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DIPLOMARBEIT

CALYPSO

ausgeführt zum Zwecke der Erlangung des akademischen Grades
eines Diplom-Ingenieurin unter der Leitung

Will Alsop

E253-4

Institut für Architektur und Entwerfen, Hochbau und Entwerfen

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Fakultät für Architektur und Raumplanung
von

Sarah Manon Resch
0525608

Wien, am

The project Calypso is a deep-sea research station on a re-used floating oil platform. As our technical facilities are developing increasingly the equipment of marine research do too. The developing methods will lead to different ship designs in terms of flexibility and size.

Nowadays the moon has even been more explored, than the world's oceans – which is nowadays approximately 2 %. Due to technical limitations the ocean floors and the deep sea in particular, are still unexplored territory. The development of technology is fostering new research designs and new methods of exploration. This in turn creates more access to knowledge to scientists as the role of deep-sea territories become eminetly important to ecosystems worldwide.

My approach is to re-use a former floating oil platform as a deep-sea research station. As the floating platform is not limited to depth of the water, it can be installed anywhere on the world's oceans.

The idea is that 100 people will workd and live for a six-month period of time on such a platform, flor exploration. As such a platform is often out of reach of stocks of basic sources such as food, potable water and electricity, it will have to be self-sufficient. It can be seen as an autarchy i.e. a small independent and self-sufficient city.

The following project shall therefore explore issues such as; missing infrastructure, self-sufficiency, social problems in interaction in isolated communities.

The following chapters give an overview of oil platforms, the ocean in general and the deep-sea. More importantly, my design approch for a deep-sea research center will be put forward.

Oil Platforms

In the late 19th Century, large quantities of oil were discovered underneath the ocean floors. The extraction thereof pushed the oil industry to expand its activities offshore. Technologies continuously developed leading to the creation of oil rigs and different kinds of ships.

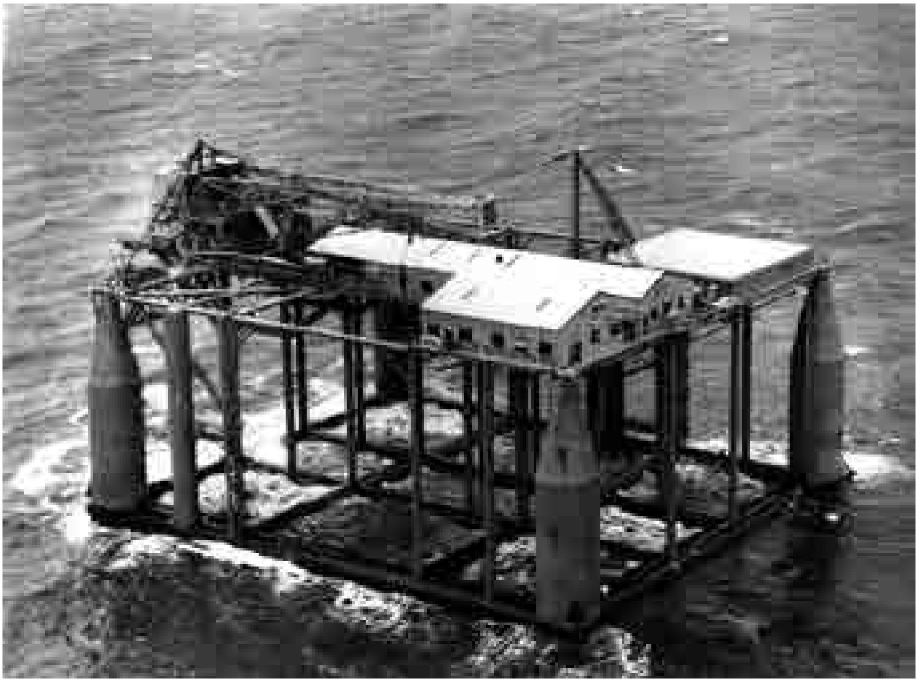
The first oil platform was drilled in California around 1896. The first rigs were built upon wooden piers. These piers extended from 450 up to 1800 feet from the shore and could reach a water depth of only 30 feet. Early submerged drilling activities occurred in the first decade of the 20th Century. A total of 278 wells were drilled, which produced 13 million barrels of oil over four decades. Later, the Gulf coast by Texas and Louisiana were explored. The first stand-alone platform was built in the shallow Pacific Ocean waters of Rincon, California, in 1932.

Besides the United State of America (USA), Venezuela pushed the oil industry ahead. Lago Petroleum (now known as ESSO) was the first company to use “concrete pilings in place of the wooden ones”[1]; fitting the concrete pilings with steel heads, which allowed for faster installation of the platforms. Within the next thirty years, the oil industry raised hundreds of concrete platforms in Lake Maracaibo. In 1950, companies started using hollow concrete piles prestressed with steel cable. J. Ray McDermott Company developed a system to prefabricate onshore yard and barged the units to the site. Prefabrication created a new industry sector, oil rigs got cheaper, safer and easier to install.

Moving to deeper waters, it got too expensive to build small platforms “just to drill one or two explorators”[2] – so, the semi-submersibles were developed. The first prototype rig, *Breton Rig 20*, had movable pontoons. The next thirty submersibles were used until the 1990’s by the industry. Next, the oil industry took advantage of a concept of the marine industry, the so called Jack-Up. In 1950, the first Jack-Up platform was installed in the Gulf of Mexico. Just a few years later, the industry took another idea that should change it forever: the lifting mechanism was developed. At the same time, drilling ships were developed. These Ships became more able to hold a high number of people, were furthermore movable and still able to perform the same way as fixed platforms, so naturally the industry had high interest to develop floaters to extract. The main problem of floaters was their lack of stability. Yet again, a naval architect developed a new concept for an oil platform. He designed the first large semi-submersible, the *Bluewater 1*.

The first idea of self-positioning semi-submersibles was developed in 1962 with the drilling of rig Eureka. The propellers at the bottom of the ship “could be rotated to move the ship in any direction”[3].

During World War ll, the British constructed the Maunsell Forts, which can be seen as the predecessors of modern offshore platforms. The ability to construct platforms in a short period of time and to fix them on to the sea was an important step in the development of oil rigs.



Blue Water Rig No. 1
The first semi-submersible oil platform installed 1961 in the Gulf of Mexico for Shell Oil Company

Up until today, the offshore oil industry developed to its probably maximum capabilities, with a current reachable depth of 3500 meters. Naval architects as well engineers and other related fields of research and development are continuously trying to develop and improve materials and ways to get to deeper depth of the ocean to explore the possibilities and opportunities that lay ahead.

Today, approximately 3.750 rigs are active worldwide. If you count inactive ones as well, there “presently [...] are 6.500 offshore oil and gas production installations worldwide.”[4] The Gulf of Mexico alone, hosts 4.000 of them.

USA
Europe
Middle East
Asia Pacific
Africa
Latin America
Canada

An oil platform, oil rig, or offshore platform, is a structure with facilities to drill wells, to extract and process oil and natural gas. Depending on the circumstances, like the depth of the water, function of the platform, and the weather conditions, the platforms are fixed to the seabed or otherwise float. Both platform types are self-sufficient in terms of water and energy.

Food, equipment, and other necessary supply, are delivered by supply ships in ISO containers, or, in case of emergency, by helicopter.
Two main platform types have been developed over the years, fixed platforms, and floaters. Both developed sub-types of platforms vary in design.

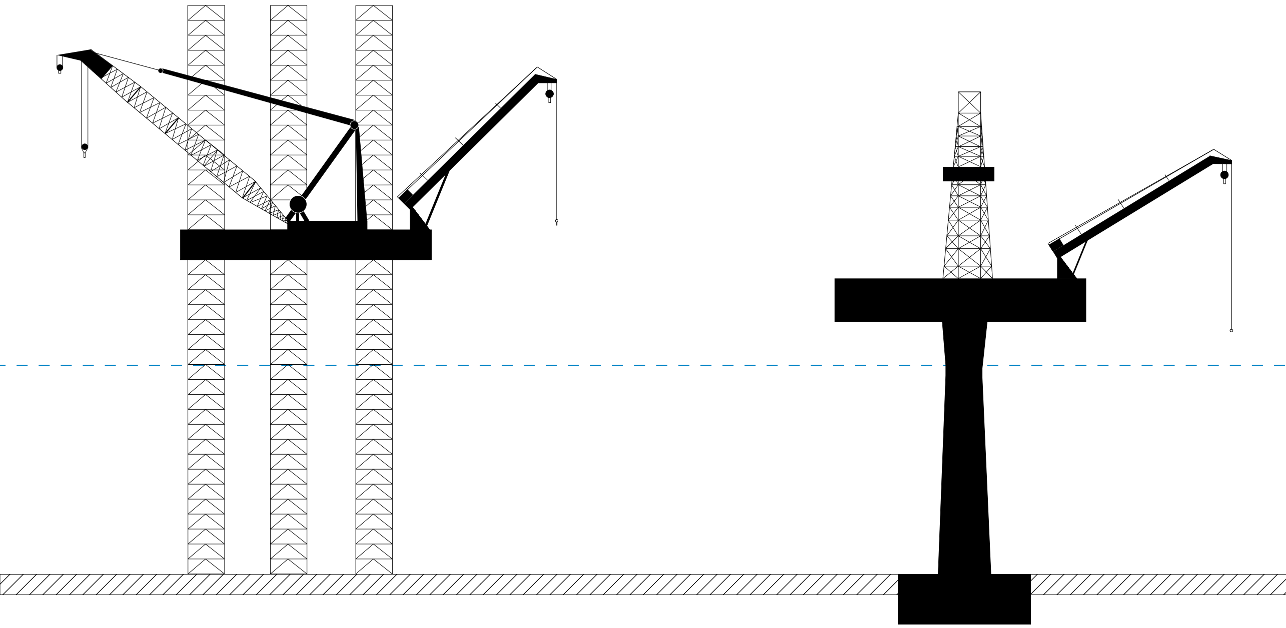
Fixed Platforms

Oil platforms that are fixed to the seabed are used for installations in water depths down to about 910 meters. Both platform types; floating platforms and fixed platforms, developed sub-types of platforms. They vary in design and function. The jack up rig, the gravity-based platform and the compliant-tower platform are the three sub-types of fixed platforms.

