 cf.

Laboratory: An equipment-filled laboratory designed for one person using a specific Scientific skill (pp. B59-62 and pp. CI155-159). For tasks where a lab is a prerequisite, it provides no bonus to skill. For procedures where a lab is a luxury, it gives a +2 bonus. A lab can only be used for one task at a time. $1,000,000, 1,000 cf, 3 kW.

Water Desalination Plant: Produces fresh, clean water from seawater. Each module produces 100 gallons per day – enough for 20 people to drink, cook, and wash without requiring strict conservation measures, or enough for 200 people to drink in survival conditions. Requires a $20 filter replacement every week. $500, 1 cf, 0.1 kW.

Amenities

Airlock: Airlocks are chambers that can be pressurized, flooded, or filled with air to match conditions on either side of two hatches, which open into different environments. They can serve as uncomfortable decompression chambers if necessary. An airlock takes 10 seconds, plus 10 seconds × any pressure difference (in atmospheres), to cycle. Each module can accommodate one person or 10 cf of equipment. $1,000, 50 cf.

Decompression Chamber: A chamber used to decompress divers to avoid the bends. It usually has two exits, to environments at different pressures. Since people often spend long times in them, decompression chambers are roomier and more comfortable than airlocks, and may include smaller secondary locks for the passage of food and other items. Per person capacity: $2,200, 200 cf.

Moon Pool: A hole in the floor to be used as a moon pool can be added to any module at no extra cost. Note that the interior must be pressurized to match the external water pressure, or the module will flood.

Vehicle Dock: The external hatch of an airlock can be designed to mate with the hatch on a vehicle, for no extra cost.

Power Generation

Nuclear Reactors

Both fission and fusion reactors are used in underwater and floating environments. Newer reactors are more efficient, but more expensive than older reactors. Use the rules on p. TS185 or p. 140 to determine size, mass, cost, and power output of nuclear reactors.

Oceanic Energy

Ocean Thermal Energy Conversion: OTEC generators (see p. 30) require long vertical pipes to access seawater at different temperature layers. Per MW of power produced, an OTEC generator costs $262,500, occupies 35,000 cubic feet, and weighs 1,050 tons. This includes pumps, heat exchangers, working fluid (usually ammonia), and turbines. Much of the volume is spread out along the length of the piping.

Tidal Power: A tidal power station must be anchored to land or the seabed, to take advantage of the rise and fall of the sea level. The greatest tides are in narrow coastal inlets, so tidal power is mostly used on land. A tidal power station costs $1,400,000 per square mile of water that it entraps. It generates an average of 35 kW per square mile × the square of the mean tidal rise in feet. Power output may be tailored to demand throughout the day by management of entrapped water.

Wave Duck: Wave energy can be extracted with floating "ducks" that use wave motion to drive a gyroscopically stabilized turbine. A typical wave duck is 100 feet long and 20 feet wide. It costs $240,000, weighs 600 tons, and generates 60 kW × the height of the waves. Ducks are not as efficient as wave tubes, but have the advantage of being deployable in the open ocean.

Wave Tube: Wave energy can also be harnessed by an anchored tube using wave motion to drive a two-way turbine. A tube turbine costs $4,000 per foot of diameter, and generates 0.03 kW × the square of the diameter × the mean wave height in feet. The largest practical diameter is 20 feet, but several tubes can be built along a stretch of coastline. Typical wave heights in a location can be gauged from the *Beaufort Wind Scale* (p. 23).

Microgenerators

Small, portable generators widely used for recharging energy banks or powering small devices. Includes an integral self-sealing fuel tank and carrying handles. They are sealed in a DR 5 carbon composite shell. See p. 139 for fuel weight and cost.

Small Internal Combustion: Generates 2 kW and uses 0.08 gph of gasoline or 0.1 gph of alcohol from a 3-gallon tank. $420, 0.55 cf, 8.3 lbs.

Large Internal Combustion: Generates 5 kW and uses 0.2 gph of gasoline or 0.24 gph of alcohol from a 5-gallon tank. $855, 1 cf, 17.5 lbs.

Small MHD: Generates 1 kW and uses 0.18 gph of hydrogen from a 1.8-gallon tank. $320, 0.43 cf, 11.18 lbs.

Large MHD: Generates 5 kW and uses 0.9 gph of hydrogen from a 5-gallon tank. $1,210, 1.55 cf, 47.25 lbs.

Muscle Generators

These consist of one or more seats and either pedals or oar handles. They are widely used by Isolates (p. FW36) as a combination exercise machine and battery recharger. Versions designed for cetaceans are available from specialty resellers. Muscle generators produce 0.02 kW × combined ST of operators, up to the maximum rated output.

Cetacean Static Exercise Unit ("Fish Trap"): A rigid frame with padded straps and restraints for securing a dolphin. Flexible active feedback devices provide a natural resistance to swimming motion and transfer power to the generator. Often used for exercise by dolphins in space, but on Earth most cetaceans would be reluctant to get into one. The generator produces up to 0.6 kW and comes with a 2 kWh battery. $360, 35 cf, 95 lbs.

Cycle: An extra-light steel frame with a cycle seat. Commonly mounted on a stabilized platform and tied to a HUD interface for virtual bike tours. The 0.4 kW rated muscle engine can charge an integral 0.4 kWh battery. $110, 5 cf, 20 lbs.

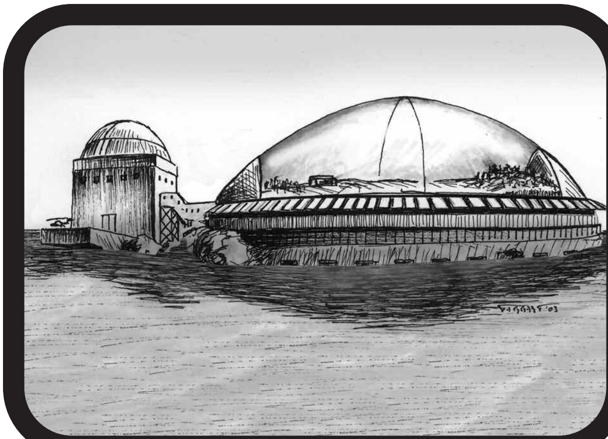
Scull: A sliding seat with foot restraints and oar handles. Statistics as per Cycle generator.

Solar Panels

Solar cell power output varies by weather conditions and from planet to planet. In any environment dark enough to cause a -1 or worse Vision penalty, cells provide negligible power. Under sunny skies (or in vacuum), the formula for power in kW is solar cell area (in sf) × P, where P is 0.5 for Mercury, 0.2 for Venus, 0.08 for Earth and Luna, 0.04 for Mars, 0.01 for most major asteroids, 0.003 for the moons of Jupiter, and 0.001 for the moons of Saturn. Farther out, solar cells produce negligible power. (The formula for P is 0.08/(square of the distance from sun in AU).)

Cheap Panels are built with light aluminum frames. Each sf is $80, 4.1 lbs. and takes up 0.082 cf when folded and retracted.

Expensive Panels are built on super-light carbon composite frames. Each sf is $130, 0.4 lbs. and takes up 0.008 cf when folded and retracted.



Personal and Expedition Gear

These items will be familiar to most people who spend much time in the water. They range from vital life support equipment to environmental protection and aquatic propulsion systems.

Basic Gear

Dive Computer: An extremely tiny dedicated computer running a diving expert system. It has an effective Scuba skill of 12 in the areas of safety, emergency protocols, and diving physics. Often included as an integral part of diving goggles or masks, interfaced to the HUD. $10, negligible weight.

Dive Whistle: Small whistle with lanyard. When blown it produces a shrill sound that can be heard at long distances above water (+19 to Hearing rolls, subtracting Range Modifier, p. B201). $1, negligible weight.

Diving Goggles: A basic set of goggles incorporating a text-only heads-up display and a biomimetic seal based on squid suckers; a tiny electric charge relaxes the mask for removal. The mask will tear off skin if forcibly removed without relaxing the suckers (requires a ST-5 roll, success deals 1 point of damage to the wearer). $5, 0.1 lb.

Diving Helmet: A hard-shelled helmet with transparent faceplate, sealed at the neck, keeping the head entirely dry. This insulates the head against cold water, extending the wearer's temperature comfort zone down by 10°F. Pressure is maintained at ambient. Equipped with internal VIG (p. TS142) and sonarcoder system. Takes 2 seconds to don or remove. PD 4, DR 20. $550, 3 lbs.

Diving Mask: Standard headgear for most recreational divers. It is a one-piece faceplate with a nosepiece and a wraparound visor with mounting points for a VIG display. It has no straps; it is placed on the face, adjusted, then squeezed to seal using the same biomimetic suckers as diving goggles. Takes 2 seconds to don or remove. PD 2, DR 10 on the face. $50, 0.5 lbs.

Frame Goggles: Diving goggles with attachments for most VIGs. $10, 0.1 lb.

Heater: A small pack placed on the user's back to warm the blood, which distributes heat throughout the body. Extends the user's temperature comfort zone downward by 15°F for both wetsuits and drysuits; bio-monitor control prevents overheating (see *Cold and Heat*, p. 51). $10, 0.1 lbs., 1B (4 hours).

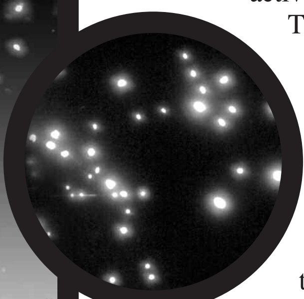
Life Jacket: A thin jacket that automatically inflates if the wearer is completely submerged (not just drenched). Provides 25 lbs. of flotation. $10, 1 lb.

Line Cutter: Safety-sheathed diamondoid blade that is hooked around entangling lines and pulled to cut. Does sw+2 cutting damage (maximum damage 1d+2) but is not normally usable as a weapon. 0.25 lb., $20.

Magnesium Flare: A flare that burns underwater, providing bright white light – no Vision penalty within T yards (see p. 52). It self-ignites and lasts 3 minutes. $2, 1 lb.

Powerfins: Power-assisted swim fins, using responsive materials powered by an energy bank. Allows non-aquatic individuals to use their full Move underwater; they can also swim long distances as if aquatic-adapted as long as the power holds out. Aquatic-adapted characters wearing these fins add +1 to underwater Move. $800, 2 lbs., 2C (4 hours).

Rescue Marker: A buoyant stick that, when broken, releases a high-visibility dye into the water and activates a small emergency beacon. The dye creates a glowing green 30-foot diameter circle in the water within 3d seconds. The beacon incorporates a GPS receiver and broadcasts SOS and location signals on emergency channels to a range of 10 miles. The beacon broadcasts for 5 hours and the dye lasts 2 hours in calm waters. $10, 1 lb.



Shark Repellent Field Generator: A two-piece electromagnetic field generator – a short ankle antenna and a flat plate mounted on the diver's back. Together, they generate a mild electromagnetic field that causes disorientation and pain to any creature with Field Sense (notably sharks) within 15 feet. Affected creatures must make a Will roll when moving into the field or suffer a -2 penalty on all rolls; most will only enter the field if desperate or frenzied. $200, 1 lb., 1B (5 hours).

Consumer Items

Deep Soda: Regular carbonated drinks don't fizz well at high pressure, so deep soda is charged with enough CO_2 to produce a satisfying effervescence at a rated pressure (marked on the can). Opening it at lower pressures causes a fizzy mess. Even when flat the soda still contains dissolved gas, and should not be drunk for 12 hours prior to decompressing, to avoid embarrassing releases of gas. $1.50 a can. Champagne versions are also available, from $25 to $300 or more a bottle.

DjinnPipe: An inhaler that generates an artificial flame-free smoke from aerosolized chemicals. Commonly used in places where flame is either dangerous or unsustainable (e.g., low-oxygen pressurized habitats like Elandra), or underwater, for recreational drugs that are smoked under normal conditions. $3.

Jellyfood: A food product related to pharm jellies. Simply scoop some up and chew. Available in a variety of flavors from malt to cinnamon. $0.50 each.

Macropearls: Gengineered oysters make it easy to grow cultured pearls as large as tennis balls. Quality is not as high as natural pearls, but they can't be beaten for gaudiness. $40-$100 for tennis ball size.

NewtGlu: Sticky pads using gecko setae (feet hair). After removing the protective covering they can be attached to almost any surface, and they have hairs on both sides. A tiny electrical pulse (from an included wand) causes the hairs to extend or release. If two large items are glued together so the pads cannot be released by the wand, a static field generator (sold separately) can get them unstuck. A one square inch patch can hold 800 lbs. indefinitely. These are infamous for their use in practical jokes. $0.10 per square inch.

S.P.I.D.E.R. Crab: Robotic companion and toy based on a popular children's InVid series. The S.P.I.D.E.R. is a stylish cybershell containing a custom NAI-4; the sealed translucent shell (PD 1, DR 3) resembles a large crab with four tentacles (ST 3), two pincers (ST 5), and a single glowing sensor eye (normal human-level vision). The AI is programmed to act like a member of S.P.I.D.E.R Squad, including mock-fighting toys from the K.H.A.O.S. ecoterrorist faction (using low-powered lasers and compressed air "torpedoes"). Crabs have Move 5 and a Tactics skill of 8. Several Blue Shadow cells have a perverse attachment to these toys (as K.H.A.O.S. is a thinly veiled allusion to their organization) and many use reprogrammed models for errands or for bombjacking. 2C (1 week). $500.

Starfish Construction Kit: For the budding young genestheticist in your family! Contains a dozen assorted starfish, starfish food, a scalpel, tubes of rejection inhibitor and growth hormones, and full instructions. Graft together pieces of starfish to form living creatures in shapes and color combinations limited only by your imagination! $80, fish tank not included.

Smartfins: Memswear (p. TS146) swimming fins that can be programmed to vary their shape and rigidity. The default settings add +2 to swimming Move. Most users set unique thrust profiles for a minor gain in effectiveness or to make swimming harder in exercise programs. $100, 1.5 lbs.

Stab Jacket: A combination buoyancy system and load-bearing vest. It can hold a rebreather system in a large back pocket and has a number of pouches and attachment points for gear and weights. In the water it has neutral buoyancy, but can be inflated using an integrated gas canister to provide 50 lbs. of buoyancy. $50, 5 lbs.

Survival Watch: Small wristwatch with a tiny Complexity 2 computer, which is operated by voice and runs a Survival-11 skill set. It monitors the wearer's pulse, skin temperature, local pressure, location (through GPS on the surface or sonar beacons underwater), as well as telling time. Powered by a small flywheel battery that can be recharged by shaking, or an AA cell for a year. Waterproof to 1,500 feet. $100, negligible weight.

Swim Fins: Smart-plastic swim fins with adjustable shape. Provides +1 to swimming Move. $10, 1.5 lbs.

Weights: Diving weights are held in quick-release pockets with 5 lbs. capacity. A belt has four to eight pockets; ankle belts have one. Scuba gear can hold up to four pockets but they cannot be easily released. $5 per pocket, negligible weight when empty. Commercial ballast is $2 per pound.

Breathing Equipment

Artificial Gill: The artificial gill described on p. TS152 extracts oxygen directly from water and mixes it with buffer gases to produce a diving system with no oxygen tank requirement. Despite several years of work they are bulky, have limited endurance, and usually carry a small oxygen tank anyway as a safety bailout in case of electronics failure. They are not mass-produced and are only available through specialty manufacturing outlets. They have neutral buoyancy.

Fluorohalide Oxygenator: This device sterilizes expended fluorohalide breathing liquid (such as "perflubron"), adds surfactants, and recharges it with oxygen. It requires access to pressurized oxygen to function at full efficiency, recharging 10 gal. per minute. If necessary it can use an integral air compressor to oxygenate the fluid, at 2 gal. per minute. Requires 1 gal. of additional chemicals ($250) for every 100 gal. of recharged fluid. $25,000, 0.5 cf, 30 lbs., 1D (2 hours if running compressor, otherwise 1 day).

Fluorohalide Respiration: This is a 10-gal. ultralight tank of oxygenated fluorohalide liquid mated to an assisted breathing system. The user slowly lets the breathing liquid fill his lungs and then activates the respirator, which helps move the liquid into and out of the lungs. An ultrasonic transducer creates convection currents to aid in CO_2 diffusion and removal. Use requires the Scuba skill; an unfamiliar user must make a Fright Check at -3 when first filling the lungs (to suppress the drowning reflex) and another at no penalty when he begins any serious exertion. A gallon of oxygenated fluid lasts up to five minutes. Portable systems cannot reoxygenate the fluid themselves but cetaceans are large enough to carry oxygenator units (see below). Fluorohalide respiration avoids all the usual problems associated with breathing high pressure gases, including allowing arbitrarily fast descents and ascents without decompression. Breathing the liquid is tiring – even resting is treated as mild exertion – and speaking is impossible. The system is dead weight unless the tanks are purged, in which case it generates 70 lbs. of buoyancy. Each gallon of breathing liquid costs $50 and weighs 17 lbs. $20,000, 20 lbs., 1C (24 hours).

Rebreathers: Closed-circuit rebreathing systems are the dominant technology used by recreational and professional divers; older technology is regarded as quaint or dangerous. The basic rebreather setup is a diving mask plus air tanks as described on p. TS152. A rebreather consists of a tank of pure oxygen, a CO_2 scrubber, and additional tanks of inert gases (nitrogen, hydrogen, helium), which are adjusted automatically by a dive computer based on the dive profile. Rebreathers are neutrally buoyant. Charging a used gas tank costs $10/hour of capacity, or $100 for helium.

Snorkel: A simple set of no-fog goggles with an attached breathing tube (1 foot long). Valves prevent water from being inhaled. $1, 0.1 lb.

Surface Compressor: Air compressor with hoses (with integral commlines) for tethered dives without scuba gear (up to 60-foot depth). Up to eight divers can use one compressor. Can also supply air for 1,600 feet of bubble fencing. Variants are used for tethered diving from deep base stations, often by deep-sea construction crews and other professionals. Requires 0.2 kW per attached diver or 200 feet of bubble fence. $500, 10 lbs.

Environmental Wear

Diving Skin: Thin body stocking used in warm water. Booties and gloves protect from accidental contact with stinging marine life and abrasion from coral. Provides no insulation. $10, negligible weight.

Drysuit: A waterproof suit with sealed cuffs for the face and hands, which keeps the wearer dry while diving. A hood or helmet, fins or weighted boots, and gloves complete the suit. It provides some insulation from the trapped air – for extremely cold water additional insulating clothing can be worn. Drysuits shift the wearer's underwater temperature tolerance range downward by up to 40°F (see *Cold and Heat*, p. 51), depending on what undergarments are worn. Drysuits can be inflated to provide neutral buoyancy. DR 2. $250, 5 lbs.

Combat Drysuit: Drysuits suitable for use in combat have the statistics of nanoweave vacc suits (p. TS159) but half the weight and cost. They are less buoyant than a conventional drysuit and should be counted as dead weight. Smartsuit and memswear versions are also available.

Wetsuit: A flexible one-piece synthetic or biofactured diving suit. There are many different styles, providing varying amounts of coverage for the torso, arms, and legs. Full-length suits that leave only the hands, feet, and head exposed are readily available, but slightly less flexible. Wetsuits insulate by trapping water next to the body, which is warmed by body heat. They are slightly buoyant. The most popular wetsuits are self-adjusting (see *Memswear*, p. TS146). A half-body suit shifts the wearer's temperature comfort zone in water downward by 10°F (see *Cold and Heat*, p. 51). DR 1. $50, 2 lbs. Full-body suits worn with the included gloves, boots, and hood shift the comfort zone 20°F for double weight and cost.

Spray-on: A triple application of suitspray (p. TS146) provides the same benefits as a normal wetsuit. It breaks down after 1d hours in the water.

Lift Bags

These are inflatable bags that are attached to objects underwater, then filled with gas for buoyancy. Lift bags are reinforced with arachnoweave (DR 1 nonrigid armor). They have attachment points for cables and chains. Many have sonar or radio tags for easy location. All have an integral CO_2 canister good for one inflation and a pocket for spares – they can also be inflated by an external gas supply. Replacement cartridges weigh 5% of the bag's rated lift (in lbs.) and cost $0.01 per lb. Bags take 1 second to inflate for every 10 lbs. of flotation. Uninflated volume is 1/100 of inflated volume.

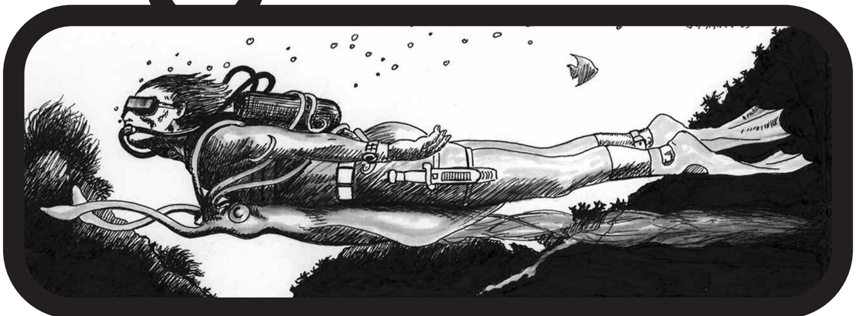
5-lb. Fishing Buoy: Used by spear fishers to float small catches to the surface. 0.08 cf inflated. $25, 0.45 lb.

25-lb. Personal Float: A larger bag that can carry small items or large fish. 0.4 cf inflated. $40, 1.2 lbs.

50-lb. Diving Bag: The most popular bag used by recreational divers. 0.8 cf inflated. $60, 1.8 lbs.

500-lb. Recovery Float: Used to float small salvage items and, in emergencies, function as a rapid ascent system. Popular with cetacean and Aquamorph divers. They are often mounted on hardsuits. 8 cf inflated. $240, 7.2 lbs.

3,000-lb. Salvage Tube: These are used to bring up boats and other large items. Several are attached vertically along a wreck; when it reaches the surface the tubes are slung horizontally under the keel so it floats high enough that it can be pumped out. They can also function as makeshift pontoons for crippled vessels. 48 cf inflated. $1,000, 30 lbs.



Personal Transport

The following items are all commonly found in coastal, surface, and underwater habitats on Earth. To deal with local water conditions, divers on Mars use modified versions that cost 1.5 times as much. Move for all these items except the sled is reduced by 1 for every 10 lbs. over 200 lbs. that the user weighs or carries. Except where noted, all devices are operated with Scuba skill (or Endurance Swimming for aquatic-adapted characters).

Divetorp: Resembling a four-foot-long torpedo with handlebars, this is simply a ducted hydrojet that can pull a diver along behind it. It provides Move 4 underwater, but users take 1 point of fatigue every half hour. Divetorps can also be rigged to haul cargo in straight lines. $1,250, 45 lbs., E (1 week).

Finsocks: High-powered powerfins (p. 115) with an integral fin-drive that can propel the wearer at Move 6. They are steered by ankle alignment, which takes practice, and switched on and off by clicking heels. Divers with a swimming Move of 6 or more gain no benefit. $790, 6 lbs., C (5 hours).

Finpants: A wearable fin-drive that covers the entire lower body, often styled to resemble that of a mermaid. It has a tiny cheap Complexity 4 computer, 0.4 cf (8 lbs.) cargo space, and DR 1 carbon composite armor. It takes (30-Exoskeleton skill) seconds to don, half that to remove. It is operated with the Exoskeleton skill. Maximum speed is Move 7. $16,375, 96 lbs., E (10 hours).

Squidpack: A biomechanical device produced by Manticore Genetics. It resembles a squat squid with four arms. It latches around the wearer's body using the tentacles and forces water out of its natural hydrojet for propulsion. The wearer's body tension and head orientation guide the squid, but it takes practice to perform more than straight-line jaunts. It provides a Move of 5 while underwater. It needs to be fed daily, but is happy with table scraps and vitamin supplements. Manticore sells the creatures at a loss to promote its biomechanical consumer product initiative, promoting them heavily along with the *Nadezdha* bioship (pp. SSS21-23). Young genestheticists often tinker with squidpacks to produce custom shapes and colors, as the modifications are simple and Manticore licenses access to the genetic template for only a few dollars. $300, 10 lbs., C (1 week).

Cetacean Equipment

Brachiobot: A small AUV with arm-like manipulators that can be controlled by a Nanny-equipped dolphin. Brachiobots come in several different types and have vectored hydrojets for thrust. A general purpose model typically has two ST 10 arms and can carry objects up to 100 lbs. at Move 5. One arm can be attached to an immobile object to gain some leverage with the other. A heavy-duty model has four ST 20 arms and an integral NAI for assessing the best ways to manipulate heavy or stubborn objects; it can lift 250 lbs. (more with two arms anchored) and swim at Move 8. *General purpose:* $27,500, 45 lbs., 1D (2 weeks). *Heavy-duty:* $86,000, 130 lbs., E (1 week).

Moistsuit: Effectively a drysuit that traps water inside. It is used to keep the skin of cetaceans moist and clean for extended periods. Suits are custom tailored for the species and individual. Moistsuits are most useful for cetaceans in microgravity space habitats. Use the statistics for drysuits, but if the creature is significantly larger or smaller than humans multiply by (weight/200).

Nanny: The standard VI interface and NAI implant that can be used to allow dolphins to interact with humans (see *Dolphin Sapience and Psychology*, p. 100). It converts dolphin vocalizations into human language and broadcasts the results to nearby VIs. Translation in the other direction (either from voice or radio) is fed to the dolphin's aural senses by bone induction. A Nanny is basically a Tiny dedicated computer running an NAI-4 and a CeTalker program (p. 119). The NAI advises the dolphin on issues of human social interaction, and can communicate independently if it feels the dolphin's best interests are at stake. Powered by the dolphin's bodily myeloelectricity. $650, 0.1 lbs.

Whale Biocomputers

Whales have the largest mass of brain tissue of any animal. Gengineering techniques can be used to enhance the thickness and complexity of the folds in the cerebral cortex, increasing surface area dramatically and producing unparalleled raw processing power. This is one avenue pursued for uplifting cetaceans, although simply making these changes to brain morphology usually results in serious mental instabilities.

Another option is to modify the neural pathways to interface with computer implants and program an NAI to use the cortex as a massively parallel processor. Researchers have had some success with this, producing whale brains equivalent to a Complexity 6 computer, although roughly 1,000 times slower. Sonar signal processing using the native sensory cortex is much faster, currently approaching speeds of the best dedicated computers. Computing experts have high hopes for the technology – much to the disgust of cetanists and Preservationists.

Drugs, Biomods, and Medical Gear

"Pathetic."

Coak turned away from the tank that held what had once been a sapient creature, able to converse and reason. A product of the same genes that had led to him, twisted, tortured, and now finally broken into the pitiful specimen swimming fitfully in circles behind him.

"Humans made you, and humans gave you the seeds of your own destruction. Now there's an irony. To escape from the shackles of Doolittlehood, you drug yourself so all you're good for is doing backflips in a zoo. This isn't a natural existence. Your suffering ends here . . ."

Fisheyes: This proteus nanomod (p. TS165) allows divers to see without goggles and improves vision in the gloomy depths by altering the reflectivity of the retina. Grants Nictating Membrane [10], Night Vision [10] and Unnatural Feature (reflective eyes) [-5]. $12,000, 1 week.

Myelin Replacement: A simple biomod can produce bioroids whose brain tissue contains a variant form of myelin, the fatty tissue surrounding nerve cores. This has no effect on cognition, but grants Immunity to Poison (Gas Narcosis) [4] (p. 103). Adds $1,000 to bioroid model cost.

Myelin Replacement Nanovirus: Cerebral myelin can also be modified in a living being by a proteus nanovirus. Gives Immunity to Poison (Gas Narcosis) [4]. $5,000, 2 days.

Perflubron Blood: Bioroids can be created with radically modified circulatory and support systems, using a "blood" composed of polymer particles coated with perflubron, suspended in plasma. Compared to normal blood, this provides greater oxygen utilization capabilities and faster elimination of undesirable gases. The blood is a milky white fluid and is sticky when exposed to air (because of a clotting agent). Perflubron blood gives Extra Fatigue +1 [3] and Resistant to Poison (Dissolved Gases) [2] (p. 104). Adds $5,000 to bioroid model cost.

Perflubron Transfusion: Perflubron blood can be transfused directly into the veins of creatures with normal blood. This is harmless, and the body breaks down the perflubron within 48 hours. For the first 12 hours following transfusion it provides Resistant to Poison (Dissolved Gases) [2], which can greatly speed decompression. If given to a person suffering the bends, it allows a roll vs. HT+4 every 5 minutes to recover completely. $50/gal. (4 doses).

Wetskyn: An advanced version of plastiskin, this is a 6"×6" biomimetic patch for underwater use on wounds. It has active directional ion channels that allow the wound to "breathe" while preventing dehydration due to osmosis in seawater. A different version is used for fresh water – both must be applied with the correct side against the wound. $20, negligible weight.

Nanodrugs

Atman: Commonly used by cetanists, this drug brings a feeling of peace and harmony with the natural world, effectively granting Animal Empathy [5]. It also produces the Delusion that the user can communicate with animals [-5], usually projected onto dolphins. Long term (1 day), pill (HT-6 to resist), $500/dose, LC 5.

BodyHeat: This stimulates the metabolism to boost heat production, while also causing mild peripheral vasoconstriction to reduce heat loss. This confers Temperature Tolerance 2 [2] for cold temperatures, but also gives a -1 DX penalty and Increased Life Support 1 (double food requirement) [-10]. Long term (1 day), injection (HT-6 to resist), $1,100/dose, LC 5.

Focus: Focus is a common drug used to make diving safer by increasing the user's awareness and reducing panic reactions. It can, however, make users *too* cautious to perform many jobs underwater. Grants Alertness +2 [10], Composed [5], and Careful [-1]. Medium term ([25-HT]/4 hours), pill (HT-6 to resist), $160/dose, LC 5.

Morlock: A "regression" drug tailored for Doolittle dolphins, which makes them behave like a wild animal. It was developed by Preservationists as a humane way to reverse the uplift process, and promoted to Doolittles as a method of experiencing a more "natural" existence. Unfortunately the drug didn't work as hoped, and is psychologically addictive. It adds Bestial [-10] while in effect, but also has a permanent damaging effect on brain chemistry. After each use the user must roll vs. HT+4. On a failure either add Stress Atavism (Mild, Rare), increase the frequency of existing Stress Atavism by one step, or (if attacks are already common) increase the severity one step. Once Stress Atavism is severe and common, the next failure makes Bestial permanent. Morlock also works on baseline cetaceans – if the user is already Bestial, it adds Berserk [-15] and triggers an immediate berserk episode. It has been used this way by some naval forces. Medium term ([25-HT]/4 hours), pill (HT-6 to resist), $450/dose (dolphin sized), LC 4.

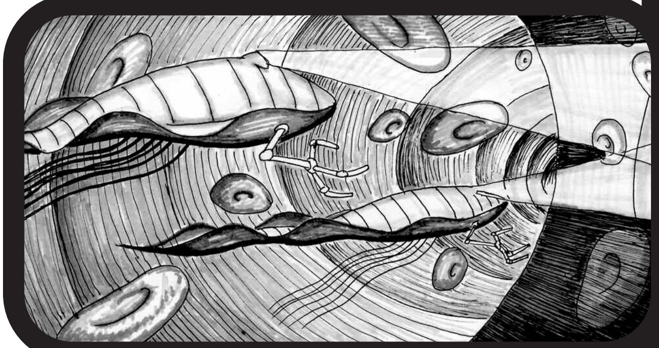
Nanosymbionts

Nanosymbionts (p. TS164) are bionanomachines that reside in a biological body to perform useful physiological alterations. They can be temporary or permanent, with permanent installation being the far more expensive option.

"AquaDude": A common nanomod for water enthusiasts. It is a cheaper alternative to Respirocytes (p. TS165). Provides Extra Fatigue +1 [3] and Breath Holding 2 [4]. $350/$17,500.

Electroreceptors: These nanosymbionts reside in nerve tissue just beneath the user's skin. They are sensitive to electrical fields and initiate artificial nerve pulses under certain conditions, granting the user Field Sense (No Absolute Direction, -50%) [5]. This allows the user to detect electrical emanations, like those from electric fish or equipment, and determine the direction and approximate power level. $600/$30,000.

Lateral Line: Similar to Electroreceptors, but these nanosymbionts detect pressure variations, sending nerve signals that simulate the lateral line sense found in fish. This gives the user Faz Sense (In water, not air, +0%) [10], which allows him to detect erratically moving fish or other creatures in the water, as well as giving a general sense of the surroundings – see p. CI55. $500/$25,000.



Communications, Sensors, and Surveillance

CeTalker: A dedicated NAI system that translates human language (or at least the parts of it that can be translated) into a form understandable by dolphins, and vice versa. It can distinguish various regional and species "dialects" of natural dolphins, as well as the Tursin language used by Doolittles. Communication with baselines is restricted to simple concepts such as food, danger, "go that direction," and so on. A CeTalker transmits audible and ultrasonic sounds into water and receives them with its hydrophone. It interfaces with a VI for human language. A program-only version is available for use with sonarcoders and other hardware. *Stand-alone:* $350, 0.2 lbs., 2A (1 month). *Program-only:* Complexity 5, $300.

Sonar and Aquatic Life

Sound intensity is measured in decibels (dB). A sound with the same "loudness" is 62 dB higher underwater than in air, because of the difference in sound transmission characteristics – subtract 62 dB from an underwater intensity to determine its equivalent intensity in air. Underwater sound levels above 180 dB can cause tissue damage in marine creatures, rupturing membranes surrounding lungs or swim bladders. Low frequency sound of this intensity can also trigger the formation of gas bubbles in the bloodstream of deep-diving animals such as whales and tuna (or deep scuba divers), producing the effects of severe bends, including strokes and death.

In the late 20th century, NATO powers tested low frequency active sonar with an intensity of 230 dB. Because water carries sound better than air, high intensities covered a vast area of sea, allegedly killing whales over 60 miles away from the test zone. Environmentalists also attributed several whale beachings around the world to nearby military sonar activity. After a period of research and public outcry, NATO abandoned plans to deploy these systems throughout the world's oceans.

Less intense sonar systems are now standard in ***Transhuman Space***. At 175 dB, though, an active sonar signal must compete with other man-made sounds and the vocalizations of whales. The cargo ships of 2100 are quieter than their predecessors, but still generate 170 dB as they ply the oceans. Whales produce sounds up to 175 dB.

All this artificial noise has an adverse effect on whale socialization. Prior to the industrial revolution, subsonic whale vocalizations carried thousands of miles around the globe, creating a dense pattern of overlapping sound, similar to being in a crowded room. With other noises now drowning out whales within a few miles, the world feels a lonelier place for them. Cetacean psychologists continue studying the effects of this on whale behavior, but findings are still controversial and laced with bias on both sides.

Combuoy: Combuoys are deployed by divers who wish to remain in radio contact with the surface. The buoy is a 0.25 cf submersible body with DR 10 carbon composite armor, a radio with a range of 200 miles – which can relay via satellite if necessary – and a sonarcoder (see below). A deep-diving variant has a 1,000-foot spool of commline instead of a sonarcoder. The line is tethered to the diver and unspools with virtually no resistance. If the diver swims near obstacles or engages in combat, a DX+2 roll is needed to avoid becoming snagged or entangled. The line can also be tethered to an AUV drone (Move 3) that automatically stays 10 feet above the diver, using sonar to bridge the gap. *Combuoy:* $2,270 (commline variant $1,870), 14 lbs., C (3 weeks). *Drone:* $3,625, 45 lbs., 1E (1 week).

Commline: Rugged optical fiber reinforced with carbon nanofilaments. Commline is 0.01 lb. and $0.1 per yard. Multiply weight and cost by ×1.2 if the line can reel itself in (at 30 feet per second). Stored commline occupies (weight/50) cf.

Portable Sonar Unit: A hand-held or suit-mounted active sonar transceiver with a range of 2,500 feet. The resulting images can be displayed on any VI or HUD. This grants the user the equivalent of Sonar Vision (Superior Signal Discrimination, +20%) [30]. $860, 1 lb., B (3 days).

Sonar Beacon: Used as a noise source for navigation and for locating targets. Can be detected at 1 mile with hydrophones. $80, 2 lbs., 2C (8 hours).

Sonar Datacoder: A sonarcoder (see below) for high-speed data transmission. It uses high frequency ultrasonic signals that can damage cetacean hearing – any character with Ultrahearing or Ultrasonic Speech within range must roll vs. HT to avoid Hard of Hearing for 1 day; critical failure indicates this damage is permanent. Datacoders are legally restricted in many jurisdictions (LC 3). It has a range of 2 miles, and a data broadcast rate of 500 MB/hour. $4,000, 100 lbs. C (5 hours).

Sonar Navigation System Buoy: SNS Buoys are most commonly used on Europa, but are also used on Mars and the sea floor on Earth. They are spherical buoys 3 feet in diameter attached to the sea floor by long cables. Negatively buoyant versions also exist that are designed to hang from a fixed ice cap (usually used on Europa, but also on Mars and in the Arctic). They emit sonar pings at one minute intervals, each buoy having a unique low frequency and ping structure so that they are individually identifiable. The pings can be detected at a range of 10 miles on Earth, 12 miles in the denser seas of Mars and Europa. A more portable emergency version exists as a one-foot diameter sphere, capable of broadcasting sonar pings to 0.5 miles on Earth, 0.6 miles on Mars and Europa. *Tethered SNS Buoy:* $30,000, 15 cf, 850 lbs., 2,000 kWh batteries (6 months). *Portable SNS Buoy:* $3,000, 1 cf, 45 lbs, 5D (10 days).

Sonarcoder: A small ultrasonic transducer that converts audible language and data into a compressed digital sonar emission. It uses the same technology (albeit lower-power) as vehicle-mounted sonarcomms (143). The emitter is usually mounted on a dive mask, with small hydrophones worn over the diving suit to pick up broadcast signals from every direction. The system can broadcast to everyone within 540 feet of water, or use a tight-beam mode with a range of 1 mile. This allows limited data transmission (50 MB/hour); triple ranges if set to voice-only mode. The user effectively gains Ultrasonic Speech and Subsonic Speech. $500, 1 lb., C (500 hours).

Sonobuoy: A buoy that can be deployed from aircraft to scan the water below with sonar and relay data back to the aircraft or a base. Sonobuoys have a small parachute for deployment, GPS for navigation and location, and a radio with 100-mile range. They have a 1-mile sonar range (Scan 11). Passive sonar only: $1,500, 1 cf, 50 lbs. C (24 hours). Active/passive sonar: $5,000, 3 cf, 160 lbs. D (24 hours).

Tracking Receiver: A specialized hydrophone and signal analysis system that detects active sonar transmissions at 2× the range of a standard hydrophone. Provides a rough bearing and range for up to ten sources. $250, 3 lbs., C (50 hours).

Weaponry

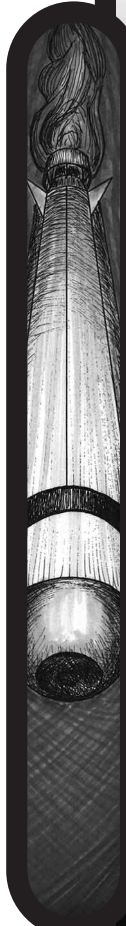
Most of the weapons on pp. TS155-159 are usable underwater, but refer to p. 53 for exceptions and details such as range reductions.

Supercavitating Bullets

Nicknamed "scabs," these are a type of smart ammo (p. TS157) designed specifically for underwater use. These bullets are dynamically shaped by piezoelectric actuators to form a supercavity (see *Supercavitation*, p. 127) and thus travel faster and farther than other bullets. They have 1/20 the gun's Maximum and 1/2 Damage ranges underwater (50 times that of non-supercavitating bullets), and half the normal ranges in air since they are optimized for water. ×2 cost.

Minitorps

15mm and 30mm mini-torpedoes are available for underwater use. Most are fitted with HEMP warheads, but SEFOP and MBC are also available (pp. TS158-159). They are fired from standard launchers and have a fixed range, independent of the launcher. All minitorps are *stabilized* (p. TS157). Homing varieties are available but of limited use because of poor light penetration in water.



Supercavitating

Supercavitating minitorpedoes use a small rocket booster (one second endurance) to initiate the vapor bubble and a longer-burning sustainer motor afterward.

15mm: Travels at Move 25 for one second after fired, then supercavitates at Move 40 for the next two seconds. It does 1d-3 crushing damage if it uses a solid warhead. Can initiate supercavitation at a depth of up to 12 feet. Size Modifier -6, pASig -1. 0.1 lb., $190.

30mm: Travels at Move 30 for one second after fired, then supercavitates at Move 80 for the next three seconds. It does 1d+1 crushing damage if it uses a solid warhead. Can initiate supercavitation at a depth of up to 27 feet. Size Modifier -5, pASig -1. 0.8 lb., $725.

Smart Warheads

See p. TS158 for specific game effects for smart warheads.

HEMP

100mm: 6d × 30 concussion and 10d cutting fragmentation; 5d × 20(10) shaped charge.
300mm: 5d × 1,000 concussion and 12d cutting fragmentation; 3d × 100(10) shaped charge.
400mm: 6d × 2,000 concussion and 12d cutting fragmentation; 4d × 100(10) shaped charge.
600mm: 6d × 6,750 concussion and 12d cutting fragmentation; 6d × 100(10) shaped charge.

SEFOP

100mm: 7d × 40 concussion, and either 2d × 100(5) crushing or 10d cutting fragmentation.
300mm: 6d × 1,265 concussion and either 6d × 100(5) crushing or 12d cutting fragmentation.
400mm: 6d × 3,000 concussion and either 4d × 200(5) crushing or 12d cutting fragmentation.
600mm: 6d × 10,125 concussion and either 2d × 600(5) crushing or 12d cutting fragmentation.

MBC

100mm: Covers 37-hex radius (444 doses) or carries a 4-hex cyberswarm.
300mm: Covers 337-hex radius (37,744 doses) or carries a 125-hex cyberswarm.
400mm: Covers 600-hex radius (119,800 doses) or carries a 296-hex cyberswarm.
600mm: Covers 1,350-hex radius (607,050 doses) or carries a 1,000-hex cyberswarm.

Weapons Table

See the Appendix (p. 148) for more details on the weapons in this table.

Name	*Type*	*Damage*	*SS*	*Acc*	*1/2D*	*Max*	*RoF*
5mm Emag	Cr.	7d+2	12	12	560	3,400	20
55mm Emag	Cr.	6d×22	30	17	3,700	11,000	10
100mm Emag	Cr.	6×60	30	19	11,000	24,000	2
15mm ETC autocannon	Cr.	9d×3	20	15	1,800	7,800	16
60mm ETC autocannon	Cr.	9d×9	25	15	1,800	7,800	4

Microbot Swarms

Underwater cyberswarms use lasercomm instead of radio for communication. This causes brief flashes of light similar to bioluminescence when in action.

Microbot Equipment Packages

The following packages are available for aquatic cyberswarms, using the rules on pp. TS168-171.

EcoClean: Mbungwe Engineering's EcoClean cyberswarm package was designed to look after vulnerable ecosystems. The swarm can be programmed to detect and neutralize many potential threats to living ecosystems, including chemical contamination, foreign organisms, and minor physical damage to nonbiotic components (such as coral substrates). A hex of swarm can patrol an area of 1,000 square feet. $3,500.

Pearlweb: The cyberswarm consists of hundreds of spherical microbots connected by machine-phase struts that can become flexible or stiff. The array of "pearls" can move and rearrange itself for maximum efficiency – forming a 3D array, line, net, or any combination thereof. In an optimal configuration a pearlweb with the Swimmer chassis has double swimming Move (Move 8); other chassis types gain no benefit. Swimmer pearlwebs are fast enough to catch most fish not actively trying to flee. Once one has caught a fish, it engulfs it, restricting water flow to the gills and immobilizing the body, then homes in on a sonar beacon with its prize. Pearlwebs are useful for selective fishing of species with no wasted bycatch and for biological research sampling. They can also be programmed for antipersonnel tasks or to carry other swimming swarms. Large pearlwebs can tackle heavy targets – one capable of catching a human requires six hexes. Pearlwebs have DX 15 and ST 2 per hex; they grapple by winning a Quick Contest of DX and entrapped victims may break free by winning a Contest of ST. $4,000.

Sample Cyberswarms

Lamprey Cyberswarm: A basic aquatic devourer swarm. The swimming microbots are powered by RTGs (p. TS169). These have been deployed on Europa in the War Under the Ice. $10,500 per hex, Move 4, 1 year endurance, 12 hit points per hex, LC 1.

Piranha Cyberswarm: These swimming devourers are disguised as small toothed fish. The individual microbots are larger than most other cyberswarms, so that potential victims seeing the swarm can recognize it and react with fear (GMs may require a Fright Check). Piranha swarms are generally used as guards for sensitive facilities. $11,500 per hex, Move 4, 1 year endurance, 12 hit points per hex, LC 1.

ReefClean Cyberswarm: A swimming swarm with the EcoClean package to take care of fragile or damaged coral reef areas. Uses a gastrobot power system; the microbots must surface a few times a day for air. $8,000 per hex, Move 4, unlimited endurance, 12 hit points per hex.

Living Creatures

Rose Fox looked around her. The world was shimmering blue. She felt the cool currents on her skin. She turned with a kick of her tail, glanced to her left, and saw the hulk of the gillmorph gliding through the water beside her. It was a Frankenstein's monster of tentacles with two human arms, the hottest new design from Biotech Euphrates. Sensing her stares, one of his eyes turned to focus on her. She quickly looked away and suppressed a shudder. She could never understand why Atlantec decided to use such horrid looking bioshells.

There was a buzz in her skull and her AI began translating the ultrasonic speech of her guide. "This way." Apparently to emphasize the point the gillmorph also signed using his arms and tentacles for her to follow him away from the ship. Its gestures were oddly hypnotic.

She swam easily with the fluid grace of her dolphin bioshell. Her echolocation indicated a large object floating in the water just ahead. Before she could tell what it was, the sun was blacked out as a vast shadow loomed overhead. She looked up and was staggered by the size of the thing. "A whale?" she thought, her mind reverting to classification habits from her days as a marine biologist. "No . . . whales aren't that broad . . ."

The gillmorph was waving a sonar transponder at the creature. It slowed and came to a stop in the water, drifting slowly to the surface. "Okay, topside," he buzzed to her.

Rose surfaced and saw the animal was a whale shark, but three times as long as any she'd heard of, and a mottled green color. The Atlantec ship had drawn alongside, and crew were climbing on to the shark's back with hoses and buckets. A man attached a hose to a port near the dorsal fin.

"Emptying the storage bladders," explained the gillmorph in croaky English, "And the engineers are replacing damaged microbots.

"There's an enormous amount of junk floating in the oceans. Plastic, non-biodegradable chemicals, microscopic droplets of oil – the flotsam of two hundred years of abuse and neglect. This leviathan takes all of it out. In the three months between maintenance calls it filters seventy million tons of seawater and collects up to three thousand gallons of stuff it can't process safely. With a hundred or so of these in each ocean we'll be able to remove over twenty thousand tons of pollution a year. Before long the oceans will be cleaner than they've been since the age of sail . . ."

Rose chittered at the gillmorph in Dolphinspeak. "You've convinced me. I'll have my AI authorize the donation immediately."