Jack up rigs are most commonly used and can reach down to 120 meters. Three or four legs hold the topside of the rig and its weight. The drilling derrick is usually cantilevered, or "mounted closer to the center of the platform and drills down through an opening in the deck"[5]. If the drilling is completed, the entire rig can be towed to another site.

Gravity-based platforms are used in waters until 300 meters deep. The one or more, reinforced concrete columns support the work platform. Chambers in the columns, and ballast tanks at the bottom of the columns can be filled with fluids or solid material for the right degree of buoyancy.

The compliant tower is less massive and more flexible than those of other rigid fixed-platform designs. It is used in waters down to 950 meters, without any need for wires or anchors. The deck is connected to a strut-and-truss structure. This structure is connected to a set of pilings driven into the sea floor. The pilings are designed to allow limited platform sway.



The fixed platform sub-types vary in design, but have common elements; the column and the topside. The column of fixed platforms leads the forces and weight into the seabed. Jack up rigs and compliant towers have truss columns. The gravity-based platform usually has one or more concrete columns, or a mix of truss and concrete columns.

The topsides can host the following processes and functions: Separation and stabilization of oil, gas, water; treatment of oil, gas, water; well testing to aid reservoir surveillance; compression; gas dehydration; metering; personnel accommodations; utilities and auxiliary system; controls and power systems; well construction and servicing; exporting treated oil and gas to a delivery point for transport to market. In short, the topside stores the whole equipment for production and drilling, as well as the living quarters.

Jack-up oil rig
Drilling platform situated in the North Sea

Floating Platforms

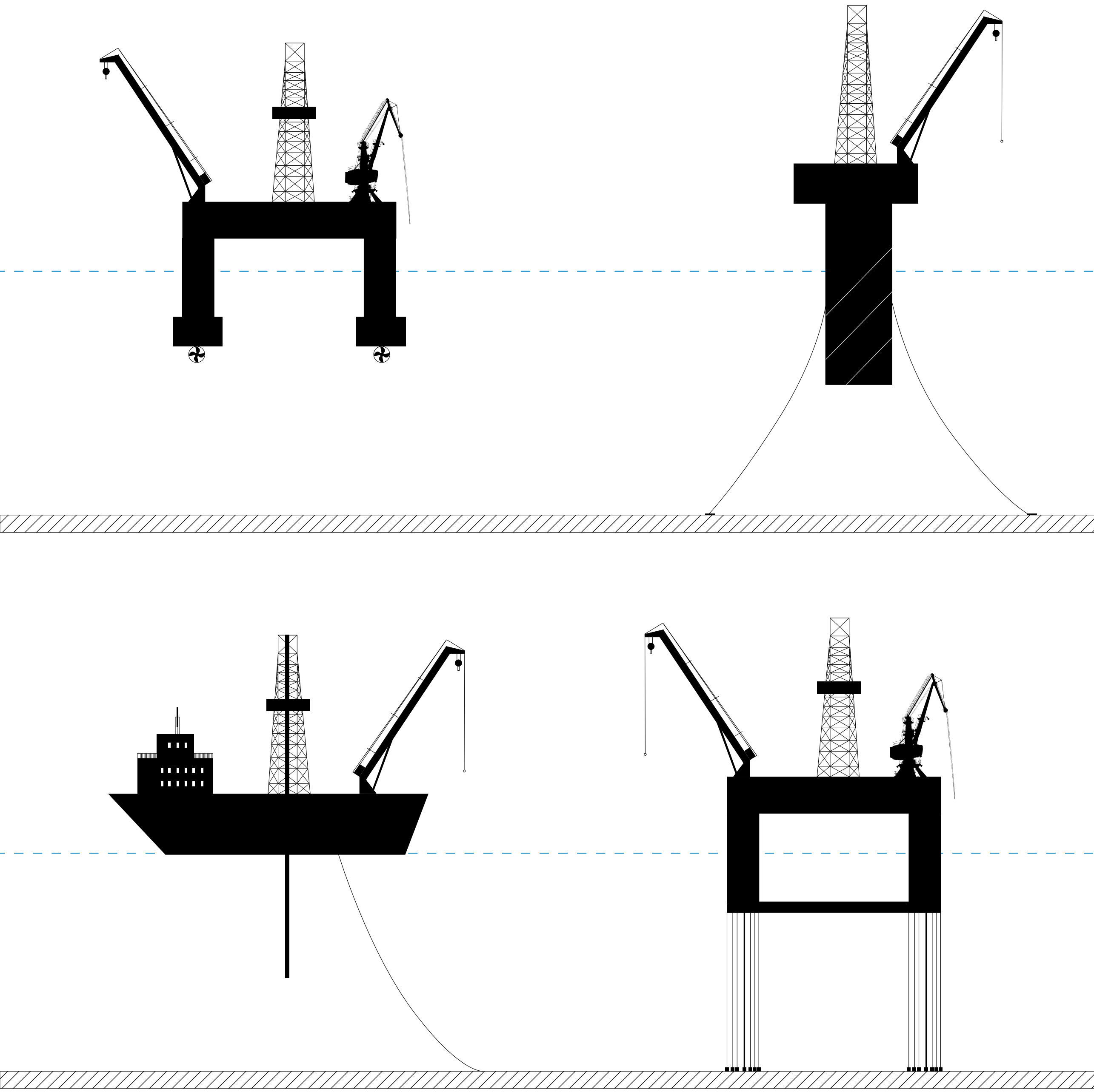
Nowadays, the state of technology and material allows fixed platforms to drill down to 910 meters. Above these depths floating platforms get installed. The tension leg platform, the spar platform, ships and the semi-submersible platform, are the sub-types of floating oil platforms.

Tension leg platforms are connected to the seabed by long hollow steel tubes, usually half a meter in diameter. These tubes are called tendons. They are either sunk into the seabed or held in place by large weights. They prevent the platform from moving up or down. Tension leg platforms can be used until 1500 meters.

Spar platforms are used in a water depth range from 590 meters to 2382 meters. The work platform is built on top of a tall cylinder, which is submerged in a vertical position below the platform. The conventional spar, The truss spar and the cell spar are the three configurations. Conventional spars have one piece of a cylindrical hull, truss spars, a midsection composed of truss elements, and cell spars are built up of several cylinders. All types are attached to the seabed with mooring lines. The ability to adjust the lines to move the spar platform horizontally gives it a better position above wells on the seabed. “Strakes [are] installed on the outer surface”[6] of the cylinder to lessen the “effects of wave action and water movement on the platform.”[7]

Ships can operate in water depths down to 3600 meters. They can be used as production system, storage place, offloading system, and tubing installation. Ships use dynamic positioning systems, or they are moored to the seabed to stay in position.

Semi-submersibles are the most stable of all floating rigs, often chosen for harsh environmental conditions. With the ability to adjust itself via dynamic positioning, the platforms can operate in water depths down to 3000 meters.



As well as fixed platforms, the sub-types of floating platforms vary in design but have common elements, named; the hull, the column, the pontoon, the topside and the system to stay stable.

The hull “provides buoyancy to support the deck, topsides, mooring loads and riser loads.”[8] At tension leg platforms and semi-submersibles, the columns and pontoons form the hull. For spars, the hull is essentially the central column. The column leads the forces of the topsides down, it is the same static system as found in conventional towers in architecture. They differ in size and quantity, depending on the system of the platform. The Pontoons can be found on Tension-leg platforms and semi-submersibles, they “connect the bottom of the columns together, to form a part of the hull”[9]. With the columns, they provide the necessary displacement to carry the vertical loads on the system. The topside on the floating platforms stores the whole equipment for production and drilling, as well as the living quarters. Floating platforms have two methods to stay stable. Either they are moored to the seabed, or they are equipped with dynamic positioning.

Drill ship
Ultra-deep water drill ship
from ENSCO

Once moored to the seabed the “lines can be made of synthetic fibre rope, wire, and chain, or a combination of the three.”[10] Depth and environmental factors such as wind, waves, and currents, determine which material is used for the mooring system. There are six different types of mooring systems; catenary, taut leg, spread mooring system, and single point mooring system. The catenary is used for shallow water, taut leg, which typically uses polyester rope which stretch when the platform drifts horizontally with wind or current. The spread mooring system is a group of mooring lines. “The symmetrical arrange of anchors helps to keep the ship on its fixed heading location”[11]. A single point mooring system connects all the lines to a single point.