Diving Squid

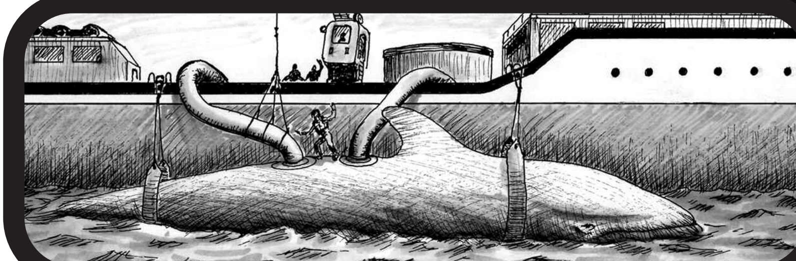
ST: 15	**Move/Dodge:** 12/10	**Size:** 4
DX: 14	**PD/DR:** 1/2	**Weight:** 240 lbs.
IQ: 4	**Damage:** 1d-3 cut	**Habitat:** SW
HT: 14	**Reach:** C, 1-2	

This is a gengineered Humboldt squid about 12 feet long, which is mostly transparent. A diving squid contains a body cavity large enough for one person to fit inside, or two if they are very friendly. A control organ can be used to command and steer the squid, which swims long distances by beating its fins. It can also make short bursts at speeds up to Move 25 by squirting jets of water. Water flows through the cavity, supplying oxygen to water breathing passengers, but air-breathers need their own air supply. Diving squid can dive to about 1,000 feet, but offer no pressure support to their passengers. They are mostly used as short-range transport by underwater dwellers.

Grappler

ST: 16	**Move/Dodge:** 7/7	**Size:** 1
DX: 14	**PD/DR:** 1/1#	**Weight:** 140 lbs.
IQ: 3	**Damage:** 1d-4	**Habitat:** SW
HT: 12/15	**Reach:** C,1,2,3	

Grapplers are bioroid designs using octopus and bivalve features. They live in a shell three feet across and passively filter feed most of the time. Neural implants allow them to recognize friends by receiving a VI code; if anyone without the pass-code approaches the grappler will reach up to three yards from its shell and grab the trespasser. It hits on a successful DX roll, with Dodge the only possible defense. A grabbed victim must win a Contest of ST to break free; if he fails he takes constriction damage. The grappler will hold one person for 48 hours, or until given a release signal. Listed PD and DR are for the body; the shell has PD4, DR 6.



Leviathan Filterer

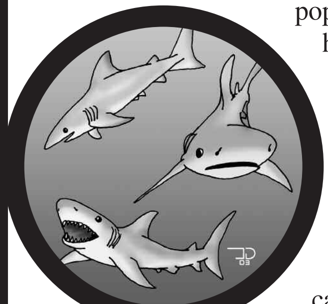
ST: 1200	**Move/Dodge:** 5/-	**Size:** 150
DX: 10	**PD/DR:** 1/4	**Weight:** 150 tons
IQ: 3	**Damage:** -	**Habitat:** SW
HT: 12/800	**Reach:** -	

This is an enormous genemod fish, designed by Atlantec to swim slowly through the oceans filtering the water of any pollutants. Leviathans are based on whale sharks and resemble them, but grow up to 100 feet long. They are passive filter feeders, and also extract solid and liquid contaminants from the water, including many types of waterborne microbots and nanobots they may encounter. Leviathans generally swim near the surface, where photosynthetic cells in their skin allow them to absorb carbon dioxide and produce oxygen. Each leviathan carries a specialized microbot swarm that keeps the creature groomed and free of parasites. The microbots recharge by attaching to solar powered recharge stations implanted in the leviathan's back. Other microbots in the gut assist in breaking down foreign matter. Each leviathan is tracked by satellite; Atlantec ships rendezvous with them to empty storage bladders, replenish microbots, and perform other maintenance.

Smartshark

ST: 25-40 **Move/Dodge:** 9/6 **Size:** 4-6
DX: 13 **PD/DR:** 1/1
Weight: 1,000-2,000 lbs. **IQ:** 4
Damage: 2d-1 cut **Habitat:** SW
HT: 12/20-35 **Reach:** C

Once people began experimenting with gengineering marine creatures, it was inevitable that someone would try to make a smarter shark. These sharks *are* somewhat more intelligent than the unmodified mako sharks on which they are based (which have IQ 3), but their simple neural structures could only take so much improvement. The most notable difference is in behavior. Normal makos are solitary creatures, but smartsharks patrol in packs and use cooperative attack patterns to kill creatures larger than the species would normally tackle, including cetaceans and humans. Several were released into the wild around the Hawaiian Islands, and have established themselves by outcompeting the baseline shark populations. Specimens have turned up all around the Pacific Rim and Preservationist groups fear further losses in several baseline shark species. (Smartshark statistics can also be used for normal sharks.)



Plants and Small Animals

Bulbweed

Modified seaweed that uses cellular osmotic processes to extract fresh water from seawater. It produces 0.1 gal. per sf per day, storing the water in fleshy bulbs that can be harvested daily.

Fibrokelp

Gengineered giant sea kelp produces useful commercial fibers. Fibrokelp grows at fantastic rates, each strand producing a yard of material a foot wide per day. After harvesting and processing, fibrokelp is used for clothing, flexible armor, sails, and building material. A layer of fibrokelp provides PD 1, DR 4 (PD 1, DR 2 vs. impaling), but items made of it cost half the price of arachnoweave (p. TS159).

Starfish Technology

*Nobody wishes on a star**fish** . . .*
– Clare Booth Luce, to Sylvia Earle, 1979
Well, let's hope not.
– Isaac Zakob, Lead Gengineer,
Mbungwe Engineering Minestar Project, 2096

Starfish are incredibly malleable creatures, genetically, and have been adapted for many uses. They have multiple sensitive and dexterous limbs, a natural regenerative ability, and come in sizes from under an inch up to eight feet across. Starfish move slowly, have no effective Dodge, and can only be killed by 1 point of crushing damage per inch of diameter. A point of cutting damage per inch of diameter will sever an arm, but both pieces will eventually regenerate into full starfish. Although more practical technology exists for most purposes, genemod starfish are popular among "wet" technologists.

Foodstars live among human colonies, eating a nutrient mix oozed from pipes for them. Different varieties are color-coded and produce flesh with different designer flavors. Arms can be cut or bitten off and eaten directly – the remaining bodies regenerate rapidly.

Lockstars have a sensitive pad on their top sides. When stroked there, their arms fold to enclose whatever they have been placed on. Another stroke releases the grip. A single lockstar has enough strength to hold 10 lbs. of force per inch of diameter (multiply diameter in inches by 1.7 and round to the nearest whole number to determine ST), and will do so for a day before relaxing and seeking food.

Maintstars live on the surface of underwater structures or vehicles. They feed on algae, barnacles, and other encrusting life-forms, keeping the structures clean and free of fouling. The latest versions can detect stressed metal with a simple magnetic sense and feel eroding aquacrete or other construction material. When they encounter such a spot, they eject an organic dye onto the area, marking it for attention by workers. Maintstars are slowly replacing more expensive maintenance microbots.

Minestars are sterile bioroids designed by Mbungwe Engineering to be scattered from ships over abyssal plains rich in manganese nodules. The foot-wide starfish sink to the seabed and seek out the nodules. When one finds a nodule, it wraps its arms around it and begins inflating an internal bladder with carbon dioxide produced by metabolism. Within a few days, the starfish floats to the surface, carrying its cargo, where skimming ships can collect it. The collected minestars are fed and stored for reuse while the ore is processed. Releasing similar creatures capable of reproduction could have disastrous consequences, and Mbungwe has been exceedingly careful to avoid this.

Gorgonfish

These vile creatures are modified hagfish, the size of pencils, and can swim at Move 4. The hooks in their jawless mouths latch onto victims and a rasping tongue digs into the flesh, causing 1 point of cutting damage. If not removed within 10 seconds, the gorgonfish will have burrowed into the victim, where it feeds on the flesh from the inside, causing another point of damage each minute until removed. They penetrate flexible armor at a rate of 30 seconds per point of DR – rigid armor will stop them completely. Removing an attached fish is difficult because of their slimy skins and wriggling, requiring a successful DX roll with one attempt allowed each five seconds. A single point of damage, or simply crushing in a hand, will kill a gorgonfish. An embedded fish may be removed with a successful First Aid-4 or Surgery roll; the attempt causes 1d-4 points of cutting damage, or none on a critical success. Gorgonfish were originally developed as a prank by a college student, but have since been used in some security applications.

Guardian Urchins

These are spiny sea urchins that produce a deadly neurotoxin. Anyone brushing against the spines must roll vs. HT-6. Failure indicates 3d damage from the venom and nausea and dizziness for 1d hours, causing a -3 penalty to all attribute checks and skill rolls. Critical failure means death within one minute. A successful roll indicates nausea and dizziness for 3d minutes, with -3 to rolls as above. Only a critical success or Immunity to Poison will negate the effects. Guardian urchins are engineered to stay within the range of a weak sonar beacon. Shallow-water shipwrecks and archaeological sites are often protected by urchins, which swarm on every available surface, making it difficult to touch anything without being scratched by one. This protects sites from casual treasure hunters, but does not deter professionals. The urchins must be removed by cybershells.

Pharm Jellies

Biotech companies have turned several jellyfish species into biological drug factories. The grow quickly, turning food particles into cells laden with desired pharmaceuticals. Processing is easy – whole jellyfish are simply fed into a pulper and the drug is distilled out of the slurry.

Vehicle Key

The vehicle descriptions list components in the format described here. Note that components with an unspecified location are considered to be a part of the vehicle's body.

Subassemblies: The major parts of the vehicle. The number following each subassembly is the Size Modifier targeting bonus to hit.

Power and Propulsion: Describes the size and type of all propulsion systems, power plants, and energy banks.

Fuel: Lists amount of fuel or energy bank storage and any additional information, such as the type of fuel tank. Endurance figures are also listed.

Occupancy: Each number is followed by an abbreviation. CCS is a cramped crew station, NCS a normal crew station, and RCS a roomy crew station. Passenger seats use CS, NS, and RS for cramped, normal, and roomy positions, respectively. An exposed position is noted with an X (e.g., XNCS for an exterior normal crew station).

Cargo: Gives capacity in cubic feet.

Armor: Vehicles without this notation have no armor. F indicates frontal armor, RL right and left, B back, T top, and U underbody. If the entire subassembly has the same armor, only one value is listed. Special circumstances are detailed below the armor values.

Weaponry: Vehicles without this notation have no integral weapons. For those that do, the location notation gives the facing of each weapon, as per *Armor*. Ammunition includes all shots stored on the vehicle, not just rounds in a magazine. Following each weapon is the targeting modifier provided by the vehicle's supporting systems.

Equipment: Grouped by location, these are the game-play-essential accessories of the vehicle; others will be described in *Design Notes*, see below. Where a number precedes the module that is the number installed or the VSP it takes up. "Bilge space" is the empty space in the hull or subassembly.

Statistics**:** *Size* is a *rough* indication of dimensions, usually height × width × length. Height is measured from the waterline for flotation hulls. *Payload* is the sum of the occupants, cargo, fuel, and ammunition weights. *Price* is the full price excluding consumables (food, fuel and ammo). *Lwt.* is loaded weight, also known as surface displacement.

The lowercase letter before a performance rating indicates a mode of travel; *a* is air, *w* is water, *u* is underwater, *c* is supercavitating. *Speed* is in mph (halve to get Move in yards per second). *Accel* is acceleration in mph per second. *MR* is the maneuver rating. *SR* is the stability rating. Hydrofoils have separate performance values listed after a slash for when they rise on their foils. For air vehicles, stall speed is the lowest air speed the vehicle can have and still fly; for submersibles see the description of hydrodynamic stall speed (p. 152). For submarines, *crush pressure* is listed.

Design Notes**:** A compilation of everything else; the vehicle accessories and data that rarely come up in play, but are useful for reverse-engineering or modifying the design.

Vehicles

This section presents several vehicle designs commonly encountered in the oceans of Earth. These designs can also be used as guidance for new designs constructed using the Aquatic Vehicle Modular Design System (p. 132).

Verodyne Sea King Hydrofoil Yacht

Verodyne's *Sea King* is the market leader in the midrange yacht market, working off the proven design of the earlier *Sea Skimmer* (p. FW133). Hundreds are found around the world, many in the hands of middle-class citizens of Fourth and Fifth Wave nations that live and work on their ships.

The *Sea King* requires the Shiphandling (Steamer) skill. It has computerized controls. It uses 180 gallons of alcohol per hour. A full load of fuel costs $6,480.

Subassemblies: Large Cutter Body +7; Large Cutter Hydrofoil +5; 0.05-VSP full-rotation open mount -3.

Powertrain: Two 2,500-kW hydrojets in the hydrofoil; two 2,500-kW ceramic engines; two 100-kWh batteries (200 kWh total).

Fuel: Six 2,160-gallon self-sealing alcohol fuel tanks; 72 hours endurance from ceramic engines.

Occupancy: 2 RCS, 2 RS ***Cargo:*** 250 cf

Armor	**F**	**RL**	**B**	**T**	**U**
All:	3/5	3/5	3/5	3/5	3/5

Equipment

Body: Duplicate maneuver controls; 10 cabins; 10-man environmental controls; small Complexity 6 computer with backup; long-range radio; small active/passive sonar (no targeting); precision navigation instruments; radio transponder; 2 bilge pumps; compact safety system; full galley; hall; 6 water filters; 53.3 bilge space.

Open Mount: Small radar (no targeting, surface search).

Statistics

Size: 12.5'×12'×80' *Payload:* 41 tons *Lwt.:* 88.8 tons
Volume: 13,800 cf *Maint.:* 21.7 hours *Price:* $842,730

HT: 8
HP: 3,000 [Body], 750 [Hydrofoils], 5 [Open Mount]

wSpeed: 120 *wAccel:* 11 *wDecel*: 3 (7)/5 (9)
wMR: 0.25/0.5 *wSR:* 6/7

Draft 9 feet. Flotation 375 tons.

Design Notes

Structures are light aluminum and waterproofed. Armor is aluminum. Standard access for ceramic engine and hydrojets. Crew stations have bridge access. Ewt. 95,445 lbs. Base wSpeed is 40 mph before planing; it can begin hydrofoiling at 60 mph.

Verodyne Sunrunner Sport Biphib

The *Sunrunner* is a small personal watercraft that can function both above and under the waves. In many respects it is the marine version of a car, capable of operating almost everywhere that people live in the sea. The vessel uses hydrodynamic lift in order to sink; it does not have a ballast system.

The *Sunrunner* requires the Powerboat skill. It has computerized controls.

Subassemblies: Medium Boat Body +3; Medium Boat Hydrofoil +1.
Powertrain: 100-kW hydrojet; two 100-kWh batteries (200 kWh total).
Fuel: 2 hours endurance from batteries.
Occupancy: 1 RCS, 1 CPS ***Cargo:*** 2.5 cf

Armor	**F**	**RL**	**B**	**T**	**U**
Body:	4/20	4/20	4/20	4/20	4/20
Hydrofoil:	3/5	3/5	3/5	3/5	3/5

Equipment

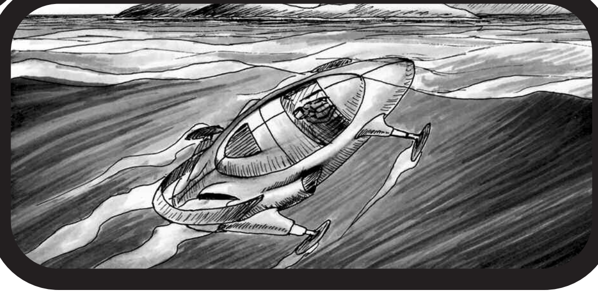
Body: 1 man-day limited life system; Complexity 6 small computer; short-range radio; short-range sonar-comm; simple sonar array.

Statistics

Size: 3'×4'×10' *Payload:* 450 lbs. *Lwt.:* 1.7 tons
Volume: 140 cf *Maint.:* 97.8 hours *Price:* $41,825

HT: 12 *HP:* 450 [Body], 150 [Hydrofoils]

wSpeed: 75 *wAccel:* 12 *wDecel*: 8 (14)
wMR: 0.75/1 *wSR:* 5/5



Draft 1.2 feet. Flotation 3.75 tons.

uSpeed: 15 *uAccel:* 12 *uDecel*: 8 (14) *uMR:* 0.75
uSR: 4
uDraft 3 feet. Crush Pressure 6.2 atm. Stall Speed 9.

Design Notes

Structure is heavy aluminum with lifting body and sealed. Hydrofoils are retractable. Armor is aluminum. Standard access for hydrojet. Ewt. 2,998 lbs. Base wSpeed is 25 mph before planing; it can begin hydrofoiling at 25 mph. Underwater performance assumes retracted hydrofoils.

Supercavitation

Cavitation is the formation of vapor-filled bubbles in a liquid caused by changes in the speed of objects moving rapidly through it. Originally a nuisance when produced inadvertently by screw propellers, cavitation can also be used advantageously.

Supercavitating hulls use careful design to promote the formation of a single vapor-filled cavity – a giant bubble – surrounding most of the vehicle. Creating a supercavity requires moving at high speed, but once the bubble forms, most of the hull is no longer in contact with water. Drag is greatly reduced, allowing the vessel to accelerate to even higher speeds, or to maintain speed with less power.

The cavity is surprisingly robust. Even detonating explosives near a supercavitating craft is not necessarily harmful as very little of the vessel is in contact with the water. Countermeasures against supercavitating vessels include fouling the intake valves of vortex combustor ramjets, causing the engine to overheat, or directly impacting the craft with a kinetic kill warhead, contact explosive, or small supercavitating counter-torpedoes.

Torpedoes and bullets can also be made supercavitating, increasing their speed, range, and (for bullets) damage.

Hicks Mk 90 Supercavitating Torpedo

The Hicks Naval Architecture Mk 90 torpedo is the standard medium-weight torpedo in use by the U.S. and Japanese navies. It has both a long-range "cruise" capability and a supercavitation sprint. A common practice is to release the torpedo from the firing bay, allowing it to float up toward the surface with only the passive-mode sonar activated; when it hits supercavitating depth it can activate the hydrojet to achieve the threshold speed and then activate the vortex combustor and accelerate to over 300 mph in two seconds. The torpedo will usually dive down once supercavitating to make its wake harder to detect.

The Mk 90 requires the Powerboat skill. It has computerized controls. It uses 3,200 gallons of metallic dust per hour. A full load of fuel costs $40. The warhead cost is not included (see p. 121 for warhead prices) and its weight is counted as payload.

Subassemblies: Large Waterbike Body +1.
Powertrain: 95-kW hydrojet; 20,000-lb. VCR; 100-kWh battery; 15-kWh power pack.
Fuel: 20-gallon light metallic dust tank; 22 second VCR endurance. Battery powers hydrojet and sonar for 1 hour. Power pack drives bubble generator for 23 seconds.

Armor	F	RL	B	T	U
Body:	3/5	3/5	3/5	3/5	3/5

Weaponry
300mm Warhead.

Equipment
Body: Complexity 7 microframe computer; short-range sonarcomm; small active/passive sonar (flat: F); advanced electric bubble generator 6.

Statistics
Size: 1.5'×1.5'×15' *Payload:* 404 lbs. *Lwt.:* 1,722 lbs.
Volume: 30 cf *Maint.:* 41.8 hours *Price:* $228,655

HT: 12 *HP:* 360 [Body]

uSpeed: 40 *uAccel:* 22 *uDecel*: 6 (17) *uMR:* 1.25
uSR: 5

uDraft 2.4 feet. Flotation 1,875 lbs.
Crush Pressure 32.7 atm. Stall Speed 1.

cSpeed: 310 *cAccel:* 232 *cMR:* 0.5 *cDecel:* 2 *cSR:* 2
cThresh 35. cDepth 4. cFloor 544.

Design Notes
Structure is extra-heavy foamed alloy and sealed. Advanced submarine lines. The frame has the supercavitating design option. Armor is titanium. No access for hydrojet or VCR. Ewt.: 1,318 lbs.

KPR Design Bureau *Rubikon* Multi-Role Missile

The standard long-range cruise missile of the Indonesian and Malaysian navies, the *Rubikon* is representative of most modern long-range hypersonic anti-ship missiles. The missile can be launched from surface platforms or dropped from aircraft. After expending its solid rocket booster it will have reached a speed sufficient to activate the ramjets. Using the ramjets it will accelerate to cruising speed (typically 20% of top speed) and maneuver to a few feet above the water, using the ladar mode of the AESA in a lookdown mode to stay above the waves. As it approaches the target it activates its AESA in LPI mode to verify the target and its location, then goes passive for the final run at maximum speed. The retractable wings can remain folded for maximum speed or extend for maneuverability.

The *Rubikon* requires the Piloting (High-Performance Aircraft) skill. It has computerized controls. The ramjets use 400 gallons of jet fuel each hour. A full load of fuel costs $639. Rocket acceleration is 69 mph/s. Performance in parentheses is with wings retracted. The warhead cost is not included (see p. 121 for warhead prices).

Subassemblies: Body +2; two Standard Wings +1.
Powertrain: Four 800-lb. ramjets; 12,000-lb. solid rocket (5 second endurance); 40-kWh battery.
Fuel: 213-gallon light self-sealing jet fuel tank. Tank provides enough fuel for 32 minutes at full power. Battery powers all systems for 3.5 hours.

Armor	F	RL	B	T	U
All:	4/20	4/20	4/20	4/20	4/20

Weaponry
400mm Warhead.

Equipment
Body: Medium-range radio; medium sensor suite [F]; radio IFF; inertial navigation system; laser spot tracker [F]; advanced radar/laser detector; Complexity 7 microframe computer.

Statistics
Size: 1'×4'×10' *Payload:*1,385 lbs. *Lwt.:* 1.73 tons
Volume: 70 cf *Maint.:* 7.8 hours *Price:* $6.5 million

HT: 12 *HP:* 75 [Body], 50 [each Wing]

aSpeed: 2,685 (3,100) *aAccel:* 22 *aDecel*: 35 (1)
aMR: 8.65 (0.25) *aSR:* 3

Stall Speed 210. Glide Ratio 28:1.
Glide Speed 1,118.

Design Notes

Body structure is light carbon composite with radical streamlining, wings are heavy carbon composite. Armor is carbon composite and structure is sealed. Structure has basic emission cloaking and radical stealth. Wings are retractable. No access space.

Chernyshev *Kasatka* Patrol Submarine

The *Kasatka* (Russian for "killer whale") is a modern combat submersible used by Iran, India, and several microstates (such as Elandra) for low-endurance patrol and surveillance. It is not a popular design for crews, with grossly inadequate accommodations compared to other patrol submarines, but it is small and extremely stealthy, even on the surface.

The submersible has an outer form hull with a pressure hull inside. It is considered very survivable for such a small vessel, but that is of little consolation to the crew, who are aware that the *Kasatka* has only limited reserve buoyancy (9% of total volume).

The *Kasatka* requires the Shiphandling (Submersible) skill when underwater, or the Powerboat skill when on the surface. It rarely operates on the surface, as it is easily swamped and has a tendency to roll. It has computerized controls.

It uses 336.6 gallons of alcohol per hour. A full load of fuel costs $3,600. Payload weight includes basic armament of six *Mk 90* torpedoes in the cargo bay and 3,400 lb. of carried equipment in the remaining cargo space. Occasionally the craft will carry four more torpedoes (two as cargo and two loaded into the vehicle bays) if it is expecting combat.

Subassemblies: Medium Cutter Body with double hull (form and pressure hulls) +6; 0.05-VSP pop-up full-rotation periscope turret -3.

Powertrain: 5,000-kW hydrojet and 5,100-kW gas turbine in the pressure hull; 8,000-kWh batteries.

Fuel: Four 1,500-gallon self-sealing alcohol tanks; 17.8 hours endurance at full power. Batteries can power all electronics for 127 hours, 1.58 hours including hydrojet.

Occupancy: 3 RCS ***Cargo:*** 350 cf (Pressure Hull)

Armor	**F**	**RL**	**B**	**T**	**U**
Form Hull:	4/20	4/20	4/20	4/20	4/20
Pressure Hull:	4/605	4/605	4/605	4/605	4/605
Turret:	4/30	4/30	4/30	4/30	4/30

Weaponry

Two reloadable vehicle bays (30 cf each) [Pressure Hull: F].

Equipment

Form Hull: Sonar array; large active/passive sonar; 2 long-range sonarcomms; 3 bilge pumps; 120 ballast tanks.

Pressure Hull: Duplicate maneuver controls; 2 bunks; 3-man gill filter; 3-man full life support; Complexity 8 high-capacity mainframe; two Complexity 6 small computers; trailing antenna; inertial navigation system; radio IFF; compact safety system; 2 bilge pumps; 10.2 bilge space.

Turret: Medium-range radio; light sensor suite; 20' periscope system.

Statistics

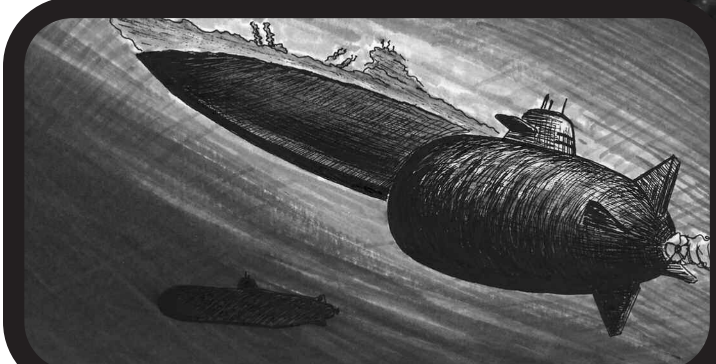
Size: 8'×7'×55' *Payload:* 26.5 tons *Lwt.:* 182.2 tons
Volume: 6,000 cf *Maint.:* 10.7 hours *Price:* $3,336,085

HT: 6 (Pressure Hull 9)
HP: 1,500 [Form Hull], 7,200 [Pressure Hull], 4 [Turret]

wSpeed: 30 w*Accel:* 5 *wDecel*: 10 (13)
wMR: 0.5 *wSR:* 5

Draft 9.5 feet. Flotation 187.5 tons.

uSpeed: 35 *uAccel:* 5 *uDecel*: 5 (8) *uMR:* 0.5 *uSR:* 7
uDraft 14.4 feet. Crush Pressure 261.4 atm (Pressure Hull).



Design Notes

Form hull structure is light aluminum with submarine lines. Pressure hull is a 500 VSP extra-heavy aluminum structure, cylindrical shape, and total compartmentalization. All subassemblies are sealed. Armor is aluminum on form hull, carbon composite on turret, titanium on pressure hull. Uses the extra detail armor volume rule – 16 VSP of form hull armor and 145.2 VSP of pressure hull armor subtracted from form hull volume. Long-term access spaces for hydrojets and gas turbine; standard access for batteries. Crew stations have bridge access. Body has chameleon surface and radical sound baffling. Ewt.: 311,351 lbs. Ballast tanks add up to 37,500 lbs. when flooded with seawater. aASig -4. pASig -8 with gas turbine, -11 running on batteries.

Tangaroa Military Division *Razorback* Subfighter

The *Razorback* and unlicensed copies form the bulk of the TSA subfighter force, often upgraded with new technology sonar and electronics.

The *Razorback* requires the Powerboat skill. It has computerized controls. A full load of supercavitating Emag ammo costs $2,400. Payload weight includes six *Mk 95 LOWS* or *AT-30-90* torpedoes in the cargo bay.

Subassemblies: Small Runabout Body +3.
Powertrain: 380-kW hydrojet; 4,000-kWh batteries; 0.5-kWh power packs.
Fuel: 9.6 hour endurance from battery with all systems active.
Cargo: 40 cf

Armor	F	RL	B	T	U
Hull:	4/100	4/100	4/100	4/100	4/100

Weaponry

Two 5mm VRF Emag [Hull: F] (120,000 rounds) +0.
Two reloadable vehicle bays (6 cf each) [Hull: F].

Equipment

Body: Complexity 7 microframe; sonar array; PESA array; medium active/passive sonar; medium-range radio; long-range sonarcomm; inertial navigation system; radio IFF; compact safety system; bilge pump; 0.7 bilge space.

Statistics

Size: 4’×5’×16’ *Payload:* 1,950 lbs. *Lwt.:* 19,989 lbs.
Volume: 300 cf *Maint.:* 30.1 hours *Price:* $440,040

HT: 12 *HP:* 1,800 Body.

wSpeed: 40 w*Accel:* 8 *wDecel*: 10 (14)
wMR: 1 *wSR:* 3

Draft 2.1 feet. Flotation 18,750 lbs.

uSpeed: 35 *uAccel:* 8 *uDecel*: 6 (10)
uMR: 1.25 *uSR:* 5

uDraft 5.4 feet. Crush Pressure 78.6 atm. Stall Speed 1.

Design Notes

Structure is extra-heavy aluminum and sealed. Advanced submarine lines. The frame has the lifting body design option. Armor is titanium. No access for hydrojet. Body has basic sound baffling and liquid crystal skin. Base wSpeed is 20 mph before planing. Ewt.: 18,039 lbs. uQuiet 19, wQuiet 20. aASig +1. pASig -6.

Short Vehicle Descriptions

The following small vehicles are covered in an abbreviated format – see the Appendix for explanations of their components and construction.

ChargerTech Carryall Cargo AUV

The *Carryall* is a small autonomous underwater vehicle (AUV) used for hauling cargo underwater. When unloaded it must keep moving at 3 mph or it will float to the surface. Requires the Powerboat skill. It has mechanical controls. $9,470.

***Structure**:* Sealed Large Waterbike (SM +1, 45 HP, HT 10, 1,875 lbs. flotation) with old light aluminum structure. Submarine lines. PD 3, DR 10 aluminum armor. 8’ long. 30 cf total volume.

***Equipment**:* 10-kW hydrojet (standard access); 40-kWh batteries (4-hour endurance); small Complexity 6 computer; short-range sonarcomm; sonar array; 4.5 cf cargo hold; 0.25 lead ballast (887.5 lbs.).

Weights: Ewt 1,335 lbs. Payload 450 lbs. Lwt 1,785 lbs.

Performance: wSpeed 10; wAccel 2; wDecel 10 (11); wMR 0.75; wSR 3; Draft 0.7’; uSpeed 15; uAccel 2; uDecel 10 (11); uMR 1; uSR 5; uDraft 2.4’; Stall Speed 1; Crush Pressure 6.2 atm.

Asagai Ikan Mas Waterski

The *Ikan Mas* (Malay for “goldfish”) is one of the most popular personal watercraft on the world market, and has enjoyed consistently high sales in Australia, the

United States, and China. Requires the Powerboat skill. It has mechanical controls. $9,470.

Structure: Waterproofed Medium Waterbike (SM +1, 30 HP, HT 12, 750 lbs. flotation) with old light aluminum structure. PD 2, DR 2 foamed alloy armor. 4' long. 12 cf total volume.

Equipment: 80-kW hydrojet (standard access); 160-kWh batteries (2-hour endurance); 1cCS; 2.5 cf cargo hold.

Weights: Ewt 370 lbs. Payload 250 lbs. Lwt 620 lbs.

Performance: wSpeed 70; wAccel 52; wDecel 8 (34); wMR 1; wSR 3; Draft 0.9'.

Tabarka MotorTech Bizerte Motorboat

The *Bizerte* is typical of many small boats. It is powered by cheap ducted screw propellers and the controls are limited to throttle and steering. Requires the Powerboat skill. It has mechanical controls. A full load of fuel is $5. $8,920.

Structure: Waterproofed Small Runabout (SM +3, 225 HP, HT 12, 9.3 tons flotation) with old light aluminum structure. Fine hydrodynamic lines. PD 3, DR 5 aluminum armor. 20' long. 300 cf total volume.

Equipment: 60-kW ducted screw (standard access); 60-kW ceramic engine (standard access; 2.16 gph of alcohol); 10-gallon self-sealing tank (4.6-hour endurance); 1 XRCS; 5 XRS; radio transponder; 16.5 bilge space.

Weights: Ewt 1,968 lbs. Payload 1,258 lbs. Lwt 3,226 lbs.

Performance: wSpeed 25; wAccel 7; wDecel 3; wMR 0.5; wSR 3; Draft 1.2'.

H.T.D Palani Hardsuit

Hawai'i Technical Designs produces cutting-edge hardsuits for the commercial and military markets. The *Palani* is one of their most popular designs, and is a common sight at underwater mining facilities. It has proven to be a rugged and dependable vehicle. It is a one-person mini-submarine, shaped like a torpedo, with a transparent bubble dome at one end and two cybernetic manipulator arms. Requires the Powerboat skill. It has computerized controls. Uses the extra detail armor volume rule. $53,935.

Structure: Sealed Large Waterbike (SM +1, 360 HP, HT 12, 1,875 lbs. flotation) and 0.1 VSP full-rotation turret (SM –2, 24 HP) with old extra-heavy aluminum structure. No hydrodynamic lines. PD 4, DR 40 titanium armor (0.48 VSP) on body, PD 2, DR 5 titanium armor on turret. 8' tall. 31 cf total volume.

Equipment: [Body] 10-kW vectored hydrojet (no access); 50-kWh battery (3.9 hour endurance); 1 CCS; 1-man environmental control; 1-man gill filter; Complexity 6 small computer; radio transponder; short-range sonarcomm; 2 cheap ST 10 arms; 0.9 ballast tanks. [Turret] Short-range radio; light sensor suite; tiny active/passive sonar (flat:F, no targeting).

Weights: Ewt 1,450 lbs. Payload 200 lbs. Lwt 1,650 lbs.

Performance: uSpeed 7; uAccel 2; uDecel 10 (13); uMR 1; uSR 5; uDraft 2.4'; Crush Pressure 53.9 atm.

Korsakov AT-30-90 *Lightweight Torpedo*

The Russian navy fielded the AT-30-90 in 2090 to upgrade their small torpedo capability against the new generation of combat submersibles; it is typical of conventional non-supercavitating submarines. The manufacturer markets a number of variants with specialized warheads, electronics, and even propulsion systems. Cheap versions without a warhead or computer are used as target drones. It has an integral 1,000-yard retractable commline (p. 120) and can be maneuvered from the launch vehicle passively before being released. It has positive buoyancy and bobs to the surface if it is not moving. Requires the Powerboat skill. It has computerized controls. The warhead cost is not included (see p. 121 for warhead prices). $13,125.

Structure: Sealed Small Waterbike (SM +0, 30 HP, HT 12, 375 lbs. flotation) with a medium titanium structure. Advanced submarine lines. PD 3, DR 5 titanium armor. 6' long. 6 cf total volume.

Armament: 300mm warhead.

Equipment: 75-kW hydrojet (no access); 35-kWh batteries (27 minutes endurance); Complexity 6 small computer; short-range sonarcomm; small active/passive sonar (flat: F).

Weights: Ewt 264 lbs. Payload 36 lbs. (warhead) Lwt 300 lbs.

Performance: uSpeed 50; uAccel 80; uDecel 5 (30); uMR 1.25; uSR 5; uDraft 1.4'; Stall Speed 2; Crush Pressure 8.9 atm; uQuiet 7; aASig +0; pASig –1.

Hicks Mk 95 LOWS *Advanced Torpedo*

The Mk 95 LOWS is similar to the Russian *AT-30-90* but can be launched from greater depths and has a more robust computer. Requires the Powerboat skill. It has computerized controls. The warhead cost is not included (see p. 121 for warhead prices). $175,010.

Structure: Sealed Small Waterbike (SM +0, 120 HP, HT 12, 375 lbs. flotation) with an extra-heavy metal matrix composite structure. Advanced submarine lines with radical sound baffling. PD 4, DR 21 metal matrix composite armor. 6' long. 6 cf total volume.

Armament: 300mm warhead.

Equipment: 50-kW hydrojet (no access); 50-kWh batteries (57 minutes endurance); Complexity 7 microframe computer; short-range sonarcomm; small active/passive sonar (flat: F).

Weights: Ewt 264 lbs. Payload 36 lbs. (warhead) Lwt 300 lbs.

Performance: uSpeed 45; uAccel 45; uDecel 5 (30); uMR 1.25; uSR 5; uDraft 1.4'; Stall Speed 2; Crush Pressure 66.6 atm; uQuiet 30; aASig -5; pASig –11.

APPENDIX: AQUATIC VEHICLE MODULAR DESIGN SYSTEM

Battleships are the ships of yesterday, aircraft carriers are the ships of today, but submarines are going to be the ships of tomorrow.

– Fleet Admiral Chester W. Nimitz, U.S. Navy, 1945

The system presented here is based on ***GURPS Vehicles,*** *Second Edition* – tailored for designing watercraft in the ***Transhuman Space*** universe. It is compatible with the Wheeled Vehicle Modular Design System from ***Transhuman Space: In The Well***. Prefabricated habitat components (p. 112) may also be used in vehicles (and some vehicle modules are suitable for use in habitats).

Starting Out

This system measures volume in VSPs (vehicle spaces) of 5 cubic feet – 1% of a 500-cubic-foot "space" on a spacecraft (p. TS173). Weight is given in pounds. Cost is in dollars. Surface area is in square feet (sf). Power requirements are in kilowatts (kW) and most fuel requirements are in gallons per hour (gph). A capital M next to a number means millions and a capital K means thousands; i.e. M$2.5 means $2,500,000. It is helpful to keep track of these statistics during the design process to make sure that they remain balanced.

Step 1: Concept

The most important part of this system is deciding what you want the vehicle to be; in particular, if the vessel is primarily intended to operate on the surface or underwater. The following sections give example concepts to help determine where the ship fits in to the world of ***Transhuman Space***.

Surface Craft

Waterbike: Small one- or two-man high-performance personal watercraft. Often designed with advanced materials and oversized propulsion systems. A few "hydroskis" also use a hydrofoil system for maximum speed and maneuverability in calm seas.

Yacht: A civilian vessel built with attention to some combination of comfort, safety, and performance, usually supporting a complement from two or three up to a dozen or more for extended periods.

Patrol Boat: Lightly-armed boat with some type of sensor package. Common armament is a mix of small emags in turrets, open mounts for infantry heavy weapons, and up to a dozen missiles.

Cruise Ship: Luxury transports are still a common sight on the world's oceans, but they are much smaller than the massive proto-freedom ships (see p. 17) that plied the seas in the mid-21st century (the largest active vessel carries 1,000 passengers). Many are built around a central theme, such as an Egyptian temple or insect hive.

Freedom Ship: More a floating city than a ship, with its own banks, entertainment facilities, small factories, and docks. A few even have aircraft landing strips.

Submersibles

Biphib: A small vehicle that is a combination of waterbike and submersible. They range in size from small one-man craft that the operator straddles like a motorcycle to two-man models that are completely enclosed.

Research Sub: Small, usually unmanned, submersible vehicles used for long-term underwater studies. A few are licensed to use RTGs or even small nuclear power plants and can stay underwater for months or years.

Recreational Sub: Civilian submersibles ranging in size from cramped two-person sightseeing models powered by batteries to large fusion-powered "yachts" that can hold over a hundred individuals in luxury.

Subfighter: Combat submarines (usually unmanned) armed with torpedoes and machine guns. These subs are

Area Requirements

The required minimum working area for a man-sized individual on the top deck is 9 sf. Cargo holds require 5 sf of top deck area for every VSP of open cargo. A standard cargo container stack requires 200 sf on the deck, with up to six containers per stack. This includes space for narrow alleys between rows.

Vehicles stowed on deck require a number of sf equal to their total surface area divided by 4. Double the result for helicopters and vehicles without folding wings.

often deployed from larger vessels using vehicle bays or conformal mounts. Many are designed with a supercavitating "sprint" option, but most sub operators avoid using it for stealth attacks. Subfighters can be deployed from vehicle bays or mounted conformably to the hull.

Cargo Sub: Although there has been little economic incentive to replace surface cargo vessels with submersibles, a number of such vehicles shuttle goods and people between underwater facilities and the surface.

Strike Submarine: An underwater weapons platform that can serve a variety of functions. Most strike subs are small and stealthy, armed with long-range missiles, torpedoes, UCAVs, and even laser arrays for attacking low-orbit assets while surfaced. Arsenal submarines take this a step further, with dozens of bays capable of holding missiles, torpedoes, special operations cybershells, or even subfighters.

Carrier Submarine: Large submersibles that can carry dozens of UCAVs, such as the *Strix* (pp. TS124-125) and a handful of larger manned aircraft. The craft are often deployed like cruise missiles, encapsulated in a sealed container and ejected underwater, launching when they break the surface.

Flotation Rating

Flotation Rating is a measure of the total buoyancy of the vessel. As long as the vessel weighs less than the fluid it displaces, it will float. Once a vessel as been through the design process outlined in this chapter, make sure that its cumulative weight does not exceed its flotation rating.

Surface Flotation: Record flotation as hull VSP × 375 × liquid density (see *Calculating Pressure*, p. 48). This value does not change based on modifiers to VSP or local gravity. This should be considered the absolute maximum design weight for the ship or submarine. *Note:* This is a simplification of the ***GURPS Vehicles*** rule.

Submerged Flotation: Here the principle of buoyancy can work against the vessel, as submersibles must be able to achieve negative buoyancy (i.e. sink) in order to dive. Submarines use the sum of sealed (and unflooded) hull and nonretractable superstructure VSP when calculating submerged flotation. When underway at their intended depth, submarines can intentionally vent some of their ballast tanks or drop weights to achieve positive buoyancy and rely on their forward movement to keep them at a constant depth.

Step 2: Hull Design

This table offers a number of common hull sizes from which a ship or submersible can be built. Each chassis includes the basic framework for the vehicle body but no armor. To the right of the hull data is an *optional* hydrofoil subassembly. A vessel may pick a hydrofoil assembly matched to a larger hull if desired (but it may not exceed the main hull's VSP).

Flotation Hulls

There are dozens of hull design techniques for vessels that rely on their displacement of water to float. The following are a few of the more common.

Catamaran: Flotation ships using two slender hulls joined by a bridging structure. Wave-piercing catamarans have a modified bow that allows them to ride through waves rather than over them, increasing stability in rough seas and improving passenger comfort. Slender catamarans have fine hydrodynamic lines. Many catamarans incorporate fin stabilizers (p. 149).

Trimaran: Trimarans have most of their buoyancy in a center hull, flanked by two smaller "wing" hulls. Build as a multihull, often with fine lines.

Foil-Cat: A catamaran or trimaran with a hydrofoil array. In many foil-cat designs, some of the outside hulls remain in the water for additional stability.

Small Waterplane Area Twin (or Tri) Hull (SWATH): Sometimes considered a specialized catamaran, SWATH vessels have one or two subsurface pods connected to the main hull by struts. This places most of the ship's buoyancy beneath the hull, reducing the effects of wave action and allowing the vessel to operate in otherwise dangerous seas. Build as a multihull with smaller submarine-lined hulls representing the pods.

Dynamic Lift: Hydrofoils and semiplaning monohulls plane, or "fly," rather than float. Hydrofoils use submerged wings to create lift, gradually transferring support of the vessel in the water from 100% buoyancy to 100% foil lift. Semiplaning monohulls use a deep, V-shaped hull at the front and a wide concave rear to generate lift as the vessel rises out of the water at high speed. Build hydrofoils as hulls with a hydrofoil subassembly. Semiplaning monohulls should be built with fine lines and the lifting body option.

Hull Table

	Hull							Hydrofoil					
Type	*VSP*	*Wt.*	*Cost*	*HP*	*Area*	*Top*	*Size*	*VSP*	*Wt.*	*Cost*	*HP*	*Area*	*Size*
Small Waterbike	1	80	$1,000	30	20	5	+0	0.2	24	$300	9	6	-2
Medium Waterbike	2	160	$2,000	60	40	10	+1	0.4	40	$500	15	10	-1
Large Waterbike	5	240	$3,000	90	60	20	+1	1	72	$900	27	18	+0
Small Boat	10	400	$5,000	150	100	30	+2	2	120	$1,500	45	30	+0
Medium Boat	20	600	$7,500	225	150	50	+3	4	200	$2,500	75	50	+1
Large Boat	30	800	K$10	300	200	60	+3	6	240	$3,000	90	60	+1
Small Runabout	50	1,200	K$15	450	300	100	+3	9	400	$5,000	150	100	+2
Medium Runabout	100	2,400	K$30	750	500	160	+4	18	500	$6,250	188	125	+2
Large Runabout	200	4,800	K$60	1,200	800	260	+5	36	800	K$10	300	200	+3
Small Cutter	500	12,000	K$150	2,250	1,500	500	+5	90	1,800	K$22.5	600	400	+4
Medium Cutter	1,000	24,000	K$300	3,000	2,000	660	+6	180	3,600	K$45	900	600	+4
Large Cutter	2,000	48,000	K$600	6,000	4,000	1,330	+7	360	7,200	K$90	1,500	1,000	+5
Small Corvette	2,500	60,000	K$750	6,000	4,000	1,330	+7	450	9,000	K$112.5	1,800	1,200	+5
Medium Corvette	4,000	96,000	M$1.2	7,500	5,000	1,660	+7	720	14,400	K$180	3,000	2,000	+6
Large Corvette	5,000	120,000	M$1.5	9,750	6,500	2,160	+8	900	18,000	K$225	3,000	2,000	+6
Small Frigate	10,000	240,000	M$3	15,000	10,000	3,330	+8	1,800	36,000	K$450	4,500	3,000	+6
Medium Frigate	20,000	480,000	M$6	22,500	15,000	5,000	+9	3,600	72,000	K$900	7,500	5,000	+7
Large Frigate	30,000	720,000	M$9	30,000	20,000	6,670	+9	5,400	108,000	M$1.35	9,750	6,500	+7
Small Escort	50,000	1,200,000	M$15	45,000	30,000	10,000	+9	9,000	180,000	M$2.25	12,000	8,000	+8
Medium Escort	75,000	1,800,000	M$22.5	60,000	40,000	13,300	+10	13,500	270,000	M$3.375	15,000	10,000	+8
Large Escort	100,000	2,400,000	M$30	75,000	50,000	16,700	+10	18,000	360,000	M$4.5	22,500	15,000	+8
Small Arcoblock	500,000	12,000,000	M$150	180,000	120,000	40,000	+11	–	–	–	–	–	–
Medium Arcoblock	1,000,000	24,000,000	M$300	300,000	200,000	66,000	+12	–	–	–	–	–	–
Large Arcoblock	10,000,000	240,000,000	M$3,000	1,380,000	920,000	310,000	+14	–	–	–	–	–	–

Type is descriptive term used for each size of hull.
VSP is the number of "vehicle spaces" of components that can be installed.
Wt. is the weight of the structural frame in pounds.
Cost is the cost of the hull in dollars.
HP is the hull's hit points, assuming a frame of medium strength.
Area is the surface area in square feet.
Top is the area of the top deck, if any, in square feet. People can walk on the deck and cargo can be stacked there.
Size is the Size Modifier (p. B116) to target the hull or subassembly.

The VSP figures in the *Hull Table* are based on *usable volume*. The usable volume of a ship is the VSP of the hull modified by hull shape. The result is the amount of volume in VSP that remains usable for the powertrain, tanks, cargo, and other components. All hulls from the table below have *average* or *submarine* lines (see *Hydrodynamic Lines*, below).

Hull Options

Hydrodynamic lines and hull shapes affect the usable volume inside a vessel, but they do not change the original VSP, which is used to determine flotation rating (see box, p. 133) and total volume. Multiply hull VSP by the numbers on the *Hydrodynamic Lines and Hull Shapes Table*.