With dynamic positioning the platform is not connected with the seabed. Four to six propellers at the bottom of the pontoons keep the platform automatically in position

Spar platform
Installed in the Gulf of Mexico

Oil Platforms
Semi-Submersible Platform

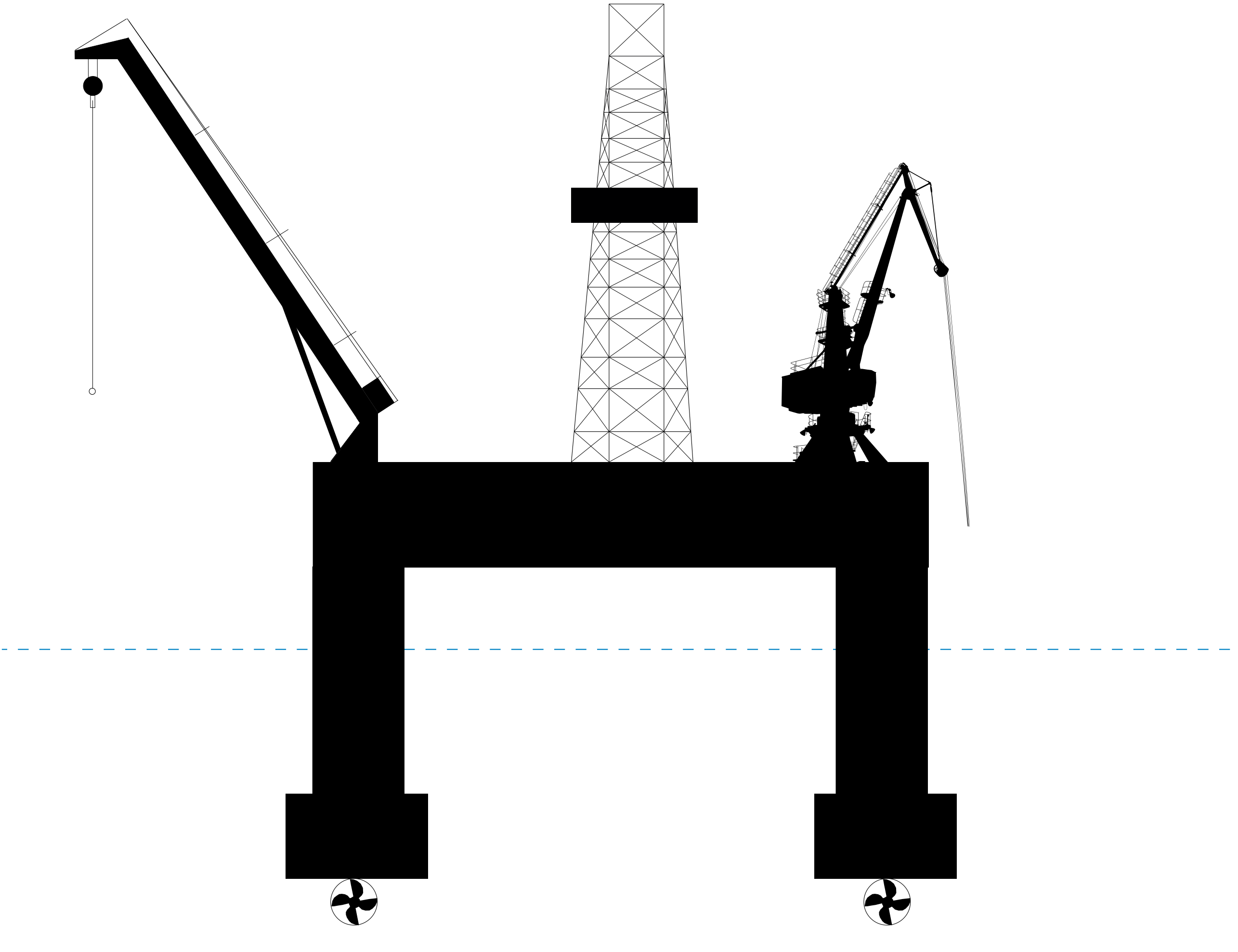
As I chose to re-use a semi-submersible rig for my project, this type of platform is described in more detail below. Semi-submersibles are the most stable of all floating rigs, often chosen for harsh environmental conditions. With the ability to adjust itself via dynamic positioning, the platforms can operate in water depths down to 3000 meters.

The Platform
Two horizontal pontoons are connected via cylindrical or rectangular columns to the drilling deck they „provide buoyancy to support the deck, topsides, mooring loads, and riser loads.“[12] “The columns are supporting the topside and provide the rig with sufficient air gap between the water surface and the deck”[13]; they are furthermore used for ballasting and storage of various bulk loads, such as mud and fuel.

Floating oil platforms can be in three modes, operational, survival and transit. In survival mode, the air gap between the topside and the water surface is between 17 to 20 meters; the required operational air gap is approximately 14 meters.

The topside provides living quarters, offices, recovery space, drilling facilities, cranes, and a heli deck. Semi-submersibles are “mobile” oil rigs; they can be moved by heavy lift boats, or sometimes even drive by themselves with approximately 10–20 km/h

Transit
Semi-submersible oil rig transit via a heavy lift vessel

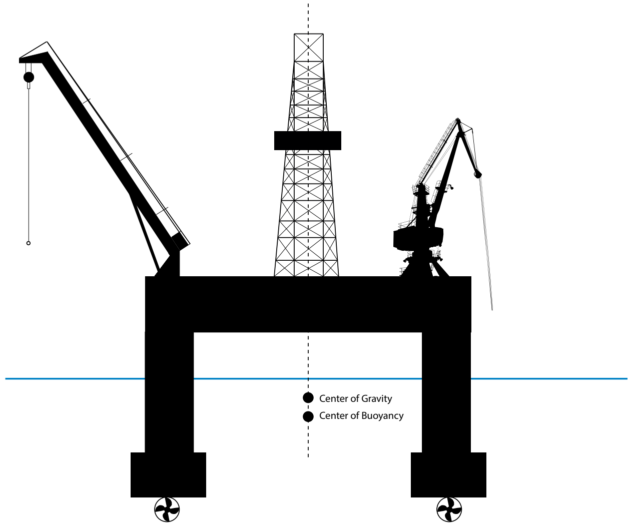


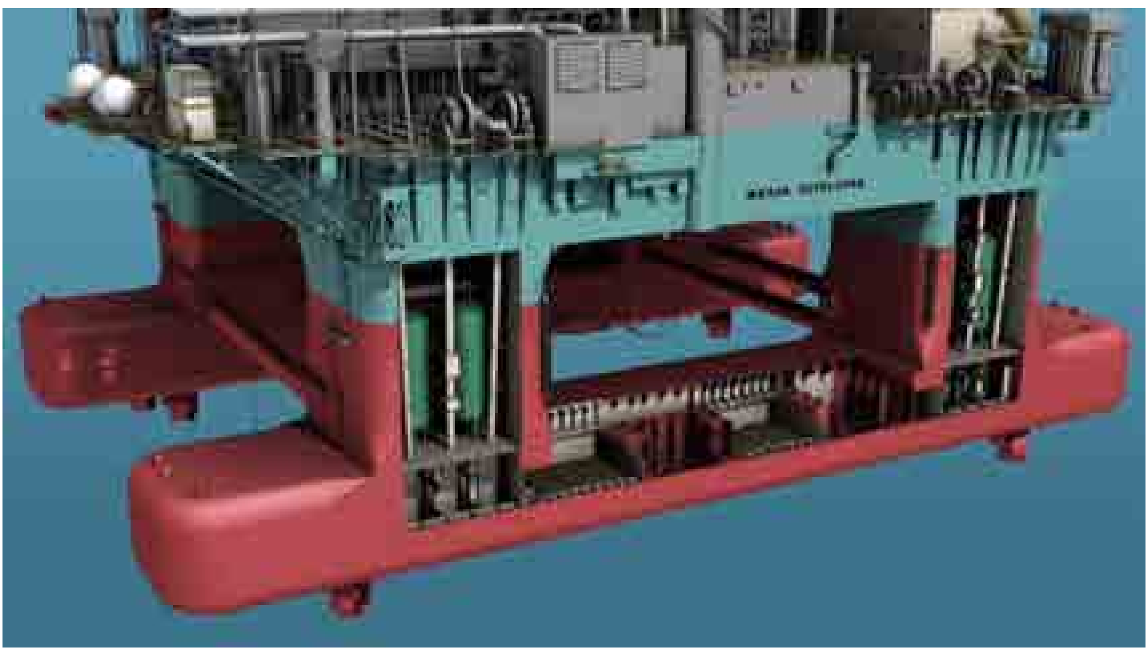
Stability and Weight

Stability and little motion of the platform is the main goal, in order to secure the safety of the crew, as well as for effective oil production. When a rig is "subjected to forces from wave, wind and currents"[14] the forces create a heeling moment, which affects the heeling angle of the rig. Generally stability of a semi-submersible could be interpreted as the "ability to withstand heeling moments and return to the upright position."[15] Stability is given when the center of gravity is higher than the center of buoyancy.

When a rig starts to heel the liquids in the tanks of the pontoons, it translates in the direction of the heeling. Therefore, the design of a semi-submersible hull structure is driven by the weight of the platform, or, more precisely, the weight of the topside. The weight of a platform can be divided in four components: topside weight, hull weight, weight of variable deck load, weight of ballast.

Semi-submersibles are designed for three configurations: operational, survival, and transit. Depending on the configuration, the pantoons and columns are filled with more or less water. In the operational condition, the "draft is at the maximum magnitude"[16]. The low pressure on the pontoons leads to less motion, which is required during operation. During hurricane season, or in case of extreme weather conditions, the rig will hold operations and "de-ballast to increase the air gap from the water surface to the rig."[17] This means that the rig is in survival configuration. The gap prevents waves from reaching the top and flooding the topside. In both configurations, the pontoons are totally and the columns partially submerged. In transit configuration, the pontoons act as catamaran hulls and are not totally submerged.





Section
Section trough the columns and pontoons of a semi-submersible, shows the chambers for de-balasting

Motion

Marine vessels have to cope with six types of motion: “The three translation degrees of freedom is heave, sway, and surge, while the rotational movements are yaw, roll, and pitch”[18]. Semi-submersible rigs are dominated by heave, pitch and roll. With dynamic positioning or mooring, the other motions can be kept low.