Hydrodynamic Lines

A craft moving through water is faced with resistance in the form of *hydrodynamic drag*. Hydrodynamic lines reduce water resistance by minimizing the wetted area (surface area actually in the water) or shaping the hull to minimize the drag induced from bow waves and other sources. Hulls from the *Hull Table* (see box) have *average* or *submarine* lines by default (for flotation hulls and submersibles respectively).

Surface vessels that are basically just a box, such as barges, have *no lines*. Cargo vessels and ships with low drafts will have *mediocre* lines. Deep-V hulls and high length-to-width ratios typify *fine* hydrodynamic lines. Submersibles with *advanced* lines will be sleek cylinders or oblongs.

Hull Shapes

Multihull: Catamaran and trimaran designs. Can only be used with vessels that have mediocre, average, or fine lines. Not compatible with the sphere or cylinder shapes.

Hydrodynamic Lines and Hull Shapes Table

Lines	*VSP*
No Lines	×1.2
Mediocre	×1.1
Average	×1
Submarine	×1
Fine	×0.9
Advanced Submarine	×0.9
Hull Shapes	*VSP*
Multihull	×0.8
Sphere	×0.5
Cylinder	×0.8

Frame Strength

This represents the overall structural integrity of the hull and incorporates many factors – cross-bracing, load balancing, stress seams, etc. – that affect hull weight and crush pressure. The table assumes a hull of *medium* strength, but other options are available. A high-performance speedboat has a *light* frame. Most submersibles have *heavy* frames. Military vessels are usually *extra-heavy*. Flimsy outer form hulls on submarines may be *extra-light* but will be prone to cracks and buckling. Multiply hull weight, cost, and HPs by the numbers on the *Frame Strength Table*.

Frame Strength Table

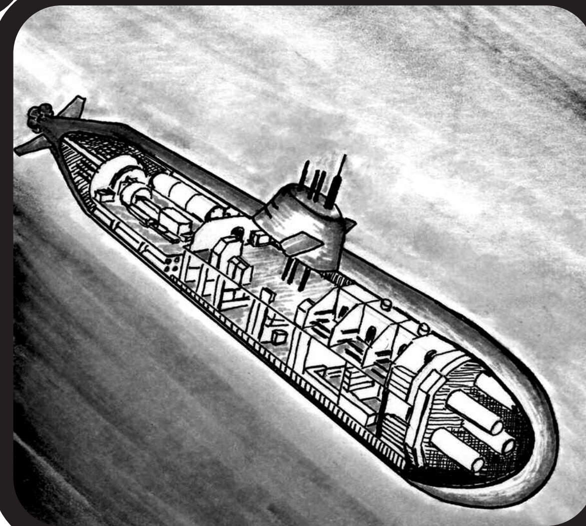
Strength	*Wt.*	*Cost*	*HPs*
Extra-Light	×0.25	×0.25	×0.25
Light	×0.5	×0.5	×0.5
Medium	×1	×1	×1
Heavy	×1.5	×2	×2
Extra-Heavy	×2	×5	×4

Materials

These materials are described on p. TS174. The *Hull Table* (p. 134) assumes the frame is made of aluminum. For different materials, multiply hull weight and cost by the numbers from the *Materials Table.*

Materials Table

Material	*Wt.*	*Cost*
Cheap Steel	×1.5	×0.25
Steel	×1.25	×0.5
Aluminum	×1	×1
Titanium	×0.75	×1.5
Foamed Alloy	×0.625	×2
Carbon Composite	×0.375	×10
Metal Matrix Composite	×0.25	×30
Nanocomposite	×0.15	×100
Diamondoid	×0.1	×500



Structural Options

For a given option, multiply hull cost by the numbers from the *Structural Options Table*. *Responsive* and *smart* are only available for ships whose structure *and* armor are diamondoid, nanocomposite, metal-matrix composite, or carbon-composite. *Flexibody* is only available for ships with the responsive option.

Flexibody: This option allows the ship's hull to undulate like a fish. It is required in order to use a fin drive (p. 139).

Lifting Body: The hull is designed to produce maximum hydrodynamic lift.

Old: Older vessels often lack the embedded computers and data networks of modern vehicles. Infomorphs can still control the vessel if it has computerized controls. May not be combined with smart or responsive.

Responsive: A responsive hull incorporates micromechanisms that alter hull shape in response to varying hydrodynamic environments and speeds, increasing maneuverability.

Smart: The hull incorporates micro-robotic sensors and processors, allowing self-diagnosis of structural damage and stress.

Supercavitating: Supercavitating ships tend to be long and skinny. Bow- or strut-mounted control surfaces stabilize the craft inside the bubble and create drag to allow maneuvering. The ship cannot have *no lines*.

Structural Options Table

Option	*Cost*
Flexibody	×1.5
Lifting Body	×1.2
Old	×0.5
Responsive	×1.5
Smart	×2
Supercavitating	×5

Submarine Hulls

There are three main varieties of submarine hulls:

Single hulls have everything inside the pressurized body. Sonar transducers are mounted externally, as they must be in contact with a working fluid in order to function.

Double hulls have internal pressure hulls surrounded by an external hydrodynamic form hull, with a free flood space at ambient pressure between them. Some larger submersibles have two or more internal pressure hulls, which may or may not have access between them after submerging.

Hybrid hulls are double-hulls, but with portions of their pressure hulls in direct contact with the sea, and areas where the pressure hulls are indented and hydrodynamic fairings cover free flood areas (such as the bow sonar) and main ballast tanks.

Double hulls and hybrid hulls allow the pressure hulls to be cylindrical – a shape that is less expensive to build and more resistant to pressure – while using an outer hull shape with superior hydrodynamic stability and efficiency.

Compartmentalization

Large vessels are split into a number of compartments that can be sealed off in case of flooding. Well-protected civilian and military ships have additional watertight interior walls, extra-strong pressure doors, and carefully spaced fuel and power systems to reduce damage in the case of flooding.

Heavy compartmentalization weighs 10% of the hull or subassembly's structural weight, figured after any adjustment for strength or materials. *Total compartmentalization* is 20% of structural weight. Either costs $5 per pound of weight added.

Step 3: Subassemblies

Many vessels have one or more subassemblies attached to the hull (or a larger subassembly). For example, a surface ship may have an additional superstructure used as a command center, living quarters, or simply a place to stand higher over the water. When adding a subassembly, select its volume in VSP from the *Subassemblies Table* below. This is the volume the subassembly adds to the vehicle

Arms are described in *Manipulators*, p. 146.

Hydrofoils typically take the form of vertically mounted "wings" with an underwater airfoil that generates lift, bringing the main body of the ship out of the water – significantly reducing drag. Only 20% of their volume is usable for components – typically aquatic propulsion systems and sensors. Components in hydrofoils are not accessible from the main hull but access space can be provided to allow easier maintenance. Do not use the *Subassembly Table*, p. 137, for hydrofoils – hydrofoil statistics are given in the *Hull Table* on p. 134.

Internal Compartments are contained inside the main hull, representing special compartments. The most common examples are the pressure hulls of submarines, reinforced compartments that hold the crew quarters, engines, and vulnerable systems. Internal compartments do not add to the ship's total area (p. 134) but may be armored or sealed separately. Subtract their volume from the hull or subassembly in which they are installed.

Lift Planes: A subassembly up to 50 VSP in size may be designated as a lift plane. Planes are usually installed in pairs of matching size. Multiply weight, cost, HP, and area by ×1.5.

Concrete Hulls

Most vessels that use rock or concrete hulls do not have a discernible "hull" and are built by pouring concrete around the molded forms where components will be fitted. Do not use the hull weights, costs, or HP from the *Hull Table*. Instead, determine how much of the vessel will be usable volume (that is, how much is hollowed out of a chunk of concrete in the size and shape of that hull) after applying any modifications for hydrodynamic lines. The remaining volume that is not used for components is solid concrete. The type of concrete and reinforcing mixture determines hull weight; do not use the frame strength modifiers on p. 135.

Hull Weight: A concrete-frame vessel weighs (in pounds) M × U, where *M* is 900 for a heavy concrete and 600 for light concrete, and *U* is hull VSP, minus the number of spaces taken up by components.

Hull Cost: Multiply hull weight by $0.01.

Hull HP: Multiply the hull HP by 0.5 for heavy concrete and 0.25 for low density.

Hull DR: The hull construction itself provides starting DR. Divide hull weight by 15 and divide the result by the surface area. Note that concrete DR is ablative (p. 138). Additional armor may be layered over the concrete.

Subassemblies: As these lack the built-in hydrodynamic lines use an M of 750 for heavy concrete and 500 for light concrete.

Open Mounts are brackets, pedestals, or masts used to mount equipment – usually sensors or weapons – *outside* the ship's structure. For more details, see box, below.

Superstructures are structures mounted on top of the hull, like a conning tower. If the vessel will have a superstructure, select its volume in VSP.

Turrets are rotating superstructures that require volume in the hull or subassembly on which they are mounted. For each turret, decide if it has limited (180°) or full (360°) rotation and where it is placed. Other turrets or superstructures may restrict the actual arc of fire. *Pop turrets* can retract into the hull when not in use. For more details, see box.

Subassemblies Table

VSP	*Wt.*	*Cost*	*HP*	*Area*	*Size*
0.05	10	$125	4	2.5	-3
0.1	16	$200	6	4	-2
0.2	24	$300	9	6	-2
0.5	44	$550	17	11	-1
1	72	$900	27	18	+0
2	120	$1,500	45	30	+0
5	240	$3,000	90	60	+1
10	400	$5,000	150	100	+2
20	600	$7,500	225	150	+2
50	1,000	$12,500	375	250	+3
100	2,000	$25,000	600	400	+4
200	4,000	$50,000	900	600	+4
500	10,000	$125,000	1,800	1,200	+5

Wt., *Cost*, *HP*, *Area*, and *Size* have the same definitions as those on the *Hulls Table* (p. 134).

Rotation Space

Turrets require rotation space in the hull on which they are mounted. Determine this (in VSP) by multiplying the subassembly's VSP by: ×0.1 if limited rotation, ×1.1 if limited-rotation pop turret, ×0.2 if full rotation, ×1.2 if full-rotation pop turret.

Open Mounts: Instead of subtracting rotation space from the supporting structure they subtract it from their own volume. Do not use the listed cost, weight, and HP from the *Subassemblies Table* – simply note the surface area. Multiply surface area by 3 to get weight in pounds, by $10 to get cost, and by 2 to get HP. For example, a 5-VSP open mount is 180 lbs., $600, 120 HP.

Subassembly Options

Subassemblies may be given different structural strengths, materials, and structural options than the hull. Use the *Frame Strength Table*, *Materials Table*, and *Structural Options Table* to design individualized subassemblies. Hydrofoils must have frame strengths at least as great as the main hull. If the *responsive* or *smart* options are applied to *any* subassemblies, they must be applied to *all* subassemblies. This does not apply to open mounts, which may not have different structural options from the hull.

Retractable: A subassembly (usually a hydrofoil or arm) can be designed to retract fully into the hull. It requires its volume ×1.2 in the hull when retracted. Extension or retraction takes 10 seconds; propulsion systems and other components installed in the retracted subassembly may not function when it is retracted (GM discretion). The vehicle may not be moving at greater than its base wSpeed when extending hydrofoils or lift planes. If retractable, a ST 10 manipulator requires 0.01 VSP of internal space; 0.1 VSP for the ST 100 arm.

Spherical Shapes have less usable volume but are far more resistant to crushing pressures. They may not have any form of hydrodynamic lines. Multiply usable volume by ×0.5. This can be applied to hulls as well – apply the modifiers for *no lines* first, then apply the spherical shape modifier.

Cylindrical Shapes are typical shapes for internal compartments designated as pressure hulls. Multiply usable volume by ×0.8.

Periscope/Sensor Mast

A periscope is an extendible sensor stalk that can be used on the surface while most of the vessel remains underwater. Sensors, and even weapons, can be placed in the periscope. Periscopes do not extend into pressure hulls; they use fiber-optic relays to transmit sensor data to crew stations or monitors. Periscopes rarely exceed 60 feet in length; beyond that point it is more economical to use AUVs and tethered buoys.

Treat a periscope as a partial- or full-rotation turret or open mount, but increase rotation space by 10% for every foot of length it can extend; e.g. a 10 VSP 30-foot full rotation periscope will have a (3 × 0.2 × 10) 6 VSP rotation space. A periscope extends or retracts at 10 feet per second.

Step 4: Armor

All ships must have some armor to help them survive the extremes of their environment. A vessel's armor may be made of a different material than the hull. With the exception of plastic armor (a cheap epoxy laminate) these armor materials are described on p. TS174.

To armor the entire ship, determine its *total area* (the sum of the surface area of the hull and all subassemblies). Alternatively, the hull and individual subassemblies can be given different armor; to armor just the hull, use the surface area of the vessel's hull type from the *Hulls Table*; to armor subassemblies (see *Subassembly Armor*, see below), use each one's own area from the *Subassemblies Table* (p. 137). Decide on the armor's material and DR using the tables (see below), and then use the formulae below to calculate its weight and cost. Most watercraft must have a minimum of DR 5 to withstand common environmental hazards such as rough waves. A high DR makes a vessel heavier, slower, and more expensive, but also more likely to survive combat or other harsh usage.

Use the surface area of the vessel's hull type to armor just the hull, or the surface area of the hull plus the surface area of the subassemblies to armor the entire ship.

Laminate Armor: The composite types of armor, and diamondoid, are considered to be laminate armor, with DR doubled against shaped-charge warheads like HEDP and HEAT.

Armor Table

Type	*M*	*C*	*D*
Plastic	0.1	$0.5	250
Cheap Steel	0.6	$0.25	2,500
Steel	0.5	$0.5	2,500
Aluminum	0.4	$1	1,000
Titanium	0.3	$1.5	1,500
Foamed Alloy	0.25	$2	250
Carbon Composite	0.15	$10	750
Metal-Matrix Composite	0.1	$30	1,500
Nanocomposite	0.06	$100	1,000
Diamondoid	0.04	$500	1,000

M is the weight of one square foot of DR 1 armor and *C* is the cost per pound of the armor. *D* is the density in pounds per VSP.

Figure armor weight (in pounds) as:

Armor Weight = Area to be armored × DR × M

Calculate the armor cost (in dollars) using this formula:

Cost = Armor Weight × C

Subassembly Armor

Subassemblies (such as arms or turrets) may be armored separately from the hull, so they have a different DR or use different armor materials. In this case, use only the area of the subassembly or the hull, rather than the structural area, when making armor calculations.

Location Armor

The armor on a subassembly or hull may have a DR that varies by facing. If face-specific armor is desired, multiply DR by the number of faces, and redistribute "DR points" among them. Hulls have six faces: front (F), back (B), right (R), left (L), underside (U) and top (T). Subassemblies have five faces; exclude the face attached to the hull. Open mounts may only be armored on one face. Arm armor may not vary by face.

Passive Defense

This depends on DR. DR 1 gives PD 1, DR 2-4 gives PD 2, DR 5-15 gives PD 3, and DR 16+ gives PD 4.

Concrete and Plastic Armor

Light concrete and plastic DR is ablative; for every 10 points of damage it sustains (regardless of whether it protects or not) one point of DR is destroyed afterward. Heavy concrete is more rugged, subtract 1/10 of its DR from each hit before determining how much is ablated.

Optional Rule: Armor Volume

A suggested optional rule accounts for the thickness of the armor on the vehicle. To find the volume of armor on a subassembly (in VSP), divide the weight of the armor by the density D listed in the *Armor Table*. This armor volume will usually subtract from the usable volume of that location, but for additional complexity it can increase the total *hull volume* (see *Volume*, p. 150) by 5 cubic feet per VSP of armor volume. Note that foamed alloy and plastic are less dense than water.

Step 5: Powertrain

Even ships that simply sink and surface will have one or more power plants that drive a propulsion system.

Aquatic Propulsion

Most vessels rely on proven propulsion technology – ducted propellers, fin drives, and hydrojets. Electromagnetic ducted waterjets, biomechanical pumpjets, and other technologies are less common. None of these systems, common or uncommon, function while supercavitating.

Ducted Screw Propeller

The ducted propeller is the most common propulsion system for civilian and military surface craft where cost is more important than efficiency or speed.

Fin Drive

The ship can bend and ripple sections of its hull like a fish to generate thrust. Only ships with a flexibody hull can use fin drives.

Hydrojets

Also know as "aquajets," hydrojets suck in water and expel it at high speed to create thrust. Their biggest advantage over screw propellers is that they are quiet, lightweight, and do not suffer from cavitation.

Powertrain Weight Table

Type	*per kW*	*Base Weight*	*Cost*	*Thrust*
Ducted Screw	4	80	$5	20
Fin Drive	3	135	$200	35
Hydrojet	1	20	$40	20

Per kW and *Base Weight* are used to figure the overall powertrain weight: Multiply the system's output in kW by the *per kW* figure then add the *Base Weight* to get overall weight in pounds.

Cost is multiplied by overall weight.

Thrust is multiplied by the output in kW to get aquatic thrust in pounds while in the water.

Volume: Most vehicles require access space for the powertrain to allow maintenance to be performed. Use the following formulae to figure the total volume of the powertrain, including access space if any is needed. For *standard access* space, divide weight by 125 to find the system's total volume in VSPs. Divide the weight by 250 if there is *no access* – requiring partial disassembly or cyberswarms for repair. For ships with *long-term access* there are human-sized engineering spaces and the powertrain can be repaired from inside the hull; divide weight by 80. In all cases, round *up* to the nearest tenth of a VSP.

Rockets

Rockets on naval craft are most often used by submersibles to attain the speeds required to supercavitate, and to propel them once they have formed the vapor bubble.

Liquid-Fuel Rockets

These use a mixture of fuel and oxidizer, expelling hot exhaust to create thrust. For underwater use the most common type is hydrogen-oxygen, since the fuel is cheap.

Vortex Combustor Ramjet (VCR)

These use a metal dust, usually aluminum or magnesium, and the surrounding water to generate thrust. They can be used while supercavitating, as the intakes extend beyond the air bubble.

Active Flotation

Any aquatic propulsion system except a flexibody can be installed to point up or down, so its thrust offsets part of the vehicle's weight or adds to it.

Vectored Thrust: An active flotation system may be built with vectored thrust (1.5 × weight, volume, and cost). This enables it to increase or decrease loaded weight for flotation purposes and to propel the vehicle. Actual thrust will vary on what percentage of the total thrust is devoted to propulsion.

Solid Rocket

These include their own fuel, but once activated they cannot be turned off! They burn 85% of their weight as fuel; refueling takes several hours and costs 20% of the original cost. Each solid rocket module provides 1,400-lb. minutes of thrust, i.e. 1,400 lbs. for one minute, 2,800 lbs. for 30 seconds, 700 lbs. for two minutes, etc. The burn time *must* be set when the rocket is designed.

Rockets Table

Type	*VSP*	*Wt.*	*Cost*	*Thrust*	*Fuel*
HO Rocket	1	240	$6,000	10,000	66,000HO
VCR	1	250	$25,000	10,000	1,600MD
Solid Rocket	1	500	$2,500	spcl.	spcl.

VSP, Weight, and Cost: This is per rocket module.

Thrust is aquatic thrust in pounds per rocket.

Fuel is consumption in gallons per hour (gph) for each rocket module. The fuel used is hydrogen-oxygen rocket fuel (HO) or metallic dust (MD). Multiply gph by 0.03 to get the VSP of fuel tanks required per hour of operation.

Volume: The total volume of the rocket is calculated in the same manner as aquatic propulsion systems (above). Rocket modules do not require access space.

Power and Fuel

The ship's propulsion system and components require power. This can be provided by any combination of the following systems.

Air-Breathing Engines

Internal combustion engines require oxygen at about Earth-normal pressure to work; they do not function underwater, in vacuum, or in extraterrestrial atmospheres significantly lacking in oxygen. All can be modified to run closed-cycle in the absence of air. Submersible vessels include a snorkel that allows operation 15 feet below the surface of the water. A snorkel has a +0 Size Modifier to detect or hit.

Fuel Table

Fuel	Wt.	Cost
Alcohol	5.8	$0.5
Synthetic Gasoline	6	$5
HO Rocket Fuel	2.1	$0.1
Hydrogen	0.58	$0.1
Liquid Oxygen	9.6	$0.1
Metallic Dust	18.4	$2

Wt. and *Cost* is per gallon.

Reactor Weight Table

Type	per kW	Base Weight	Cost	Core	Endurance
Radiothermal Generator	5	75	$50	$3,750	14 years
Fission Reactor	2	4,000	$50	K$250	2 years
Fusion Reactor	1	22,000	$200	M$5	200 years

Per kW and *Base Weight* are used to figure the overall weight: Multiply the engine's output in kW by the *per kW* figure then add the *Base Weight* to get overall weight in pounds.

Cost is multiplied by overall weight and added to the *Core* cost.

Volume: The total volume of the power plant and its required access space are calculated in the same manner as aquatic propulsion systems (p. 139). Radiothermal generators typically do not have access space and are very compact; divide weight by 500.

Ceramic Engine: An advanced rotary engine made of lightweight materials, and capable of running on many different fuels. Most burn cheap alcohol blends.

Gas Turbine: Derived from jet engine technology, with spinning turbine blades rather than pistons. Optimized turbines are designed for fuel-efficiency.

MHD Turbine: Magneto-hydrodynamic turbines use magnetic fields and ionized plasma as their working medium. They are coupled to a hydrogen-burning turbine.

Hydrogen Fuel Cell: These electric power plants produce power chemically by combining hydrogen and oxygen. As a by-product, fuel cells produce water, which may be stored for consumption, or turned back into fuel. Every gallon of hydrogen used produces 0.63 gallons of water. It takes 2 minutes to start up a hydrogen fuel cell.

Hydrocarbon Fuel Cell: These consume hydrocarbon fuels and atmospheric oxygen, producing water and carbon dioxide.

Nuclear Power Plants

Radiothermal Generator (RTG): These power plants use a thermoelectric system to convert the heat from a decaying radioisotope to energy. There are no moving parts and the radioisotope lasts several years.

Fission Reactor: An atom-splitter. Power is produced directly using thermoelectric materials rather than by driving a steam turbine.

Fusion Reactor: Generates energy through the D-helium-3 cycle (p. TS66).

Batteries and Power Packs

Batteries have largely replaced internal combustion engines as the primary source of power in small- to mid-sized marine vessels. Batteries can report their remaining charge through a data connection (built into the installation slots) or via v-tags.

Batteries are 1 lb., 0.02 cubic feet, and $30 per kWh of storage. Battery technology

Engine Weight Table

Type	per kW	Base Weight	Cost	Fuel
Ceramic engine	3	15	$6	0.03M
– if turbo or supercharged	2	10	$12	0.03M
Gas turbine	1	15	$30	0.055M
– if optimized	2	25	$12	0.045M
– if high-performance	0.5	10	$80	0.06J
MHD turbine	1	35	$20	0.18H
– if high-performance	0.4	28	$80	0.2H
Hydrogen fuel cell	5	25	$5	0.115H
Hydrocarbon fuel cell	5	50	$5	0.04M

Per kW and *Base Weight* are used to figure the overall weight: Multiply the engine's output in kW by the *per kW* figure then add the *Base Weight* to get overall weight.

Cost is multiplied by overall weight.

Fuel is consumption in gallons per hour (gph) for each kW of output. The fuel used is multi-fuel (M), hydrogen (H), or jet fuel (J). Multiply gph by 0.03 to get the VSP of fuel tanks required per hour of operation.

Volume: The total volume of the engine and its required access space are calculated in the same manner as aquatic propulsion systems (p. 139).

and common consumer battery sizes are discussed on pp. TS140-141.

Power Packs: These carbon nanotube flywheels can release energy instantly. They are used to power beam weapons and emags. Multiply energy storage capacity by ×0.1.

Volume: Batteries rarely have access space (they have just enough room for an operator to plug them in) Otherwise they use the same guidelines for access space as aquatic propulsion systems.