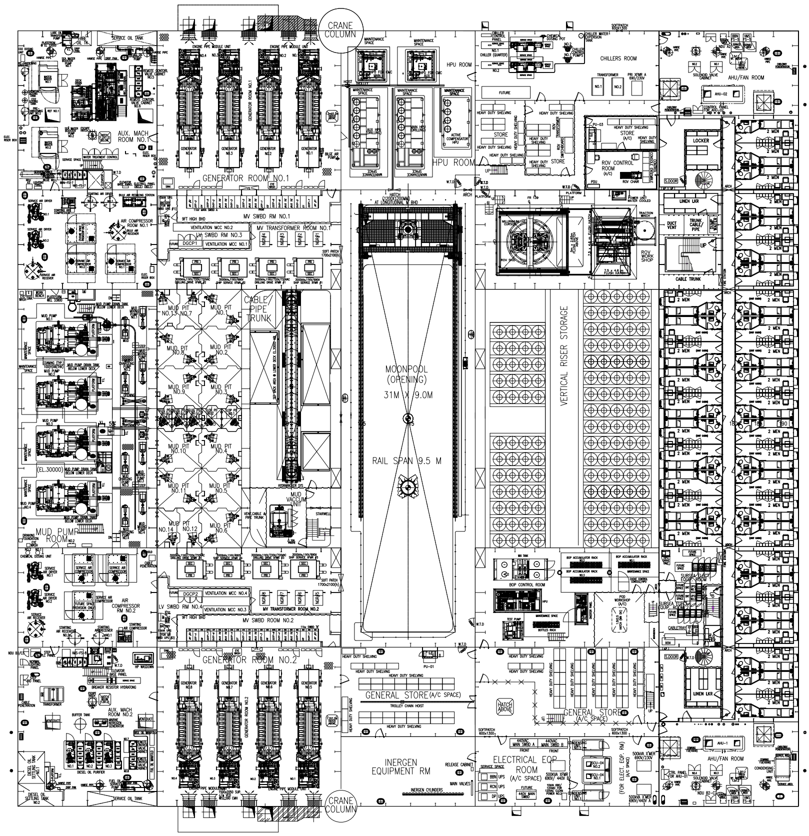
Semi-submersibles stay in position via mooring or dynamic positioning. “In relatively shallow water, a system of chains and anchors holds the floating rig in place.”[19] In deeper water, dynamic positioning is the solution, using global positioning system satellites and computers.

The chosen Platform

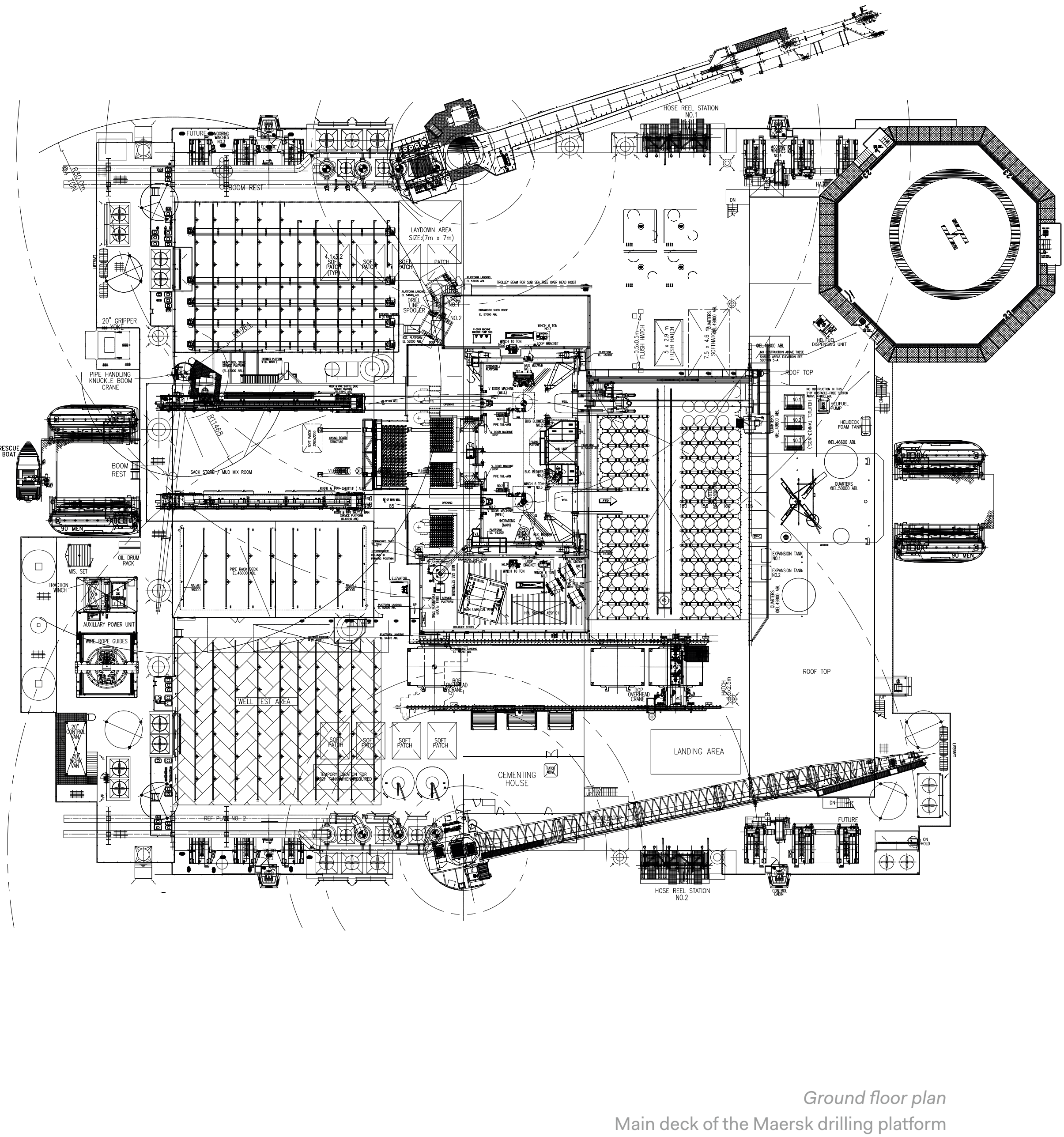
The chosen platform is a semi-submersible drilling and producing platform. Next to drilling and producing equipment living quarters are situated on one side of the platform. The platform has three floors, the main deck with 100 by 90 meters overlaps the two decks below it with 80 by 80 meters.

Three holes are in the platform. The moonpool in the exact middle of the platform with 9,2 by 43,7 meters was used to drill for oil, and goes trough all three floors. The other two holes on the right and the left of the moon pool go trough the main deck and first floor; usually, equipment like drilling heads and pipes for drilling are stored in these areas. Both are 25 meters long, but very in width, 16,8 and 8,6 meters. With 13.500 variable load it is a medium size semi-submersible rig.

Maersk Developer
Semi-submersible drilling platform with accommodation block, from “Maersk Drilling”, installed near Morocco



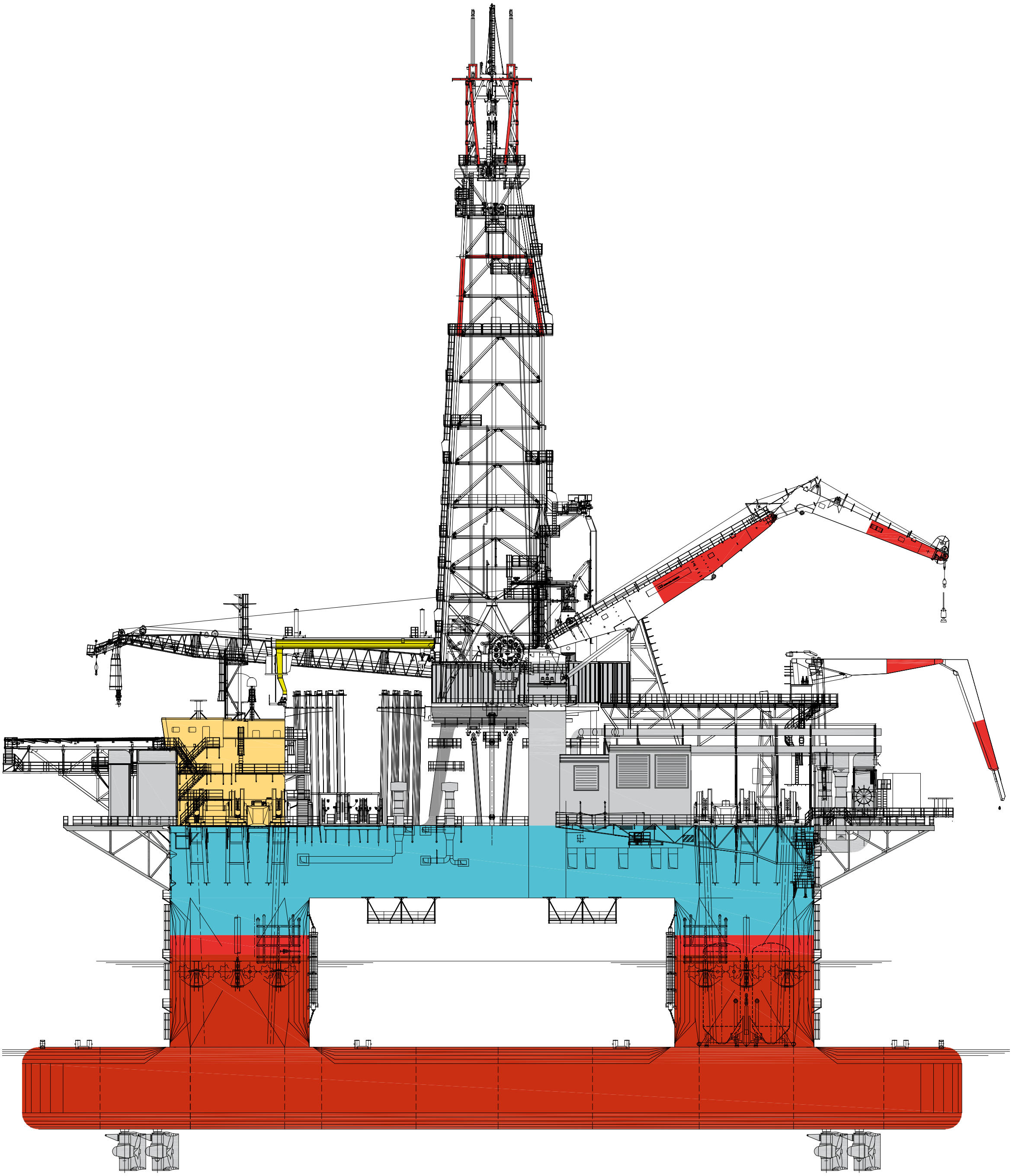
Ground floor plan
Lowest level of the Maersk drilling platform
1_800



Ground floor plan

Main deck of the Maersk drilling platform

1_800



Section
Maersk drilling platform
1_800

Life on board of an oil platform is unusual, already getting there is adventurous. Ships, but more often helicopter with up to 24 passengers, transport the crew from the mainland to their workplace. The crew size of the offshore platforms depends on size, “number and complexity of wells, the equipment, and the overall philosophy of [the] operating company.”[20] The number varies between 60 to 150 people.

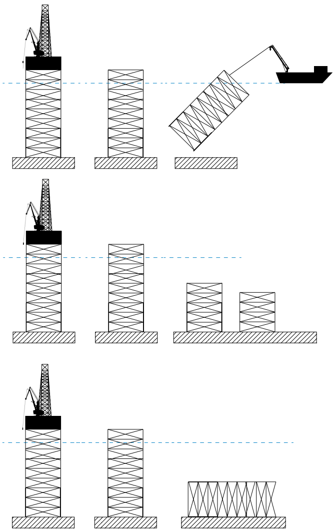
In order not to become too isolated and to have and maintain family, friends, and a social life outside of the platform, depending on the location of the platform and therefore distance to mainland, the crew works in a two, three or four week modus. This means for every two weeks of work on board, two weeks home. The daily shifts are usually 12 hours long.

The payment on oil rigs is high, to make up for the 12 hour shifts, staying away from home, and working in a dangerous and unusual environment. It is becoming more popular for the respected companies to try to equip the platform with as much luxury as possible. The limit of space on the platform makes it hard to create pleasant areas for working, living and recreational spaces.

Depending on the company and platform, the crew sleeps in single- or up to four-bed rooms with private bathrooms and toilets. For social welfare, on newer platforms, all crew members have the same room quality. Engineers, cooks, head of the platform, cleaning personnel and workers live next to each other. Next to the most important rooms, the dinning room and the kitchen, facilities such as Skype rooms, a gym and a little cinema are part of such recreation areas. Being locked on the platform for at least two weeks, with no way out, sport is the main key to keeping the mood of the crew balanced.

Besides physical exercise sufficient, nutritional and good food is important for the crew to stay motivated, healthy and happy. Usually, four meals are served daily: breakfast, lunch, dinner, and a midnight snack. The cooks are key members of the platform. Often, cleaning personnel, cooks, and head personnel of the platform are seen as parental figure of the platform. In contrast to long shifts, little contact to mainland, friends and family, being served with food, cleaning, and a family-like working environment, makes life on platforms more attractive.

Oil Platforms
Environmental aspects of oil platforms



Total removal	50.000.000
Reefing	17.000.000
Partial Reefing	15.000.000

Oil rigs are high-end technical „machines“, unique in performance and design. But what happens to the hundreds of oil rigs after the well is dried out or they are no longer up to the latest technical standard and therefore make no attractive economic gains?

Most often, the present „structures were constructed in the 1970s and were hailed as technological feats when they were installed.“[21] The costs of decommissioning are high; a total removal can cost up to 50.000.000 US Dollar. It is an expensive and long process from permitting, constructor pipeline removal, and power cable decommissioning, material disposal to site clearance.

About 100 platforms have to be removed each year. Ecologists slowly grow worried, and so the Bureau of Safety and Environmental Enforcement (BSEE), was founded. More and more regulations were created over time. The removal of one oil rig with explosives kills at least 800 fishes, aside from the hundreds that were already killed during drilling and producing.

As some fisherman and divers noticed, some platforms may be great hosts for fishes, sponges, algae, and other species. The state-run Rigs-to-Reefs Program developed rules and ideas to instead of demolishing the platforms, converting them into an artificial reef. “Some species have increased in number because of the platform.”[22] Already 140 platforms are reefed in the Gulf of Mexico.

There are three ways of reefing; tow and place, partial removal and toppling. Severing the rig from the bottom is the easiest approach, but harms marine life since the explosives could kill the fish, therefore a five meter distance to the sea floor is required, to safe most of the fishes.

The idea of reefing is an applaudable one, as it gives the companies’ advertisement an ecological touch in contrast to the polluting and environmentally damaging aspects of it. In addition, the companies can save a lot of money. Reefing has, however, also its disadvantages. Reefed platforms must be toppled or dropped to a depth of at least 25 meters beneath water surface, but the fishes that lived there before are used to 18 meter or even shallower water. The fishes and other species would not survive the change of depth.

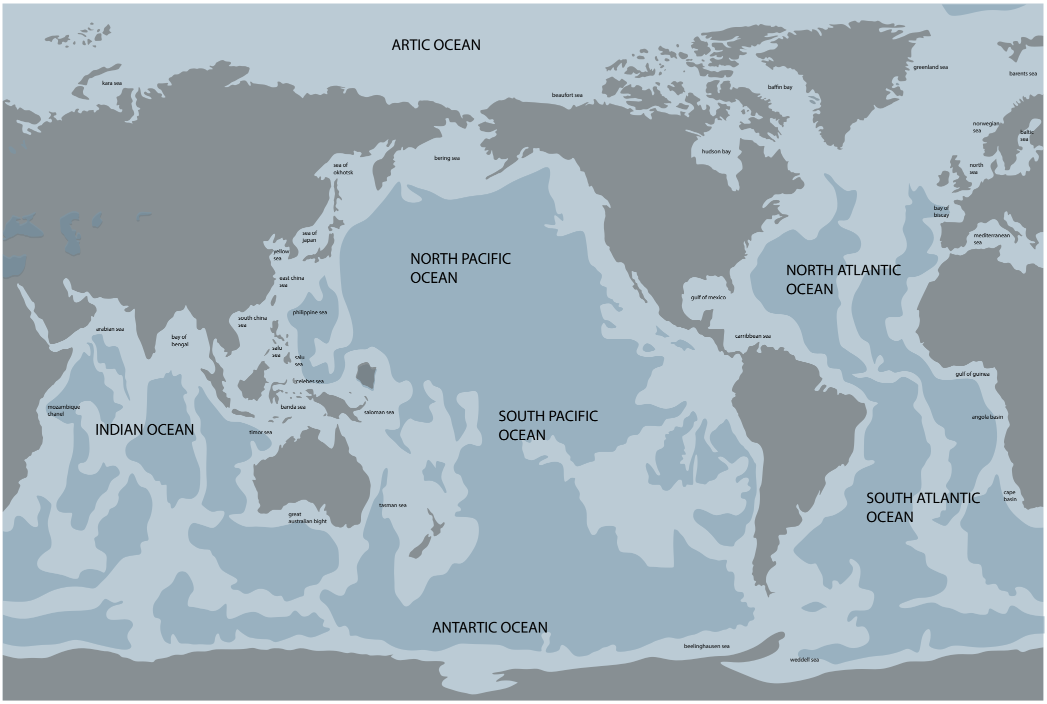
As mentioned before, it is a good way to minimize the impact of the oil industry. From a marine scientist’s perspective, fishes, sponges, and the other species should not breed in areas where they usually would not.

Rig-to-Reef program
Underwater view of a oil rig years after reefing

The world's oceans

72 % of the planet's surface is covered with saline water. The ocean makes up 71 % of it and contains 97 % of earth's water. Five bodies of water form the earth's ocean: the Pacific Ocean, the Atlantic Ocean, the Indian Ocean, the Arctic Ocean, and the Antarctic Ocean.

They are all interconnected and form one continuous body of water. Seas, bays, and gulfs differ in size, shape, depth, physical and chemical characteristics, but they are all connected with or within the ocean.


ARTIC OCEAN
kara sea
beaufort sea
baffin bay
greenland sea
barents sea
norwegian sea
baltic sea
hudson bay
bering sea
sea of okhotsk
north sea
bay of biscay
mediterranean sea
sea of japan
yellow sea
NORTH PACIFIC OCEAN
east china sea
NORTH ATLANTIC OCEAN
gulf of mexico
philippine sea
south china sea
arabian sea
bay of bengal
carribbean sea
salu sea
salu sea
gulf of guinea
celebes sea
mozambique chanel
banda sea
saloman sea
SOUTH PACIFIC OCEAN
angola basin
INDIAN OCEAN
timor sea
SOUTH ATLANTIC OCEAN
cape basin
tasman sea
great australian bight
ANTARTIC OCEAN
beelinghausen sea
weddell sea