Storage Tanks

Storage tanks can hold fuel, water, or other liquids. Tanks are rated in increments of 3 VSP, each holding 100 gallons. Fuel tank modules may be combined to produce a big tank, or divided for a smaller tank. All tanks are self-sealing and will automatically close small punctures if damaged.

Light tanks are built with expensive polymers and composites to decrease weight, but they are slightly more prone to leaks.

Storage Tanks Table

Type	*VSP*	*Wt.*	*Cost*
Standard Tank	3	100	$1,000
Light	×1	×0.5	×2

Ballast Tanks

Ballast tanks come in two varieties: main and variable.

Main ballast tanks (MBT) are the large variety of ballast tanks and are usually mounted external to the pressure hull. They are open at the bottom so they always stay at ambient pressure and have a vent valve at the top. On the surface the MBT are filled with air or other gas; to submerge the vent valves on top open, venting the gas and allowing water to flood in from below. To surface, the vent valves are closed and gas is added to the top of the MBT, displacing water through the open bottom. Emergency MBT blows use gas from high-pressure air tanks or explosive gas generators to rapidly displace the water from the tanks. Most submarines have 10-30% of their volume (known as reserve buoyancy) taken up by MBTs.

Variable Ballast Tanks (VBT) are smaller and several are distributed over the length and breadth of the submarine to assist in balance and stability by pumping the contents between themselves and the MBT. These tanks are usually within the primary pressure hull.

For most design purposes the two types are used interchangeably. They are purchased as storage tanks; multiply cost ×2 to cover the trim and venting pumps. Ballast tanks can normally be emptied in 30 seconds or filled in 6 seconds at 1 atm. For extra realism, multiply time required to empty the tanks by the square root of the outside pressure in atmospheres times the percentage of tank capacity being emptied. Each VSP of ballast tank can add up to 312.5 lbs. × liquid density to loaded weight when flooded.

Air-Breathing Engine Options

The engines described here are only necessary for submerged vehicles, or those operating above the water on other planets.

Multi-Fuel

Multi-fuel assumes the use of gasoline. Multiply fuel consumption by 1.2 if alcohol is used. Hydrocarbon fuel cells will not run on alcohol but can run on hydrogen; multiply fuel consumption by 3.45.

Closed Cycle Operation

Some engines can operate closed-cycle in the absence of oxygen. Closed-cycle systems, with the exception of hydrogen fuel cells, are not completely closed since they must vent exhaust gasses – which creates noise and a chemical trail that can be followed by wake sensors.

Ceramic Engine, Gas Turbine, MHD Turbine: The engine operates in a carefully managed atmosphere created from oxygen (stored as a cryogenic liquid), recycled exhaust products, and an inert gas (such as argon). The engine exhaust – carbon dioxide, nitrogen, and water vapor – is cooled, filtered, and separated, and the inert gas is recycled. The remaining exhaust gases are mixed with the surrounding liquid and discharged (often from the ballast tanks). Multiply weight, volume, and cost of the engine by ×1.5. Add an additional fuel consumption of 2.35 gph of liquid oxygen (LOX) per gph of other fuel consumed. At extreme pressures (100 atmospheres or more) it can be difficult to discharge these gasses.

Hydrogen Fuel Cell: Add a LOX requirement equal to half the fuel consumption. Fuel cells have only water exhaust and are completely silent.

Hydrocarbon Fuel Cell: Add an additional fuel consumption of 2.35 gph of liquid oxygen (LOX) per gph of other fuel consumed.

Regenerative Fuel Cell

This is a hydrogen fuel cell that can operate in reverse, retaining the water exhaust and regenerating the hydrogen. Every 1 kWh regenerates 0.115 gallon of hydrogen. It requires atmospheric oxygen or must be operated in closed cycle. Multiply weight and volume by ×1.5 and cost by ×2.

Step 6: Vehicle Component Modules

Aquatic vehicles are built out of "vehicle component modules" or simply "modules." All modules are rated for VSPs, weight, and cost. Certain modules are also rated for power requirements (in kW) and fuel consumption (in gph). Select a number of modules to fill out the vehicle's internal space.

Internal Space

Internal space is the hull's VSP, minus any modifications for hydrodynamic lines or reduction for turret rotation space. Modules may also be placed in subassemblies, which have their own internal space (but see p. 136 for restrictions on hydrofoils). Be sure to note if a component is in the hull or a subassembly.

Crew and Passengers

The components below cover both the practical needs of the crew and the comfort requirements of the occupants.

Controls

These are used to maneuver, accelerate, and decelerate the vehicle. A vehicle must have controls unless it is unmanned. Submersible versions include the necessary diving controls and systems. The first set of controls costs $1,000, with no weight, volume, or power requirements. The statistics for extra sets of controls are listed in the *Control Modules Table* (see below).

Computerized Controls: Standard controls display information on multifunction digital displays. Digital links connect every system on the ship to report status, damage, and any mechanical problems.

Mechanical Controls: Old mechanical controls are found on some manned vehicles; they cannot be remote controlled or operated by infomorphs.

Duplicate Controls: Large ships and submarines may have multiple sets of controls.

Control Modules Table

Type	*VSP*	*Wt.*	*Cost*
Computerized Controls	0	0	$1,000
Mechanical Controls	0	0	0
Duplicate Computerized Controls	0.1	25	$500
Duplicate Mechanical Controls	0.2	50	$100

Seats and Crew Stations

Seats are just that – a seat inside the vehicle that isn't assigned to control anything. A crew station is a position manned by a single crew member. It controls one or more vehicle systems, and includes a seat and console. Cramped stations and seats have very little room and are uncomfortable to work in, normal stations have more elbow room, and roomy stations are typically seen in those vehicles built for comfort or long duration occupancy. All seats include seat belts.

Cycle Stations: If the vehicle has a cycle crew station, passengers are normally also in cycle seats (weighing only 5 lbs.). It can only be used on vehicles that require only one crew station and are 10 VSPs or less. Cycle seats are exposed.

Seat Modules Table

Type	*VSP*	*Wt.*	*Cost*
Cramped	4	20	$100
Normal	6	30	$100
Roomy	8	40	$100
Exposed	×0.5	–	–
Cycle Station	0	10	$50
Cycle Seat	0	5	$50

Options for Occupants

Bridge Access: Large vessels often group several important crew stations together as a "bridge" to allow space for officers to move about and to install common facilities. Multiply the volume of all dedicated bridge stations by ×3.

Improved Access: Extra space can be added to vehicles with crew stations or seats, to allow occupants to move without displacing anyone else, and to recline the seats comfortably. Multiply seat volume by ×1.5.

Quarters

Quarters are bunks or cabins for vessels that will be occupied for long periods. They include laundry, wash, and waste deposal facilities commensurate with the number of occupants and common facilities like bathrooms, passageways, and food preparation facilities, at no extra cost. Extra VSPs may be added to quarters to increase their spaciousness without increasing their cost or weight.

Hammock: A hanging bed constituting minimal sleeping accommodations for one person.

Bunk: A fixed bed, usually in a cramped alcove or room with other bunks. The hammock and bunk both include a small (1 to 5 cubic feet) locker for personal possessions.

Cabin: A furnished room for one or two people. A luxury variant with more opulent fittings is also available.

Quarters Modules Table

Type	VSP	Wt.	Cost
Hammock	20	100	$20
Bunk	20	200	$100
Cabin	100	2,000	$3,000
Luxury Cabin	200	4,000	$10,000

Environmental Systems

Environmental Control: Provides standard heating, air conditioning, etc. It cannot deal with extreme conditions, but adjusts temperatures by up to 40°F toward the occupants' comfort zone.

Gill Filter: An artificial gill and regulator system that draws oxygen from the surrounding water and adjusts oxygen partial pressure to match the internal environment (up to 100 atm.).

Limited Life System: As for environmental controls, but also provides bottled oxygen and water for a limited time. Limited life systems are rated in *man-days*; 100 man-days will keep one person alive for 100 days, or two people alive for 50 days, or four for 25 days, etc. The vehicle must be sealed.

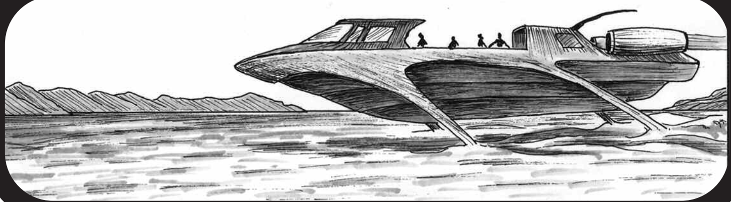
Full Life System: A self-regenerating life system capable of working indefinitely by recycling waste products. A full life system has a basic volume, weight, and cost, plus an additional requirement for each person it supports. The vehicle must be sealed.

Environmental Modules Table

Type	VSP	Wt.	Cost	Power
Environmental Control	0.02	5	$50	0.25
Gill Filter	0.04	10	$400	5
Limited Life System	0.4	100	$500	*
Full Life System Core	2	800	$5,000	–
– plus, per person	2	200	$500	10

* The power requirement of a limited life system is 0.5 kW × the number of occupants (*not* the number of man-days).

Support: Each environmental control module or full life system component will support *one* occupant. Buy one for each person the vehicle is expected to hold. Each limited life system module provides one man-day of life support and provisions; multiply the weight, VSP, and cost by the number of occupants and desired duration.



Electronics

Computers

The computers listed on p. TS141 are available for ships. Volume in VSP is equal to weight divided by 250; power consumption is negligible. Large ships often have several computers networked together for redundancy.

Communication Systems

Radio: A standard radio. On Earth, parts of Mars, and other areas with a local cellular network, radios can be used to connect to the phone system, so their range becomes moot. Radios are not useful underwater.

Sonarcomm: Uses pulse-coded sonar to transmit information. Text-only messages can be sent much farther (10× the listed range).

Laser Comm: A tight-beam communication system. The recipient must be visible and have a laser comm of his own. It is impossible to eavesdrop on a laser communication without blocking the beam.

Laser Receiver: A sensitive system of detectors and signal processors enabling laser comm signals to be received at greater depths. It multiplies the effective range of the transmitting laser by ×100 for purposes of determining if it can be received. It has no transmitting capability.

Trailing Antenna: A 900-foot-long cable that can be extended by a submerged vehicle to float to the surface and act as a standard radio antenna.

Communications Modules Table

Type	VSP	Wt.	Cost	Power	Range
Short-Range Radio	neg.	0.12	$25	neg.	100
Medium-Range Radio	neg.	0.5	$100	neg.	1,000
Long-Range Radio	0.02	5	$300	neg.	10,000
Short-Range Sonarcomm	neg.	1.25	$250	neg.	1
Long-Range Sonarcomm	0.02	5	$300	0.1	10
Laser Comm	0.2	50	$3,750	0.4	20,000
Laser Receiver	4	1,000	$3,750	neg.	spcl.
Trailing Antenna	0.06	15	$150	–	–

Range is in miles.

VLF Receiver: Any of the radio modules can be designated as very-low frequency receivers. VLF radio has a longer range underwater (see p. 21), but datalinks are not possible and two-way voice communication is problematic. VLF transmitters require massive antennas and are not usually installed on vehicles. Multiply VSP, weight, and cost by ×10.

Sensors

Unless otherwise noted all sensors require a line of sight and must have a facing chosen at installation. Sensors may be mounted in small turrets (p. 137) to give 180° or 360° coverage. Most sensors cannot see over the horizon.

PESA: Passive Electromagnetic Sensor Arrays combine a passive millimetric-band radar, thermograph, and low-light imager. They provide the advantages of Infravision (p. B237) and Night Vision (p. B22). They have a magnification capability equal to their range in miles, with a minimum magnification of 1×.

Ladar: Tunable ladars (LAser Detection And Ranging) are difficult to confuse or jam, but they are highly degraded by turbid water and do not detect objects beyond the air-water boundary with any great success.

Radar: A conventional radar system. Can be spotted by radar detectors at twice its range.

Low-Resolution Imaging Radar (LRIR): A low-frequency millimetric radar, able to determine a target's general shape and outline.

High-Resolution Imaging Radar (HRIR): This uses millimetric radar frequencies, allowing resolution approaching human vision. It cannot resolve flat details or color.

AESA: Active Electromagnetic Sensor Arrays are capable of switching between radar and laser imaging (ladar) functions. Halve range (-2 Scan) when operating in ladar or LRIR mode. In HRIR mode range is 1/50 normal (-10 Scan), with each "mile" actually representing 35 yards. It can switch to a "low probability intercept" radar mode as well; halve range (-2 Scan) but it can only be detected at 1.5 times the radar's (halved) range.

Sensor Suites

Navigational Lights: All vessels are assumed to have a number of small navigational lights that can illuminate a 3-foot area out to 135 feet and can be seen 2,700 feet away. They reduce fog penalties by half. There is no cost for standard running lights.

Searchlight: Projects a bright beam of visible light, illuminating a 30-foot radius out to 5 miles. The searchlight itself is visible for 10 miles.

PESA Array: A band of four PESAs arranged around the ship.

Sonar Array: A set of five active/passive sonars with the no-targeting and flat array options spaced around the sides and bottom of the hull. These can create a detailed map of the surrounding seabed and locate nearby objects. In busy harbors they will map out the locations of other sonar-equipped vessels and note the location of sonar beacons. This system provides a +2 to Navigation rolls close to shore or shoals.

Light Sensor Suite: A small PESA and low-res imaging radar in one package, suitable for most civilian vessels or as a periscope sensor on submersibles. The PESA has a 12-mile range (Scan 17), and the AESA has a 4.5-mile range (Scan 15).

Medium Sensor Suite: An upgraded set of sensors designed for light combat vehicles and some scientific missions. The PESA has a 36-mile range (Scan 20), and the AESA has a 45-mile range (Scan 21).

Heavy Sensor Suite: A set of sensors intended for combat vessels. The PESA has a 100-mile range (Scan 23), and the AESA has a 225-mile range (Scan 25).

Sensor Modules Table

Type	*VSP*	*Wt.*	*Cost*	*Power*	*Range*	*Scan*
Searchlight	0.2	50	$2,500	5	–	–
PESA Array	neg.	0.2	$80	neg.	1.5	12
Sonar Array	0.04	15	$750	1.25	0.1	5
Light Sensor Suite	0.04	10	$22,770	1.1	*	*
Medium Sensor Suite	0.4	93	$216,180	11.25	*	*
Heavy Sensor Suite	3.8	959	$2,065,625	126.56	*	*
Individual Sensors						
Small AESA	0.03	7.5	$12,500	1.25	5	15
Medium AESA 0.3	75	$125,000	12.5	50	21	
Large AESA	3	750	M$1.25	125	500	27
Small PESA	0.05	12.5	$50,000	neg.	25	19
Medium PESA	0.9	112.5	$450,000	neg.	75	22
Large PESA	5	1,250	M$5	neg.	250	25
Small Ladar or LRIR	0.05	12	$15,000	3	6	15
Medium Ladar or LRIR	0.5	120	$150,000	30	60	21
Large Ladar or LRIR	5	1,250	$625,000	312.5	250	25
Small Radar	0.02	5	$2,500	1.25	5	15
Medium Radar	0.2	50	$25,000	12.5	50	21
Large Radar	0.6	250	$75,000	37.5	250	25

Range is in miles.

No Targeting: AESA, Ladar, LRIR, and radars are available in versions that cannot be used for targeting. Multiply VSP, weight, and cost by ×0.5.

Air/Surface Search: Radars can be optimized for ground or air search, at the expense of the other (Scan –5 in secondary mode). Multiply cost by ×0.5.

Sonar Modules Table

Type	*VSP*	*Wt.*	*Cost*	*Power*	*Range*	*Scan*
Tiny Sonar	0.08	20	$2,000	1	0.5	9
Small Sonar	0.16	40	$4,000	2	1	11
Medium Sonar	4	1,000	$100,000	50	5	15
Large Sonar	16	4,000	$400,000	200	10	17
Massive Sonar	64	16,000	$1,600,000	800	20	19
Immense Sonar	144	36,000	$3,600,000	1,800	30	20
Options						
Active/Passive	×1.5	×1.5	×1.5	×1	–	–
Passive	×0.5	×0.5	×0.5	neg.	×2	+2
Flat	×0.5	×0.5	×0.5	0.5	–	–
No Targeting	×1	×1	×0.5	×0.25	–	–
New Technology	×0.5	×0.5	×4	×1	–	–

Individual Sensors: Sensors can also be bought individually. Ladars and low-res imaging radars (LRIRs) have the same statistics.

Sonar

Sonar detects targets by emitting a beam of sound using *transducers* and measuring the time it takes for the echoes to return. Active sonar can determine range, size, and speed of a moving object as well as the shape of stationary objects and the ocean floor. Repeated pulses can determine the general shape and course of a moving object.

The basic sonar system is a multifrequency three-dimensional array with hydrophones and transducers built into the skin, providing 360° coverage. Basic sonars are active-only, and cannot effectively function in a passive (listening) mode. However, they can function as an IFF pinger at twice their normal range. A number of options are available for sonar:

Active/Passive: The sonar can switch to a passive hydrophone mode. Listening range is double that of the active range (+2 Scan).

Passive: The sonar cannot operate actively. It can determine approximate distance, course, elevation, and speed to a target but not size or shape.

Flat: Sonar systems that only cover a single hemisphere (forward or rear) are more compact and less expensive.

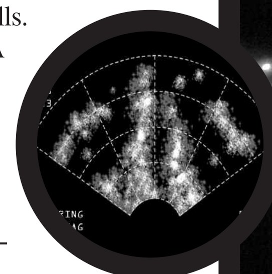
No Targeting: The sonar cannot be used for targeting.

New Technology: The sonar uses cutting-edge multifrequency adaptive technology that can range from low-frequency, long-range scans to high-frequency sonar imaging, and do it fast enough to form a broad sensor composite of the surrounding area. New sonars are also more compact, taking advantage of the latest in distributed computing and signal analysis.

Navigation

These modules help the vehicle find its position. A magnetic compass is free, but useless on worlds without a strong magnetic field (e.g., Mars). All computers come with Global Positioning System (GPS) hardware and software for free.

Precision Navigation: A system of gyroscopic compasses, star-tracking devices, and radio-navigation systems that can be used on planets without a GPS network. When using dead reckoning the instruments give +5 to all Navigation rolls.



Inertial Navigation System: A sophisticated gyroscopic system that allows a vehicle to keep track of its location as it travels. It is accurate to within 1 foot per 10 miles traveled, but will correct any drift when it encounters known landmarks or a navigational relay.

Radio IFF: "Identify Friend or Foe," a specialized radio that broadcasts encrypted identifying information. IFF systems can be detected at the same ranges as a long-range radio. A transponder is a civilian version and can also broadcast an emergency signal to any LEO satellite overhead.

Navigation Modules Table

Type	*VSP*	*Wt.*	*Cost*	*Power*
Precision Navigation	0.08	20	$5,000	neg.
INS	0.04	10	$12,500	neg.
Radio IFF	0.02	5	$1,000	neg.
Radio Transponder	0.01	2.5	$500	neg.

Countermeasures

Laser/Radar Detector: This sensor automatically warns of any radar emissions or if a laser targets the ship. It can also determine the range and bearing of a radar or radar jammer (out to twice the radar's range or 20 times an area jammer's usual range) as well as the make and model of the system and its current operating mode (if an appropriate database is available).

Area Jammer: This device projects a signal that interferes with radio and radar, subtracting -10 from any rolls to detect with radar or communicate with radio by everyone within 50 miles (friend or foe). Reduce this penalty by 1 for every additional mile.

Sonar Jammer: The aquatic version of the area jammer, interfering with sonar systems by broadcasting carefully crafted multifrequency acoustic signals to overpower and deceive active and passive sonars. Sonar Vision and passive sonar is penalized by -8 within 4 miles; active sonar suffers only half the penalty. Reduce the penalty by 1 for every additional half mile. Individuals with Ultrasonic or Subsonic hearing within the radius of effect of a sonar jammer must make a HT roll each hour at the same penalty to avoid disorientation (-2 on all tasks) and are effectively deaf.

Countermeasure Modules Table

Type	*VSP*	*Wt.*	*Cost*	*Power*
Laser/Radar Detector	0.06	15	$1,500	neg.
Area/Sonar Jammer	0.8	200	$40,000	1,000

Manipulator Modules Table

Type	*ST*	*Volume*	*Area*	*Wt.*	*Cost*	*Power*	*HP*	*Size*	*Reach*
Expensive	10	0.06	1	6	$11,000	0.05	12	-4	1
Expensive	100	0.6	5	45	$85,000	0.5	60	-2	2
Cheap	10	0.06	1	11	$6,250	0.05	12	-4	1
Cheap	100	0.6	5	70	$61,250	0.5	60	-2	2

Reach is the arm's reach in yards. Each arm may also contract to half this length.

Manipulators

A vehicle may have arms, designed for manipulating external objects. Unlike most modules, arms do not usually occupy VSP in the vehicle; they are attached to the outside. The total weight of all arms may not exceed half the ship's hull weight. The vehicle face each arm is attached to must be specified. They are not considered to be armored or have any surface options (such as sealing), but can be given those options just like a subassembly.

Expensive arms are made with carbon composite, extra-heavy frames, and smart structure.

Cheap arms are made with aluminum alloy and extra-heavy frames.

Miscellaneous Equipment

These are other modules that may be installed in or on vehicles.

Airlock: As per the *Airlock* habitat module, p. 113.

Arrestor System: Retractable nanoweave wire or net that can snag an arrestor hook. On a successful catch the landing vehicle is slowed by up to 100 mph (or landing vehicle HT ×10, whichever is less). Vehicles without an arrestor hook are slowed by half that amount, but if not stopped completely they must make a control roll. Vehicles that are not stopped continue on at their new, reduced, speed.

Bilge Pump: Bilge pumps pump out 10 gallons of liquid each minute. To determine how long the pump will take to empty a space while under pressure, multiply pumping time required at 1 atm by the pressure difference between the compartment and the outside in atmospheres.

Crane: Used to lift and move heavy cargo. Requires an operator with Professional Skill (Crane Operation). Each module provides from 2 to 6 feet of height and one-ton lifting capacity.

Empty Space: Any space left over after all modules have been selected is simply empty space. This can either be *bilge space* for storing excess water and helping to balance the vessel or be free flooding and fill with fluid if the vehicle submerges.

External Cradle: Ships often attach smaller craft or pods to their sides or decks. The cradle includes a winch or boom for launching or recovering the mounted object. Each module holds 1.25 tons of vehicle.

Fuel Electrolysis System: Converts water into hydrogen and liquid oxygen. It can be useful for vehicles with turbines or fuel cells (p. 140). Each electrolysis module can process 40 gallons of water per hour, producing 63 gallons of hydrogen and 30 gallons of oxygen.

Galley: A small area for cooking and presenting meals for vessels that lack bunks or cabins. Only one person can work in a small galley at a time. A *full galley* can accommodate three people and includes all the amenities of a professional kitchen; +2 to Cooking skill.

Hall: A furnished room that can comfortably accommodate 10 people. Usable as a restaurant, bar, conference room, etc.

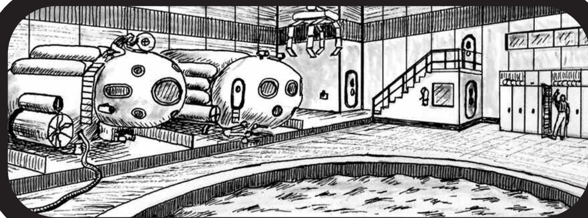
Launch Catapult: This electromagnetic catapult accelerates any aircraft under 75 tons to 20 mph almost instantly.

Minifacturing Workshop: A workshop with a 3D printer, plus appropriate tools and spare parts for using the Armory, Electronics, Engineer, and Mechanic skills. Up to three people can use it at once, and it gives +2 to skill. A *compact* minifacturing workshop is also available; it can only be used by one person at a time.

Safety System: A fire-suppression system that senses fires and floods the burning compartment with inert gas to extinguish them. A *compact* version is also available.