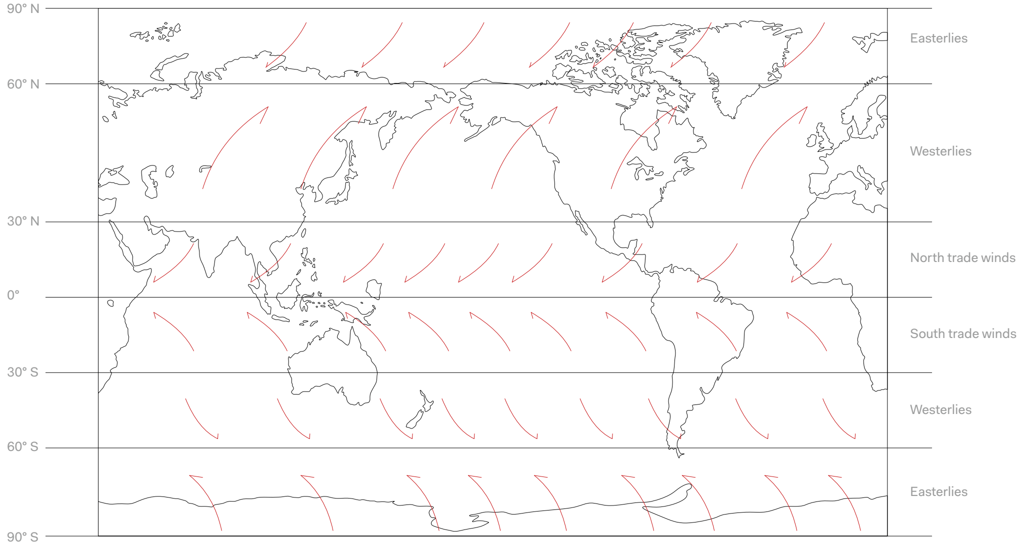
Weather and Winds

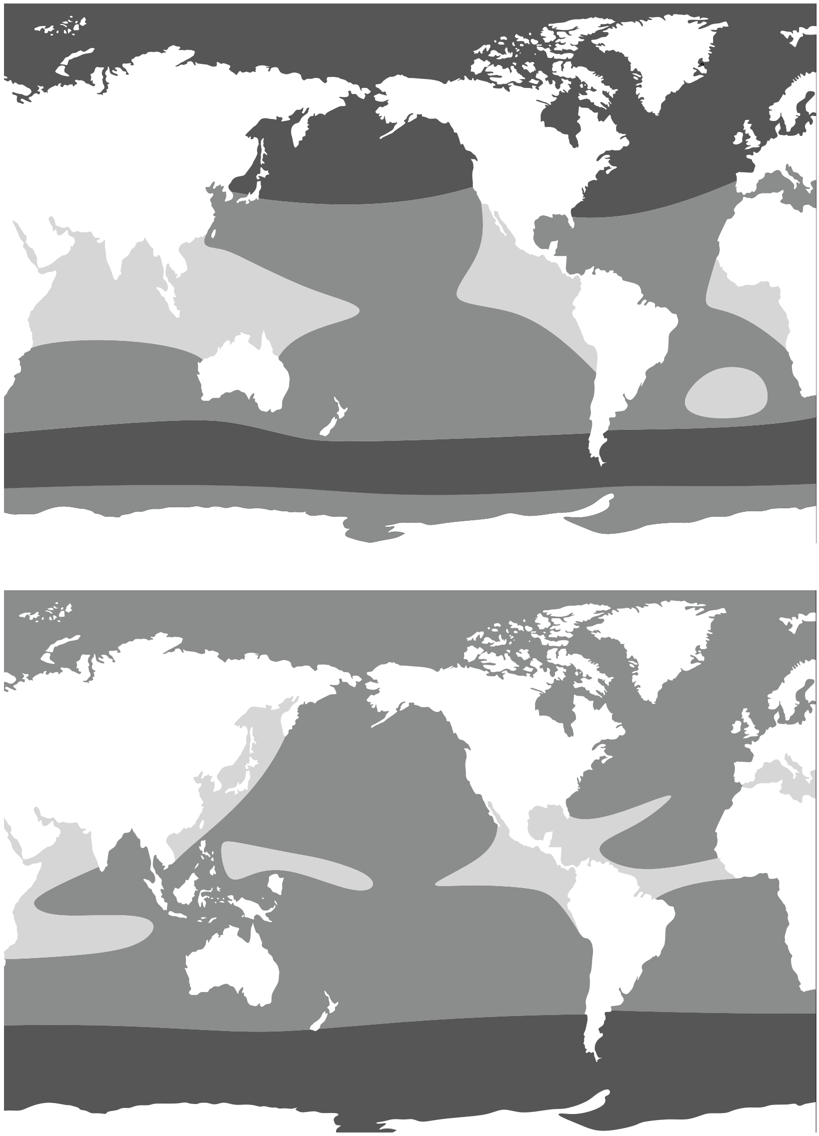
The globe is encircled by six major wind belts, the easterlies the westerlies and the trade winds, north and south of the equator. All six of them move north in the southern summer and south in the northern winter.

The easterlies about the 30–60° north are dry, cold, prevailing winds, which are usually irregular and weak. They blow from the high-pressure areas of the polar highs at the North and South Pole towards low-pressure areas within the westerlies at high latitudes.

The westerlies between 30° and 60° are prevailing from the southwest in the Northern Hemisphere and from the northwest in the Southern Hemisphere. They are strong winds, and play an important role for the world's atmosphere.

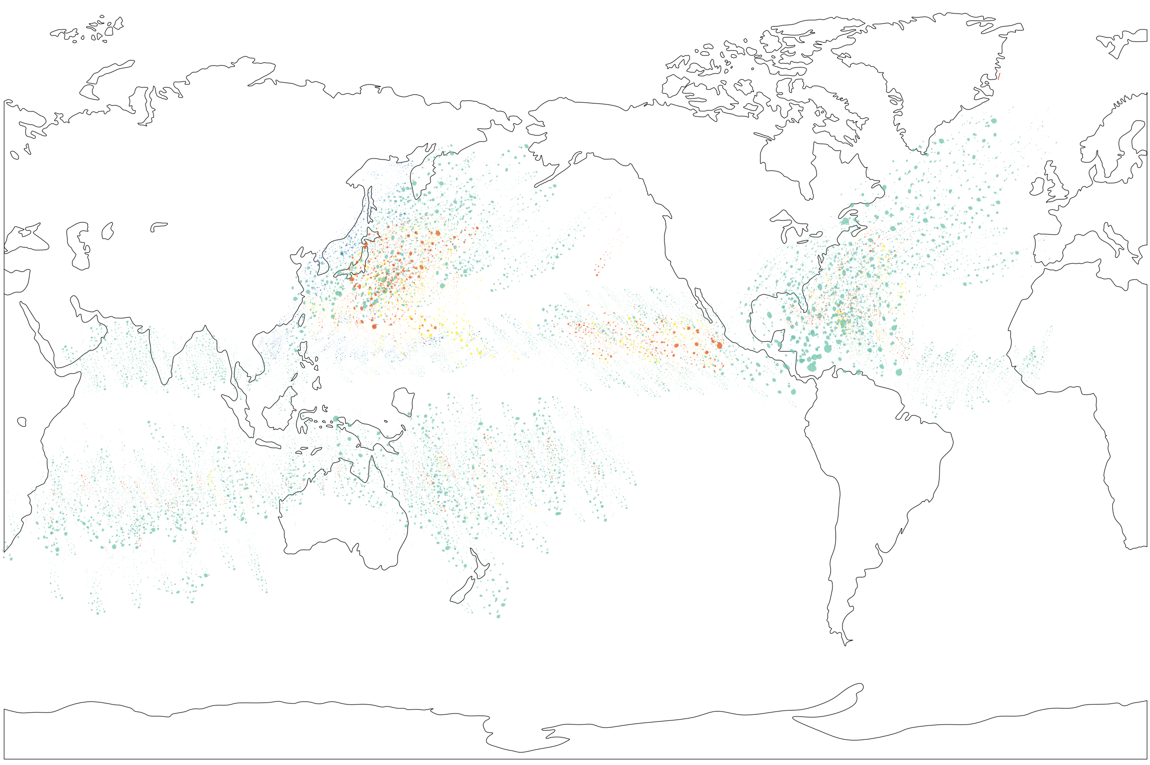
The trade winds blow from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. Sailors used to use the steady and moderately strong wind to sail across the world's oceans. At the Earth's surface 30° north and south the region is warm, dry and nearly without wind. This area is called horse latitudes. Without or too little wind, sailing ships got stuck in these latitudes. In terms of limited water on board they had to throw over the horses.





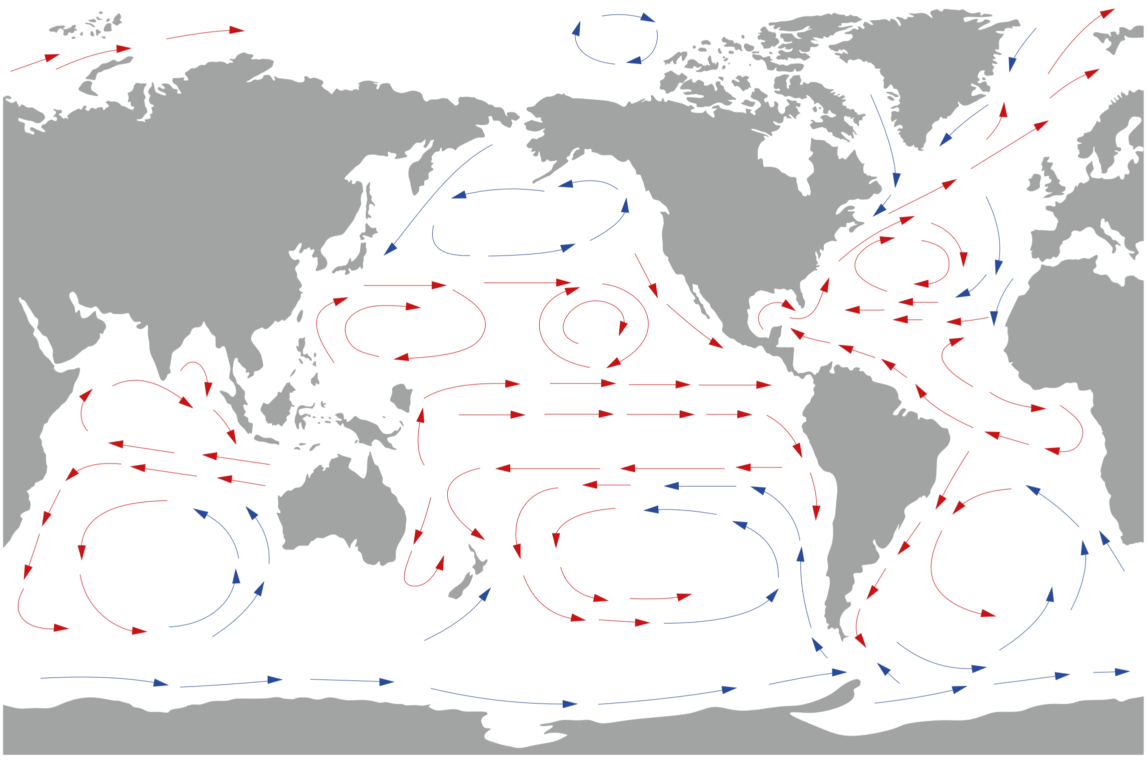
Wind speed
Different wind strenghten
Janurary (a.)
July (d.)