Science Lab: As per the *Laboratory* habitat module, p. 113.

Stage: Usable for briefings, dancing, plays, nightclub acts, act. Includes a sophisticated sound and light system.



Surgery: A well-equipped surgery, including a gyrostabilized operating table, diagnosis table, and EMU. One person may be operated on at a time. A variant surgery module is available for veterinary medicine. The differences are minor, and it can be used for work on humans at -2 to skill (and vice-versa).

Water Filter: A reverse-osmosis water purification system that can turn even heavily polluted water into a drinkable form. It can process 1,000 gallons of water per hour if it is reasonably clean to begin with, 500 gph of salt or brackish water, or 200 gph of heavily contaminated water. There must be a tank or water bladder to store the filtered water. Double output if the water is not needed for drinking or cooking. Smaller vessels mount fractional sizes (0.02 – 0.04) for the crew.

Winch: A motorized winch. It can lift one ton (ST 100) at up to 12 feet per second, or tow much greater weights.

Miscellaneous Modules Table

Type	*VSP*	*Wt.*	*Cost*	*Power*
Airlock	10	500	$1,000	neg.
Arrestor Hook	1	100	$1,000	0
Bilge Pump	2	200	$500	1
Crane	4	1,000	$4,000	1
Empty Space	var.	0	$0	0
External Cradle	1	250	$2,500	
Fuel Electrolysis	1	100	$5,000	56
Galley	10	100	$50	–
– Full Galley	80	3,000	$1,900	1
Hall	200	80	$500	0.1
Launch Catapult	160	40,000	$200,000	500
Minifacturing Workshop	250	30,000	$170,000	1
– Compact Workshop	100	10,500	$55,000	0.5
Safety System	0.8	200	$5,000	0
– Compact Safety System	0.2	50	$500	0
Science Lab	200	20,000	$1,000,000	3
Stage	200	250	$1,000	0.1
Surgery	50	280	$50,000	0.5
Water Filter	1	125	$100	0.5
Winch	1	25	$1,000	0.5

Vehicle Storage Areas

These are spaces inside the vehicle designed to store vehicles and their associated equipment.

Dry Dock: A floodable hangar lets watercraft dock inside; it takes one second per cf of capacity to fill or empty. The hangar must be pressurized to be emptied at depth; this takes a number of seconds equal to the number of VSPs being flooded × difference in pressure in atm.

Hangar Bay: A large bay for storing smaller vehicles. Craft in the hangar bay have access to fuel stores and can recharge from the ship's power system. Includes any necessary elevators or ramps to a flight deck (see p. 149).

Vehicle Bay: A vehicle bay is a specialized hangar built to hold a specific vehicle type very snugly. If the vehicle is manned it can be accessed directly through a small door. The craft then exits through a small hangar door. There is not enough room for maintenance or vehicle recovery. The craft can usually be transferred from the bay to a nearby hangar or back again. *Reloadable* bays can be quickly restocked from inside the vehicle using an autoloader, taking 2 seconds per cf.

Vehicle Storage Module Table

Type	*VSP*	*Wt.*	*Cost*
Dry Dock	2	200	$250
Hangar Bay	1.5	150	$125
Vehicle Bay	1.05	50	$75
Reloadable	×1	×2	×2

Multiply *VSP*, *Weight*, and *Cost* by the number of VSPs stored. Vehicle bay weight and cost will not exceed 1,000 lbs. and $3,000, regardless of volume. Hangar bay and dry dock weight and cost will not exceed 2,000 lbs. and $5,000, regardless of volume.

Solid Ballast

These are simply weights attached to the submersible to increase its loaded weight to the point that it can sink. They are usually attached to hardpoints so that they can be ejected in an emergency. Most are coated with a protective polymer for environmental reasons.

Alternatively, the vessel can use buoyant pressure-resistant material. This is usually syntactic foam, a composite of air-filled diamondoid beads and plastics.

Ballast Table

Ballast	*Wt.*	*Cost*
Foam	25	$10
Concrete	750	$7.5
Iron	2,250	$45
Lead	3,550	$1,420
Tungsten	6,000	$18,000

Wt. and *Cost* is per VSP of the material.

Standard Containers

A standard Twenty-foot Equivalent Unit (TEU) waterproofed cargo container measures 20’×8’×8’ and holds 250 VSP of cargo. An integral computer and radio transponder tracks stored goods using v-tags and monitors access to the container (and broadcasts an alarm if there is an unauthorized entry). The computer can write new records but cannot delete or modify them. There are ports for inspection cyberswarms to gain access to the containers. When received, the contents are checked against the records from the originator, the shipping company, and the container manifest to look for discrepancies. 1,280 cf., 2,000 lbs., $10,000.

Cargo and Storage

Cargo carried by ship is divided into four major categories: *bulk* (homogenous material such as grain or ore that is carried loose in holds or tanks), *breakbulk* (small packages in crates or on pallets), *RO/RO* (roll on, roll off – vehicles stored on hangar decks and wheeled containers) and *containerized*. As the first three categories (particularly breakbulk) may be containerized for ease of handling, cellular container ships make up a large fraction of ocean-going trade.

Cargo Hold: Five cubic feet of cargo space. Multiple cargo modules can be combined to form large cargo areas. Hatches and ramps required to load and unload cargo are included.

Container Cell: This is storage space and rails for two standard TEU containers (see box, p. 148). Integral cargo handling equipment can move containers into and out of the hold to loading spaces or hatches for pickup by crane. The system can be set up inside existing cargo holds, or removed to free up space for open cargo holds.

Exposed Cargo: Ten cubic feet of cargo space, half of which is exposed in an open cargo bed on the top deck with no overhead cover. Cargo in the open cargo area adds to total volume (but may only be used for storage).

Container Modules Table

Type	*VSP*	*Wt.*	*Cost*
Cargo Hold	1	–	–
Container Cell	650	1,000	$3,000
Exposed Cargo	1	–	–

Cybershells: Cybershells take up weight/100 VSP on average.

Provisions: 1 VSP of provisions provides enough food and drink for 20 man-days of survival (2 people for 10 days, or 4 people for 5 days, etc.). Supplies optimized for vehicles with full life support (FLS) last 100 man-days per VSP. Normal supplies cost $120/VSP and FLS supplies cost $600/VSP.

Step 7: Weaponry

Whether they are used for patrolling, piracy, or military action, many vessels need weaponry. In this system, all weapons are fully stabilized (cancels up to -3 in movement penalties). Weapons in turrets have universal mounts (they can elevate up to 90°). Weapons are assumed to face forward out of the body or turret. If installed any are installed to face in a different direction, specify this in the vehicle’s statistics.

5mm Emag: Medium-barreled, low-powered railgun with a very high rate of fire.

15mm ETC Autocannon: A cheap, rapid-fire electrothermal-enhanced cannon.

60mm ETC Autocannon: Often used on older military vessels.

55mm Emag: Short-barreled cannon that can engage a wide variety of targets.

100mm Emag: Long-barreled, rapid-fire railgun used for shore bombardment and low-intensity naval fire support.

Missiles: Missiles are also launched from vehicle bays. Submersibles launch them encapsulated in sealed packages that float to the surface; this can be controlled so that the missile will not breach the surface until it receives a signal or a preset time elapses. Once they breach the surface they are ejected using a rocket booster. The *Rubikon* (p. 128) is an example of a modern multi-role missile.

Torpedoes: These are robotic unmanned submersibles, launched from vehicle bays. Three torpedo types are listed on pp. 128, 131. Additional torpedoes can be built using the construction system.

Warheads: Various warheads can be installed for self-destruct or attack purposes. A depth charge is simply a warhead mounted on a hardpoint.

Concealed Weapons

If the weapon and its stabilizing hardware is entirely concealed in the vehicle, multiply the VSP required by 2.5. Guns mounted in pop turrets and retractable subassemblies *must* be concealed.

Bubble Generators

A bubble generator is a set of components that increase the efficiency of cavitation bubble formation and maintenance. A bubble generator is rated for its "bubble factor," used for performance calculations (p. 153). The system weighs 1 lb. × the cube root of the total area (minus the area of retracted components) × bubble factor. The system does not take any space but costs $25 per lb. Advanced bubble generators weigh half as much, but cost $100 per lb. They require either (weight/10) gallons of HO fuel or (weight × 200) kW *per second* of operation.

Weapon and Ammunition Modules Table

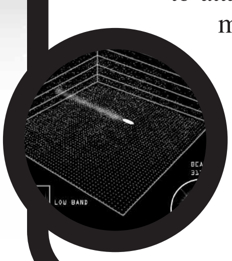
Type	*VSP*	*Wt.*	*Cost*	*Power*
5mm VRF Emag	0.02	9	$3,400	18 kW
120,000 rds. Solid	0.1	(150)	($1,200)	–
15mm ETC autocannon	0.4	100	$14,900	12 kW
1,000 rds. Solid	0.1	(100)	($200)	–
60mm ETC autocannon	11.5	2,900	$172,000	168 kW
20 rds. Solid	0.15	(112)	($220)	–
55mm Emag	10.5	2,615	$345,000	6,250 kW
120 rds. Solid	0.2	(150)	($1,200)	–
100mm Emag	86.4	21,600	M$2.9	15,000 kW
20 rds. Solid	0.2	(150)	($1,200)	–
100mm Warhead	neg.	(1.3)	($20*)	–
300mm Warhead	0.2	(36)	($540*)	–
400mm Warhead	0.5	(85.3)	($1,280*)	–
600mm Warhead	1.7	(288)	($4,320*)	–

Ammo Options: The smart ammo options from p. TS157 may also be applied to vehicular weapons. Simply multiply the ammo module costs by the given multiplier.

Warheads: * ×1 if solid, ×2 if HEMP, ×5 if SEFOP. See pp. TS158-159 and p. 121.

Hardpoints: Hardpoints are reinforced points and pylons to which external, jettisonable "stores" such as missiles or equipment pods can be attached. Hulls, turrets, and lift planes can have hardpoints. Hardpoints weigh 5 lbs. and cost $10 per 100 lbs. capacity. A structure may have up to 20 lbs. × HPs in hardpoint capacity attached to it.

Untapped hardpoints are not wired to provide power to attached pods or draw fuels and cost half as much.



Conformal Mount: This is a clamp recessed into the vehicle's hull, fitting a specific vehicle or subassembly. The mount itself takes up 0.05 VSP for every VSP of craft that will attach, plus the weight and cost of a hardpoint.

Step 8: Surface Features

Waterproofing makes a hull or subassembly watertight and resistant to corrosion.

Sealing is watertight, but also protects against pressure.

Fin Stabilizers: A gyroscope and small retractable fins to control a ship's roll in rough seas.

Flight Deck: This makes part of the top deck into a runway with a length equal to 3 × the square root of the area assigned to it. Half of the deck must be clear to perform takeoffs and landings.

Landing Pad: An open area on the deck for landing VTOL aircraft.

Liquid Crystal Skin: A coating of color-changing material that allows the vehicle to assume any paint job or camouflage pattern – Vision and light-imaging sensor rolls to spot the vehicle are at a -2 penalty if an appropriate camouflage pattern is chosen, or a +2 bonus if a contrasting pattern is used. Patterns require five seconds to change.

Chameleon System: This combines liquid crystal skin with sensors that scan the surroundings, and change the skin to match. It gives a -6 (-3 if moving) to be visually spotted or hit, or detected by ladar. Optionally, the sensors may be turned off, and the skin may be set to any programmed color scheme.

Solar Cells: These photoelectric collectors convert light (usually sunlight) into electric power. They generally serve as a backup power supply, in conjunction with rechargeable batteries (p. 140). Solar cells cannot be combined with stealth, infrared cloaking, a chameleon system, or liquid crystal skin. Solar cell area subtracts from top deck area. Each sf generates 0.08 kW on Earth – see p. 114 for values on other planets.

Sound Baffling: This masks the vessel's sound emissions, usually through the use of anechoic tiles, aerogel, active sound cancellation, and judicious planning before construction. Civilian vessels often have some level of sound baffling for aesthetic and legal reasons. All give a penalty to be detected by passive sonar: *basic* -5, *radical* -10, *extreme* -20. Halve the penalty against active sonar.

Emission Cloaking: This masks the vehicle's heat, magnetic, and millimetric emissions. It imposes a penalty on rolls to detect the vehicle with non-optical passive sensors: *basic* -5, *radical* -10.

Surface Feature Modules Table

Feature	*Wt.*	*Cost*
Waterproofing	0	$2
Sealing	0	$10
Fin Stabilizers	0.01	$0.2
Flight Deck	0.1	$1
Landing Pad	0.05	$0.5
Liquid Crystal Skin	0.1	$20
Chameleon System	0.5	$100
Solar Cells	0.1	$30
Basic Sound Baffling	0.5	$25
Radical Sound Baffling	1	$250
Extreme Sound Baffling	2	$2,500
Basic Emissions Cloaking	1	$150
Radical Emissions Cloaking	2	$1,500

Wt.: The weight of the feature, per square foot.

Cost: The cost of the feature, per square foot.

Except for the flight deck and landing pad, multiply weight and cost by the total area of the vehicle.

Step 9: General Statistics

Now that you have selected the hull, modules, and propulsion systems, it is time to combine them to generate the statistics below.

Volume

Take the hull VSP, using the original value from the *Hulls Table* (ignoring modifications for hydrodynamic lines). Multiply by 6 to give the *hull volume* in cubic feet (cf). To this figure, add the VSP of each subassembly, multiplied by 5 (again, use the unmodified value). Add the listed volume of any arms. This gives *total* volume in cubic feet.

Weight

Empty Weight (Ewt): The sum of all components with their weight not listed in parentheses.

Payload: This equals the total weight of the following items:

● *Fuel*: This is the weight of any fuel carried in storage tanks. Use the *Fuel Table* (p. 140).

● *Ammunition*: As specified in the *Weapon and Ammunition Modules Table* (p. 149).

● *Occupants*: Add 200 pounds per crew member or passenger (assuming typical human-sized occupants).

● *Cargo*: Add the weight of cargo usually carried. If exact numbers are unknown, add 100 lbs. per VSP of cargo, or 200 lbs. per VSP of open cargo (i.e., about 20 lbs. per cubic foot), which can allow for cargo holds that are not fully packed. A weight of up to 5 times that value is appropriate for vehicles carrying densely packed cargo.

● *Other*: Any other items that are not part of the vehicle, such as robots, cybershells, or other vehicles.

Loaded Weight (Lwt): Sum of empty weight and payload. It is usually simpler to list it in tons (loaded weight/2,000).

Submerged Weight: This is either 62.5 lbs. × total volume, or the normal loaded weight plus the weight of any liquid in free-flood areas and unsealed compartments, whichever is greater.

Make sure that the vessel's cumulative weight does not exceed its flotation rating (p. 133).

Cost

This is the sum of all component prices not listed in parentheses. Those prices in parentheses and fuel are the payload price, which are not listed among the vehicle's primary statistics, but should be mentioned in the general description.

Maintenance Interval

This is the period of time a vessel can safely operate between maintenance checks and overhauls. The formula is:

Maintenance interval in hours = 20,000/(square root of vehicle cost)

Round to one decimal place. If all structures are *smart*, double the maintenance interval. See p. TS189 for rules on failing to perform proper maintenance.

Structural Strength (HT)

This is a measure of structural robustness. A ship may have a low HT and many hit points. HT is calculated as follows:

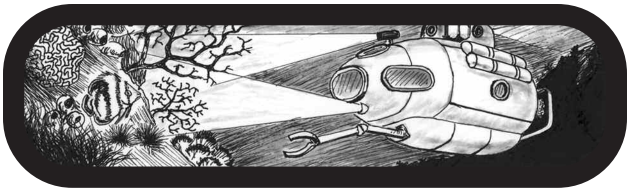
Structural HT = (200 × hull Hit Points/Loaded Weight in lbs.) + 5

If the vehicle has hardpoints, use the weight with hardpoints loaded – do not calculate two different values. Round HT to the nearest whole number. Maximum HT is 12. A HT of less than 5 would not be considered seaworthy!

Calculate HT separately for internal compartments.

Endurance

If the vehicle runs on fuel, divide the total capacity of all fuel tanks by the gph fuel requirement of the engine; this gives the vehicle's endurance in hours. If it requires two kinds of fuel (e.g., hydrogen and oxygen), compute the endurance for each separately, and use the lower number. If it runs on batteries, divide the total battery capacity in kWh by the total power requirement in kW to get endurance in hours. If the vehicle is powered by a fission, fusion, or radiothermal power plant, simply note the plant's lifespan in years.



Acoustic Signatures

Active Acoustic Signature (aASig)

This is equal to the vehicle's Size Modifier, subtracting the penalty from sound baffling against active sonar.

Passive Acoustic Signature (pASig)

A vehicle is not detectable if it is not moving and not operating machinery that generates noise. Otherwise it has a base signature of -2, plus propulsion modifier and power plant modifier, minus sound baffling penalty. The Size Modifier is not used.

Propulsion modifier is determined by multiplying supercavitating thrust or aquatic thrust ×0.1 for rockets, ×0.02 for ducted screw, or ×0.01 for hydrojets, then referring to the table below. Findrives have a propulsion modifier of 0.

Power plant modifier is determined by the power output of ceramic engines, turbines, and MHD turbines. Use the table below.

Thrust or Power	*Modifier*
Under 100	+1
101-1,000	+2
1,001-10,000	+3
10,001-100,000	+4
etc.	

For example, a vehicle with a 50,000-kW gas turbine and hydrojet has a propulsion modifier of +2 and a power plant Modifier of +4, for a total pASig +4.

Quiet Speed

This is the speed at which the "flow noise" of liquid rushing over the hull of the vehicle becomes a significant factor in its pASig. Halve pASig, rounded down, if traveling at or below quiet speed.

Quiet Speed = square root of (Speed × Q)

Q depends on sound baffling: 1 if none, 10 if basic, 20 if radical and 40 if extreme.

Calculate a quiet speed for wSpeed and uSpeed. There is no quiet speed for supercavitation! Round to the nearest mph if speed is under 20 mph, otherwise round to the nearest 5 mph.

Step 10: Performance

A single vehicle may have several separate profiles calculated, each with different combinations of propulsion systems and systems in use.

Water Performance

This is the ship's performance on the waves.

Hydrodynamic Drag (wDrag)

This is based on the wetted area of the vessel, which largely conforms with its loaded weight in pounds.

wDrag = [(cube root of Loaded Weight) squared]/Hl

Hydrodynamic Lines (Hl): This is 15 for fine lines, 10 if average lines, 5 if mediocre or submarine lines, or 1 for no hydrodynamic lines. Multiply Hl by 1.2 if the vessel has the multihull design option.

Round to the nearest whole number. Minimum wDrag is 1.

If there are underwater pods or structures, add their uDrag (or 0.8 × uDrag if conformal). Hydrofoils are the only exception to this rule.

Water Speed (wSpeed)

First determine the *total aquatic thrust* – the combined aquatic thrust from all functioning aquatic propulsion systems or rockets. Then use the following formula:

wSpeed = [cube root of (Total Aquatic Thrust/wDrag)] × 6

Round to the nearest mph if speed is under 20 mph, otherwise round to the nearest 5 mph.

Planing: If total aquatic thrust is at least [(Hl × 5) + 5]% of loaded weight, the vessel can skim over the water. Multiply top speed by 2. Calculate after rounding the base wSpeed. Multiply total aquatic thrust by ×1.2 to see if the vessel can plane if it has a lifting body hull.

Extra Detail: SWATH

To better represent how SWATH vessels work, use their pods' uDrag in place of wDrag for calculating wSpeed. Most SWATH vessels will not be able to plane or use hydrofoils (unless each pod has hydrofoils); use the pods' surface area/10 in place of Hl when determining planing, and their combined area to see if a vessel can hydrofoil.

Hydrofoils: If a vessel with hydrofoils (p. 134) has a surface top speed of 20 + (hull area/100) mph or more after accounting for planing it can rise up on its foils. Multiply top speed by 1.5. Note that a planing hydrofoil multiplies top speed by 3.

Water Maneuver Rating (wMR) and Water Stability Rating (wSR)

These represent the agility and stability of the vessel in the water, incorporating the size of the vessel (larger vessels are more stable but less maneuverable), controls, and hydrodynamic shape. 0Use the *hull volume* plus the volume of any hydrofoil assembly (if present and not retractable).

Volume (cf)	*wMR*	*wSR*
up to 100	0.75	4
101-1,000	0.5	5
1,001-10,000	0.25	6
10,001-100,000	0.1	6
100,0001-1,000,000	0.05	7
over 1,000,000	0.02	8

wMR: Shift one category *up* for each of the following: computerized controls, responsive structure, and flexibody. Once the topmost column is reached, add +0.25 to wMR for each remaining option.

wSR: Reduce by -1 for average hydrodynamic lines, -2 for fine or submarine lines. Add +2 for multihull, +1 for computerized controls, and +1 for fin stabilizers. Minimum wSR is 1.

Water Acceleration (wAccel)

wAccel = (Total Aquatic Thrust/Loaded Weight) × 20

Round to the nearest tenth of a mph/s if the result is under 1 mph/s; if 1-5 mph/s round to the nearest mph/s; if above 5 mph/s round to the nearest 5 mph/s.

Extra Detail: Hydrofoil Maneuverability

To better represent the maneuverability of hydrofoil craft, use the foil's volume alone to determine wMR and wSR when it has risen out of the water. Only apply the modifiers for computerized controls and responsive structure. These can be listed as hMR and hSR.

Foil-Cats: Multihulls with hydrofoils may sacrifice stability for maximum speed. Multiply top speed by 1.25 when foiling, but subtract -1 from hSR.

Water Deceleration (wDecel)

The base safe deceleration possible on water in mph per second is:

wDecel = 100 × (wMR/Hl)

Maximum base wDecel is 10 mph/s. The vehicle may add half its wAccel to water deceleration, rounding up, but show the increased deceleration in parentheses.

Draft

This is the minimum depth of water, in feet, in which the vessel may travel without running aground.

Draft = [(cube root of Loaded Weight)/15] × Draft Factor

Draft factor is 1 if no hydrodynamic lines, 1.1 if mediocre, 1.2 if average, 1.3 if fine, 2 if either submarine lines or advanced submarine lines.

Round draft to one decimal place.

Hydrofoils: Halve the vessel's draft when it is using hydrofoils. If the foils are not retractable, the draft is doubled when the vessel is not hydrofoiling.

Underwater Performance

Submarines have a set of performance statistics when traveling on the surface (see above) and another when they are underwater.

Hydrodynamic Stall Speed (hStall)

This is the minimum speed at which the vessel must be moving to maintain a constant depth; otherwise, it will either sink or begin to rise. If the result is *negative*, the vessel will sink if it moves slower than the absolute value of that speed; if the result is *positive*, that is the speed needed to keep the vehicle from floating to the surface.

hStall = [(Flotation Rating - Submerged Weight)/Lift Area] × 0.05

Submerged weight and *flotation rating* are in lbs.

Lift area is 10% of the hull's surface area, 15% if it is also a lifting body. Add the surface area of any lift planes.

Underwater Drag (uDrag)

This is based on the surface area of the vessel.

uDrag = [(Total Area × 2.5)/Submarine Lines] + D

Submarine Lines: This is 20 if advanced submarine lines, 10 if submarine lines, 4 if fine lines, 3 if average lines, 2 if mediocre lines, or 1 if the vessel lacks hydrodynamic lines.

D: This is the total uDrag of items mounted outside the hydrodynamic fairings of the hull (such as those on external cradles or on hardpoints). If towed, a human has uDrag 60 and an average dolphin has uDrag 6. Vehicles and subassemblies on conformal mounts multiply their uDrag by ×0.8.

Round to the nearest whole number.

Underwater Top Speed (uSpeed)

uSpeed = [cube root of (Submerged Thrust/Underwater Drag)] × 6

Submerged thrust is any aquatic thrust that can be used underwater.