Usually, winds over the world's ocean reach an average of 50 km/h at most; within a hurricane they reach an excess of 160 km/h. Hurricanes need a sea surface temperature of about 26° C to form. They develop between May and December, July, August and September is the hurricane high season. The graphic below shows the storm development between May and September. From tropical storm to hurricane category 5 (turquoise to red)



The movements of seawater is“driven by the wind systems on earth’s surface.”[23] 40 different ocean currents create movement on the surface and are “almost like rivers in the sea, but carry a much greater loading than any freshwater river.“[24]

As water is heavier than air, it moves slower than the “prevailing winds that create them.”[25] The fastest currents with 4–7 km/h are the Gulf Stream and the Kuroshio Current.



Waves

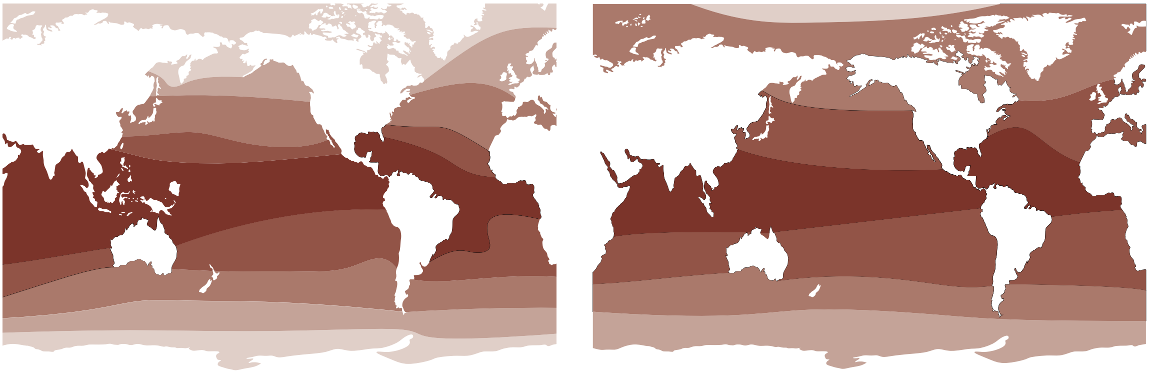
Waves usually formed when wind is blowing across the surface, the “size and energy of waves are determined by the wind’s speed, duration and fetch.”[26] In general, the speed and length of the wave determines the size of the wave. The average height of ocean waves is between 0.5–3 meters, storm waves can be up to 30 m tall.

Air temperature

The sun’s energy is the mover for wind, therefore influencing currents, waves and air temperature. Ultimately, winds shifting air masses around the globe create the weather. As seen below, the air temperature at the worlds ocean almost never goes below 0° C.

Water temperature

Approximately 15 % of ”the ocean is covered by sea ice for some part of the year.“[27] The temperature of the first meters depends on the air temperature. Below a certain depth, the water temperature of all oceans is the same (see chapter: The ocean vertical).

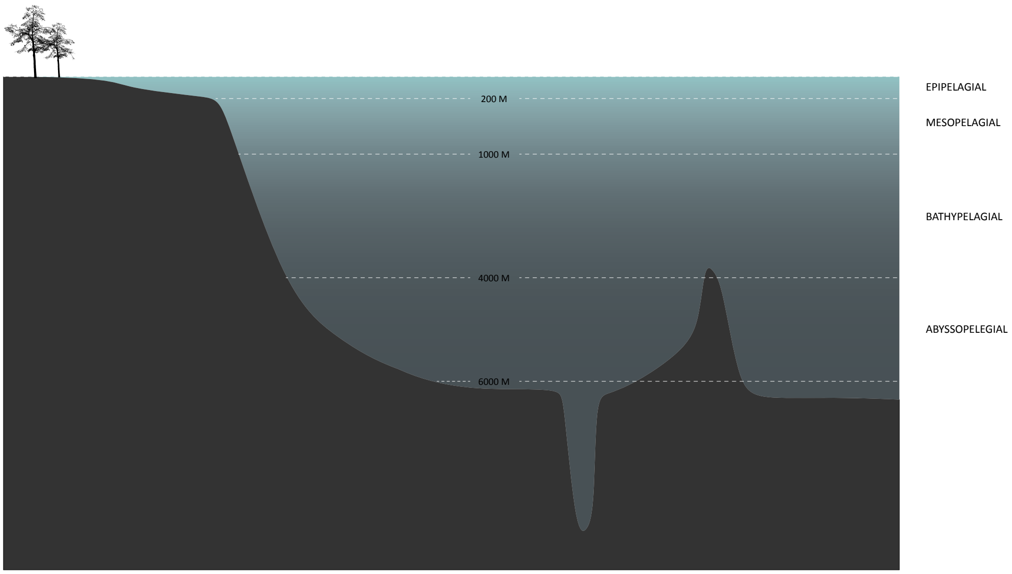


Air temperature
left january, right july
0-35 °C

The ocean vertical

As described in the previous chapter, the ocean's surface does not change a lot in terms of location or season; it changes in terms of depth. The ocean is much deeper than the land is high, the average height of land is around 2.700 meters, while the average depth of the ocean is about 3.800 meters. The Mariana Trench near Japan with, 11.022 meter below sea level, wins against the Grand Canyon with 6.300 meters depth. With the depth of the oceans light, temperature, and pressure is changing.

The depth of the ocean is divided into four zones: Epipelagial (the sunlight zone), Mesopelagial (twilight zone), Bathypelagial (midnight zone) and Abyssonpelagial (the Abyss).



Light

At already 100 meters of depth, only 1 % of light remains penetrating the sea surface, below the Bathypelagial zone, there is no sunlight penetration. Therefore the animals, that live in such depths, produce their own light (see chapter: Deep Sea).

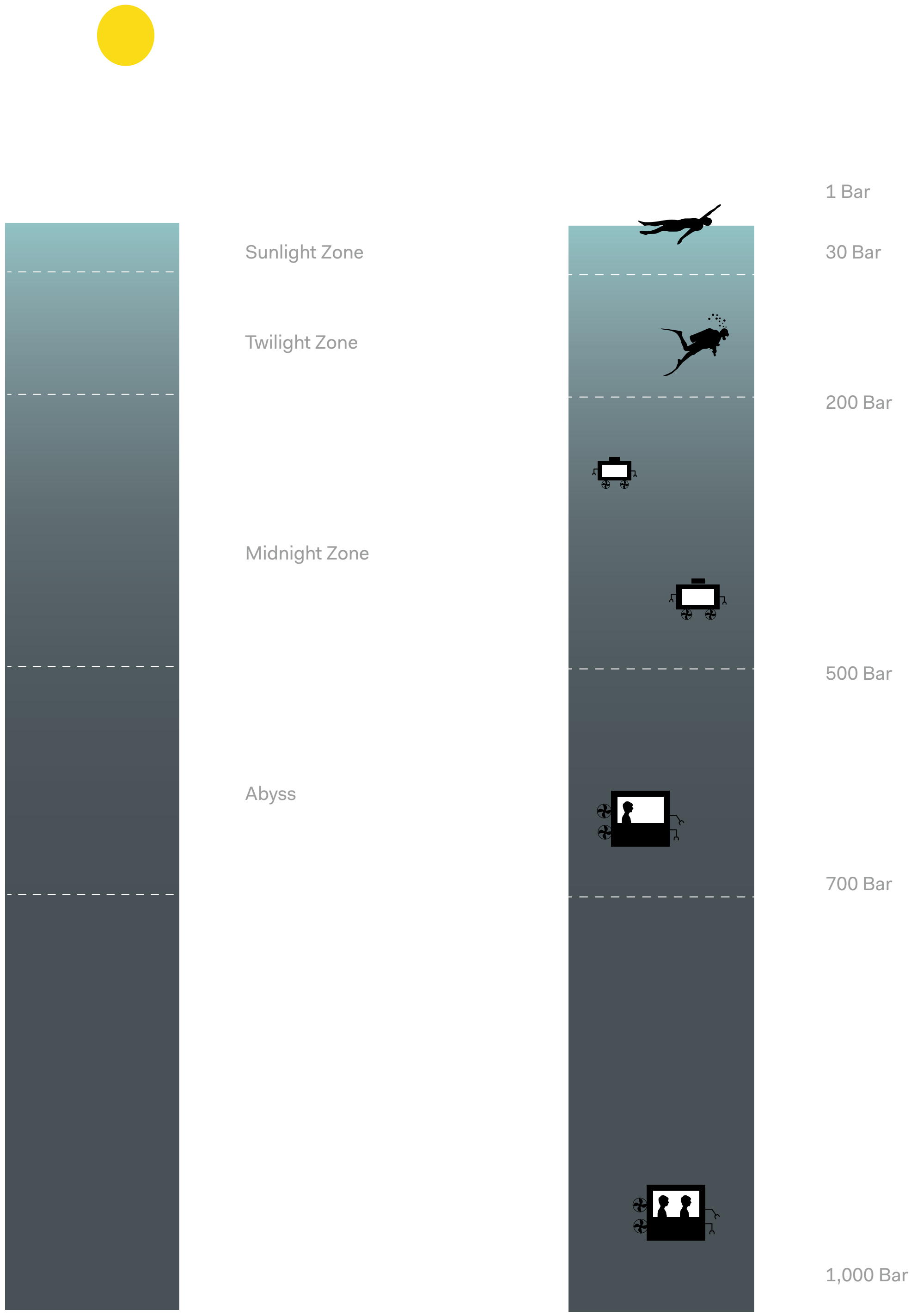
Temperature

Most open oceans have three different layers of temperature. The "topmost warm layer, typically reaching a depth of 100–300 meters, that is kept mixed by wind action at the surface."[28] Below that layer, until the depth of 300–600 meters, is "a step temperature gradient called the Permanent Thermocline."[29] The Thermocline forms a physical barrier, the temperatures are relatively constant in the range -1 to +5° C. This layer forms 75 % of the volume of the world's oceans.