Round to the nearest mph.

Underwater Maneuver Rating(uMR) and Underwater Stability Rating (uSR)

Use the table for wMR and wSR but use *total volume* and the following modifiers:

uMR: Shift one category *up* for each of the following: computerized controls, advanced submarine lines, responsive structure, and flexibody. Once the topmost column is reached add +0.25 to uMR for each remaining option.

uSR: Reduce by -1 for average hydrodynamic lines, -2 for fine lines. Add +1 for computerized controls. Minimum uSR is 1.

Underwater Acceleration (uAccel)

wAccel = (Total Aquatic Thrust/Submerged Weight) × 20

Round to the nearest tenth of a mph/s if the result is under 1 mph/s; if 1-5 mph/s round to the nearest mph/s; if above 5 mph/s round to the nearest 5 mph/s.

Underwater Deceleration (uDecel)

The base safe deceleration possible underwater in mph per second is:

uDecel = 100 × (uMR/Submarine Lines)

Submarine Lines are described above.

Maximum uDecel is 10 mph/s. The vehicle may add half its uAccel to water deceleration, rounding up, but show the increased deceleration in parentheses.

Offworld Aquatic Performance

The performance figures assume Earth seawater. In other liquids, multiply flotation, wDrag, and uDrag by (liquid density/the density of seawater). Densities are given in the box *Calculating Pressure* (p. 48). This only makes a significant difference for liquid ethane – multiply by 0.55.

Offworld Supercavitation

The cDepth and cFloor statistics assume Earth conditions. On other worlds, adjust these depths as follows:

Adjusted Depth = [K × (1 - Atmosphere)] + Depth

Atmosphere and *K* are defined in the box *Calculating Pressure* (p. 48).

Submerged Draft (uDraft)

The draft of the submersible is:

uDraft = (cube root of Submerged Weight)/5

Round to one decimal place.

Crush Pressure

This is the maximum pressure that the submersible's watertight compartments can withstand before being crushed or caving in.

Crush Pressure = Internal Pressure + [3 × (DR + 10) × Frame Modifier × Shape Modifier/(Size Modifier × 34)]

Internal pressure is the pressure inside the hull, usually 1 atmosphere.

Size Modifier is the hull or subassembly's Size Modifier, minimum 1.

Frame modifier is 0.25 if extra-light, 0.5 if light, 1 if medium, 2 if heavy, 4 if extra-heavy.

Shape modifier is 6 if it has submersible lines and 3 otherwise. Spheres have a shape modifier of 24 and cylinders have a shape modifier of 6.

To convert pressures to depths use this formula:

Depth (feet) = (Pressure - Atmosphere) × K

Atmosphere and *K* are defined in the box *Calculating Pressure* (p. 48).

To get yards, divide by 3; to get miles, divide by 5,280.

Test Depth: Most submersibles operate well within safety limits, not exceeding a test depth. To find test depth, multiply the crush pressure by 0.2 for extra-light, 0.5 for light and medium, or by 0.8 for heavy and extra-heavy frames.

Supercavitation Performance

Supercavitating Threshold (cThresh)

This is the minimum underwater speed the vehicle must reach to initiate supercavitation.

cThresh = square root of [(uDraft + 11 - B) × 175]

B is the bubble factor if the vessel is using a bubble generator (p. 149). Without a bubble generator the minimum cThresh is 44.

Supercavitating Top Speed (cSpeed)

This is the top speed the vessel can reach while supercavitating.

cSpeed = [square root of (Total Supercavitating Thrust/uDrag)] × 6

Total supercavitating thrust includes only the thrust of engines that will function during supercavitation, i.e. rockets. Hydrojets, screws and so on do not function inside the bubble. Round to the nearest 5 mph.

uDrag is the underwater drag (p. 152).

Supercavitating Depth (cDepth)

This is the maximum depth, in feet, at which a vessel can *initiate* supercavitation. If the result is less than submerged draft, the vehicle can't supercavitate.

cDepth = [(uSpeed squared/175) - 11 + B] × 3

Supercavitating Floor (cFloor)

This is the maximum depth, in feet, at which the vehicle can *maintain* supercavitation.

cFloor = [(cSpeed squared/175) - 11 + B] × 3

This value may be greater than cDepth, indicating the vehicle may dive to a greater depth once it has managed to initiate supercavitation.

Supercavitating Acceleration (cAccel)

cAccel = (Total Supercavitating Thrust/Lwt) × 20

Round to the nearest whole number.

Supercavitating Maneuver Rating (cMR)

Use the table for wMR but use *total volume* and shift *down* two categories. Shift up one category for computerized controls or responsive structure.

Supercavitating Stability Rating (cSR)

This is 1 for vehicles with a total volume under 100 cf in size, 2 if between 100-999 cf, 3 for 1,000-9,999 cf, 4 for 10,000-99,999 cf, or 5 for anything larger. Subtract -1 if the vessel has a lifting body. Add +1 for computerized controls.

Supercavitating Deceleration (cDecel)

cDecel = cMR × 4

A vessel may decelerate at this rate safely via controlled collapse of the supercavity.

Diving and Ascending

Submarines dive and ascend dynamically by changing their angle in the water. The steeper the angle and the greater the forward speed, the faster the change in depth. Practical angles are up to 20°, or 30° in an emergency. Use the table to determine ascent or descent speed, by multiplying forward speed by the depth change speed multiplier.

Angle	*Depth change speed multiplier*
5°	0.09
10°	0.17
15°	0.26
20°	0.34
25°	0.42
30°	0.50

To find the vertical speed of an unpowered submersible, first recalculate uDrag using average lines if the vehicle has better than average lines. Then calculate uSpeed using (flotation - weight) in pounds instead of submerged thrust. A positive number indicates the speed at which the submersible will rise, a negative number gives the speed of sinking.

Naval Action

This section provides a quick set of vehicle rules optimized for naval vessels. For more general rules, see ***GURPS Vehicles***, *2nd Edition*.

Movement

A vehicle moves 1 yard per second for every 2 mph of speed. If using 5-yard hexes as suggested in GURPS Vehicles, this works out conveniently to one hex for every 10 mph of speed. The vehicle moves when its operator would normally begin his turn.

Water vehicles moving at high speeds cannot turn at will. The vehicle's wMR is the number of gravities it can "pull" safely in a turn. To determine turning radius per p. B139, square the vehicle's current speed, then divide by (40 × MR).

Routine Travel

Routine water travel requires a single skill roll when docking or undocking and traveling in congested areas (narrow straits, crowded harbor). Daily control rolls (see below) should be made when traveling in very shallow waters and reefs. Severe weather may require frequent rolls, sometimes with penalties (use the control interval and CRM from the *Beaufort Wind Table*, p. 23).

Control Roll

The vehicle operator must make a control roll against his skill if he performs a hazardous deceleration, maneuvers exceeding the MR, or if the ship suffers damage.

If a control roll fails, the operator has temporarily lost control and he can attempt no maneuvers until his next turn. Subtract the vehicle's wSR from the number of points by which the roll failed, to a minimum of zero. All weapons have a penalty to hit of -1 per point of the result and lose any aiming bonus. Standing characters must make a DX roll at the same penalty or fall down – or possibly off the vehicle. If the result is 5 or greater, the vehicle is swamped, capsizes, or springs a leak.

Supercavitation: If a control roll exceeds SR by more than 2 while supercavitating, the vapor bubble surrounding the vessel collapses and the vehicle begins to decelerate at crash cDecel (see *Hazardous Deceleration*, see below). At the beginning of each turn in which speed exceeds uSpeed, it must make a HT roll or suffer as if resisting crushing pressure (see below).

Maneuver

A *maneuver* is a deliberate change in direction. Maneuvers are rated for the Gs (gravities) they require. The G-force imposed by a bend maneuver equals (vehicle speed × bend degrees)/1,200, rounded to the nearest 0.25 G. Multiple maneuvers may be conducted in one turn, but the G forces accumulate . . .

Vehicle operators cannot perform maneuvers totaling 2 × MR. Once the accumulated Gs exceed MR, each maneuver requires a control roll at a penalty of -1 per 0.25 by which the accumulated Gs exceed MR. Double the penalty if the MR is under 1; quadruple if MR is under 0.5. There is an additional penalty of -1 for every 20 mph × MR that the vehicle is moving.

Hazardous Deceleration

Water vehicles may decelerate at up to 2× their normal Decel. This requires a control roll, at -1 per 5 mph/s by which the braking exceeds Decel, rounding down. Double the penalty if Decel is under 10 mph/s; quadruple it if Decel is under 5 mph/s.

Supercavitation: The vehicle may undergo crash deceleration via controlled collapse of the supercavity. In crash deceleration, cDecel in mph/s is equal to (current speed - cThresh) × cMR. A control roll is required, at -1 per (cMR × 50) mph/s over ordinary cDecel (rather than -1 per 5 mph/s); treat a failure as an ordinary loss of control underwater.

Damage

Crushing or explosive damage amounting to more than 5 points per ton of vehicle weight forces a control roll. The modifier to the control roll depends on the ratio of the damage (before subtracting DR) to the mass of the vehicle:

Damage per Ton	*Control Modifier*
4 or less	Not a Hazard
5-9	0
10-19	-2
20-49	-4
50-99	-6
100-199	-8
200-499	-10
500 or more	-12

Add +2 if the damage was caused by a collision initiated by the operator. If two vehicles intentionally ram each other, both operators are "initiating" the collision.

Explosions and Pressure: When a submersible dives, its hull has to resist external pressure. As concussion damage also takes the form of pressure, these two effects are cumulative. Reduce DR by the fraction of crush pressure at which the vessel is operating; remaining DR is still squared against concussion.

Collisions

A vessel hitting an immovable object takes (total body hit points × collision speed in mph)/200 dice in damage. If two vehicles collide, each *inflicts* damage based on this formula and the relative velocity. The damage received is that inflicted by the other vehicle.

Crushing Pressure

A pressurized submersible operating below its test depth (p. 153) must make a roll vs. HT+2 every hour to avoid flooding, or whenever placed under stress such as combat maneuvering or depth charge attack.

Each minute of flooding causes hull damage equal to 1d × (External Pressure - Internal Pressure). If a submersible exceeds its crush pressure, it must roll vs. HT for each pressurized assembly, with a penalty of -1 for every 1% it exceeds the crush pressure; failure breaches the hull and causes a permanent loss of 1 HT. Add +2 for heavy compartmentalization or +4 for total compartmentalization.

At 0 HT the vessel or compartment is destroyed, imploding with a distinctive sound that can be detected with hydrophones (Size Modifier as a bonus to detection).

Attacking Vehicles

Attacks on a vehicle will normally be directed against the side of the body facing the attacker. An attacker may choose to target a subassembly instead, in which case the Size Modifier of the subassembly is used instead of that of the hull.

Sensors

Sensor rolls take "no time" but the interval between detection attempts is set by the GM. The rolls should be made by the GM secretly. Add together the sensor's Scan number and the vehicle's Size and Speed/Range modifiers, other penalties, and special adjustments to get the adjusted skill modifier to Electronics Operation (Sensors).

Note that passive sonar can be used for targeting unless it has the *no targeting* option.

Speed/Range Modifier: Speed is *subtracted* from range rather than adding to it, to a minimum of 2 yards A moving target is more likely to be noticed.

Underwater Penalties: Radar has a Scan penalty of -1 per 3 yards of range. Ladar and visible light sensors have a Scan penalty of -1 per T yards (water transparency rating; see *Light Attenuation by Water*, p. 52), infrared sensors -3 per T yards.

Sonar Range: Multiply the range of active and passive sonar by 1.2 on Mars and Europa.

Special Modifiers – Passive Sonar: Use the pASig of the target rather than its Size. If the target is using active sonar add its Scan to pASig. Background noise can range from -1 (singing whales) to -5 (busy harbor, explosives).

Special Modifiers – Active Sonar: +2 if the target is supercavitating. Bubble walls or intervening objects completely block sonar.

Special Modifiers – Radar: Detecting surface contacts on the ocean is penalized by the same amount as that listed for the CRM (see *Beaufort Wind Scale*, p. 23).

Special Adjustment – Prior Contact: Other vehicles sharing sensor information over datalinks have a +4 bonus to detect an object detected by anyone in the group.

Maintaining Contact: Once achieved, detection is maintained without need for die rolls unless the target moves out of line of sight, travels beyond the sensor's maximum range, or there is interference (underwater explosions, etc.) and the operator fails an Electronics Operation (Sensors)-4 roll.

Damage

A vehicle's DR works just like a character's DR, although it may vary depending on location (body or turret) and facing (front, back, right, left, top, underside). A hit vehicle always gets a Passive Defense roll based on armor PD, except against explosions. Damage is recorded separately for each subassembly. If a location's hit points are reduced to 0 or less, it is disabled, but can be repaired. If reduced to -5 × original hit points, it is destroyed, and cannot be repaired. *Sealed* vehicles have their DR *squared* against any explosive concussion damage.

Unsealing Vehicles: If a sealed location loses 10% of its hit points (20% if it has heavy compartmentalization, 50% if it has total compartmentalization) it is no longer sealed. Submersibles suffer a breach.

Flooding

A watercraft that takes sufficient damage will begin to flood. A vessel is *breached* if it takes (body hit points/10) or more from "below the waterline" damage that penetrates DR. For surface vessels, any attack from below, or any explosion inside the vehicle, is "below the waterline." Submersibles should track damage above and below the waterline separately and note which attacks could result in a breach.

Every minute, the vessel will take on (1 lb. × liquid density) of the surrounding liquid multiplied by the points of damage that caused the breach. Breaches of 10 points or less will automatically seal in 1 minute unless the hull is *old*. Otherwise, roll 1d after the first minute to see if the flooding can be controlled, adding +3 if the structure has total compartmentalization, +2 if heavy compartmentalization: on a roll of 5-6 the breach has been sealed. Failure means the flooding cannot be easily controlled – roll 1d every following minute with the same bonuses; on a 6 the flooding is stopped.

Keep track of the weight of liquid taken aboard; if it exceeds flotation (see *Flotation Rating*, p. 133) then the vehicle begins to sink! When sinking, any subassembly that is not sealed will count as breached, further flooding the vehicle. Bilge pumps or frantic bailing (using buckets, helmets, etc. at 2 gallons per minute) can help control flooding.

GLOSSARY

amniotism: "New Age" philosophy encouraging living in the ocean, which is considered the spiritual home of life.

ANS: Australian Naval Service.

aquaculture: Husbandry of aquatic life forms for the harvesting of food and other resources.

aquatic-adapted: Refers to ***GURPS*** characters with either the Amphibious advantage or the Aquatic disadvantage.

archaeobiology: The resurrection of extinct species by cloning preserved tissue.

arcoblock: A floating arcology, capable of providing permanent housing for thousands of people. Some are able to move under their own power, but many are permanently moored.

aseptic bone necrosis: Degeneration of bone mass caused by repeated compression and decompression of the body. See *Pressure*, p. 51.

Atlantean: A member of the Atlantean Society, a social group encouraging brotherhood and community support amongst underwater dwellers.

atm: Atmospheres (of pressure).

atoll tower: A tower constructed on the seabed and reaching up to or beyond the surface.

AUV: Autonomous Underwater Vehicle.

bends, the: Pain caused by dissolved gas bubbling out of body tissues during decompression. See *Breathing*, p. 48.

benthic: Found on the floor of seas or lakes.

benthos: Organisms inhabiting the benthic environment.

bombjacking: Taking control of a cybershell or bioshell, fitting it with explosives, and sending it to explode in a secure area to which it has access.

CEP: Cetacean Enhancement Program. A U.S. Navy program to develop combat-capable cetacean cyborgs. See *War-Dop*, p. 102.

cetanist: A person espousing the belief that cetaceans are spiritually uplifting beings, and wishing to live as a dolphin or whale by uploading into a cetacean bioshell.

citizenship haven: A nation offering Permanent Non-Resident Citizenships (PNCs) to people as a cheap way of raising revenues.

cnidarian: Radially symmetrical invertebrates with a sac-like cavity in their bodies. Includes jellyfish, anemones, and coral.

Coriolis effect: The deflection of objects moving along the surface of a rotating sphere, such as a planet. Objects in the northern hemisphere are deflected to the right, those in the southern hemisphere deflect to the left. This produces characteristic patterns of winds and ocean currents.

CRABE: *Centre de Recherche AstroBiologique d'Europa*. A European science foundation researching the unique life forms discovered in Europa's ocean.

deek: Slang term coined by uplifted dolphins for humans and infomorphs who have a fetish for pursuing sexual relations with cetaceans.

deep sound channel: A layer in the oceans at the base of the thermocline, where sound is trapped in a channel and can propagate vast distances.

drifter: An inhabitant of a floating community that sails on the open seas. See *Drifting*, p. 17.

dry technology: Tech based on mechanical engineering principles. cf. *wet technology*.

DSL: Deep Scattering Layer. A layer of marine life that migrates from the depths to the surface at night, and reflects sonar. See p. 25.

E: An E-model War-Dop cybernetic combat dolphin. See p. 102.

ecohostile: Disruptive to an ecosystem.

EDF: Europa Defense Force. Preservationist radicals who initiated the War Under the Ice to protect Europa's ecosystem from Avatar Klusterkorp's pantropic life forms.

EEZ: Exclusive Economic Zone. As defined by the Law of the Sea, a region extending 200 nautical miles from a nation's shore, up to 350 nautical miles if the continental shelf extends that far.

euphotic: Describing the region of the sea where enough sunlight penetrates to allow photosynthesis – from the surface to about 350 feet deep.

fauxfish: Artificial, vat-grown seafood meat. Usually fish, but can include shellfish.

genesthetics: Using living beings as artistic raw material, shaped by genetic engineering techniques. Also known as *gene sculpture*.

halocline: The boundary between layers of water of different salinities.

heliox: A breathing gas mixture of helium and oxygen, used for pressures up to 11 atmospheres.

high pressure nervous syndrome: Muscle tremors and other effects caused by high partial pressures of helium. See *Breathing*, p. 48.

high seas: The regions of the ocean outside the limits of any nation's EEZ.

hydrox: A breathing mixture of hydrogen and oxygen, used for pressures up to 18 atmospheres.

JMSDF: Japanese Maritime Self-Defense Force.

krakenism: Fringe belief that the seas should not be explored or colonized because unknown evil lurks beneath the waves.

Law of the Sea: A U.N. treaty which came into effect in 1994, establishing international laws for the use of the oceans, the sea bed, and the resources within.

lighter: An auxiliary vehicle used to transfer cargo from ship to ship or shore.

littoral: Of the shore region of a sea or lake.

methanogen: Life form that metabolizes carbon dioxide and hydrogen, producing methane as a byproduct.

methanotroph: Life form that metabolizes methane for energy.

moon pool: An opening in the floor of a pressurized, air-filled room that leads directly to water.

nanogaian: One who believes that Earth should be populated with self-replicating nanobots, to produce a single planet-sized living "being."

nekton: Organisms capable of swimming in the seas under their own propulsion.

neomalthusianism: The belief that low-technology societies have demonstrated a lack of survival ability and should be exterminated. cf. *technodarwinism*.

nitrogen narcosis: Inhibition of mental processes caused by nitrogen binding to brain tissue at high pressures. See *Breathing*, p. 48.

non-aquatic: Refers to ***GURPS*** characters without either the Amphibious advantage or the Aquatic disadvantage.

Oceanus Noctis: The Ocean of Night; the name of Europa's globe-wide, sub-ice ocean.

oxygen toxicity: Toxic effects caused by the absorption of oxygen at high partial pressures. See *Breathing*, p. 48.

partial pressure: The component of pressure exerted by a particular gas in a gas mixture. See *Calculating Pressures*, p. 48.

pelagic: In the open ocean, above the sea floor.

perflubron: Common name for perfluorooctylbromide, a chemical with a high binding affinity for oxygen. It can be used as a substitute for blood, or as a breathable oxygenated liquid.

PLAN: People's Liberation Army Navy, China's navy.

plankton: Organisms that float freely in ocean currents, unable to propel themselves.

PNC: Permanent Non-Resident Citizenship. A type of citizenship offered by some nations, establishing nothing more than nationality and specifically not conferring a right to reside in the issuing state, in exchange for a fee. See *Citizenship Havens*, p. 17.

Promethean: One who encourages exploration and colonization of remote locations simply because it leads to more knowledge and human mastery over the cosmos.

pycnocline: The boundary between layers of water of different densities.

SAD: Seasonal Affective Disorder. Clinical depression caused by lack of exposure to sunlight. See p. 54.

scab: Slang for "supercavitating bullet."

supercavitation: The formation of a bubble of gas around a submarine craft moving at high speed, reducing drag. See *Supercavitation*, p. 127.

surfi: A person who embodies the lifestyle of a late 20th century surfer, as part of a cultural revival movement.

technodarwinism: The belief that societies with high technology have demonstrated their inherent superiority to lower technology societies, and that the principles of evolution justify their dominance. cf. *neomalthusianism*.

TEU: Twenty-foot Equivalent Unit. A standard cargo container, see p. 148.

thermocline: A narrow layer of sea water where the temperature changes rapidly with depth. Water below the thermocline is at 29°F to 37°F.

thiotroph: Life form that metabolizes sulfide compounds for energy.

TNI: Tentara Nasional Indonesia, the Indonesian navy.

trimix: A breathing gas mixture of helium, nitrogen, and oxygen, used for pressures up to 18 atmospheres.

tsunami: A huge wave caused by an undersea earthquake or volcanic eruption.

turbidity current: A dense current of sediment-rich water that flows along the sea floor, down the slope of the continental shelf or slope.

UAV: Unmanned Aerial Vehicle (a cybershell aircraft).

Universalism: A political belief that parts of Earth and space should be left unclaimed and unowned by anyone.

uplift: The process of granting sapience to animal species.

VCR: Vortex Combustor Ramjet. A form of underwater rocket propulsion. See p. 139.

wet technology: Technology based on biological and genetic engineering principles, as opposed to mechanical. cf. *dry technology*.

whalesinging: The practice of an infomorph uploading into a whale bioshell and participating in whale songs with natural whales.

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INDEX

THE OTHER FRONTIER

As humanity reaches to the planets, a last frontier remains on Earth. The oceans offer immense wealth, and the freedom to pursue it. Governments, corporations, political idealists, and outlaws are staking their claims in this realm. There are oceans on other worlds, too – Europa, Mars, Titan – all unique and full of possibilities.

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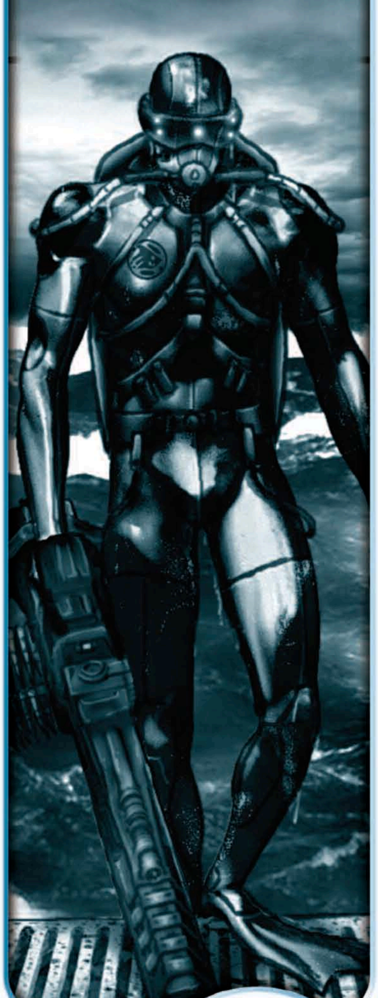

Transhuman Space is *required* to use this supplement. ***GURPS Basic Set,*** *Third Edition Revised,* and ***Compendium I*** are also recommended. The ideas in ***Under Pressure*** can be used with *any* roleplaying system.

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