Pressure

As well as light and temperature, the pressure also varies with the depth of the oceans. At the oceans surface, the pressure is 1 bar, which is equivalent to 10.000 newton per square meter.

For each 10 meters lower, the pressure increases by 1 bar. In the deepest parts, for example in the Mariana Trench, the ambient pressure is 1.000 bar, 1 ton / m^2. Pressure is the major problem for exploring the depths of the ocean. All technical equipment has to withstand it. For human beings, diving is possible for up to 700 meters; a special atmospheric diving suit can protect the body from the pressure experienced at deeper depths.



Sunlight Zone
Twilight Zone
Midnight Zone
Abyss
1 Bar
30 Bar
200 Bar
500 Bar
700 Bar
1,000 Bar

The Barreleye
This deep-sea fish has extremely light sensitive eyes that can rotate

Marine life

In the marine ecosystem, the phytoplankton produces the main part of organic matter; the other part is seaweed, sea grass, and mangrove produce. Species at the seabed live from other species or from the so-called sea snow, a term describing garbage which flows down from the upper sea levels. Despite its smallness, zooplankton (phytoplankton) and plankton are the essential part of the marine food chain. Even the biggest animals are dependent on it.

Plankton and other species need light to live, therefore they live in the Epipelagial and Mesopelagial zone. As mentioned before, there is no sunlight from the Bathypelagial downwards, so fishes, sponges, and craw fishes produce their own light and live without photosynthesis.

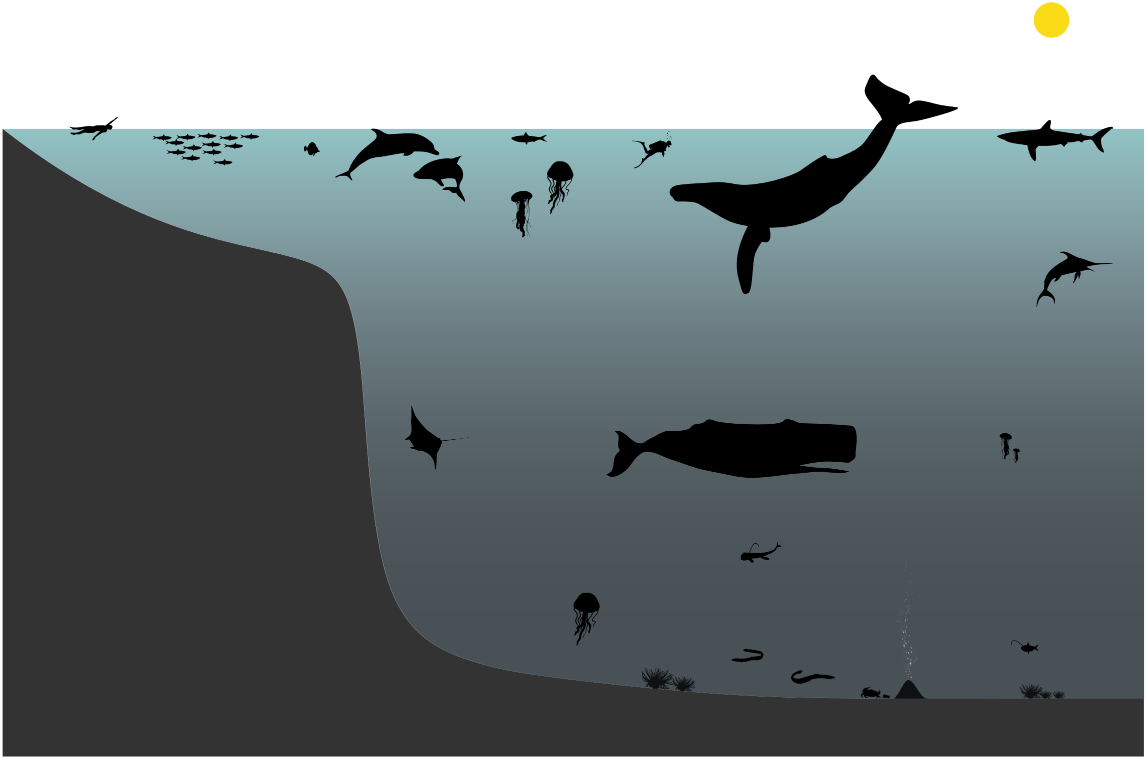
Ocean Floor

The ocean floor "forms the largest surface habitat on earth."[30] The world's oceans have a common structure. The continental shelves, continental slopes and continental rise leads to the ocean floor. The ocean' s floor is nearly unexplored. Next to oil and gas, silver, gold, copper, cobalt, manganese and zinc can be found underneath in the ocean floor. Latest explorations also found materials that could be used as renewable energies.

Deep Sea

The deep sea is one layer of the ocean, downwards from the Bathypelagic Zone. The Bathypelagic and Abyssopelagic zones form the biggest biological environment on the planet. Today, around 2.000 species of fish have been found so far. They have to deal with high pressure and oxygen concentration in the depth of the ocean. In these zones, the temperature does not change with weather or seasons, it is steady around 0–5° C.

There is no sunlight, so the fishes usebioluminescence to produce their own light. It "is used less as a defensive strategy or camouflage and more as a lure or means of communication."[31] The eyes of the fishes are often degenerated or really small. Sensory hairs, antennae, a strong sense for smell, or lateral lines help them to orientate in a pitch-black living environment. Most of the fishes feed on sea snow, predator fishes attract smaller fishes with glowing parts of their body.



Oceanography

Oceanography

History

The studying of the oceans, i.e. Oceanography, is a relatively new scientific research field that commenced in the mid 18th century. The Gulf Stream was the first part of the ocean studied from a scientific aspect.

Before that, the main focus was on exploring the ocean in search of unexplored territory, not necessarily understanding the function of it. In 1850, after charting all of the world's coastlines, the idea arose that most of the ocean must be very deep. The first research ship, a modified navy ship equipped with laboratories, set its sails in 1872. The cruise sounds, bottom degrees, trawls, and water temperature, was taken and around 4.700 new species of marine life were discovered. The University of Edinburgh was the first one offering oceanography as an academic discipline and remained the center for oceanographic research well into the 20th century. Other nations sent out scientific expeditions, up from the late 19th century. Jacques Cousteau is the most known marine researcher. He gave oceanography public attention trough his self made movies about the ocean and his expeditions.

The age of electronics has changed the way of conducting research, as well the WW II, when electronic navigation systems were developed. RAR (Radio Acoustic Ranging), deep-ocean cameras, early magnetometers, early technology for guided ROVs (Remotely Operated Vehicles), and side scan sonar instruments were developed. Due to such technical developments, greater depths have been reached. In 1960, the Mariana Trench was observed down to 11.022 meters.

Fields of research

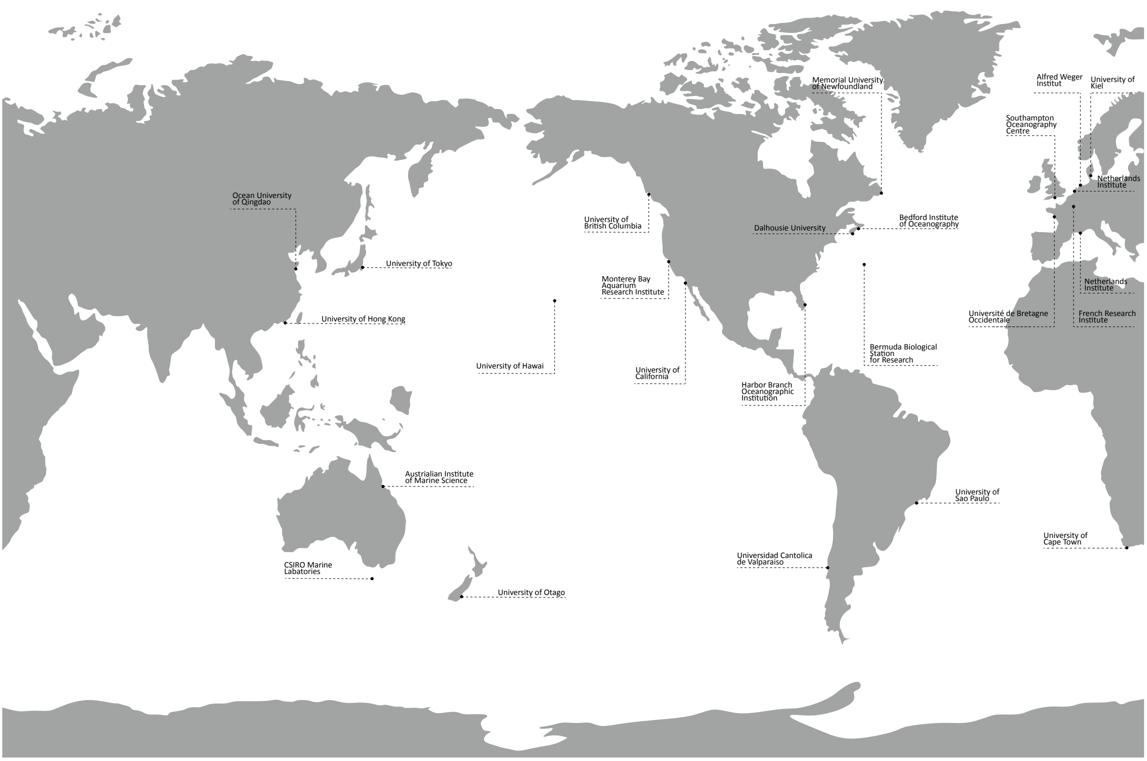
Oceanography, as a marine science, can be divided into four fields: Chemical Oceanography, Geological Oceanography, Biological Oceanography, and Physical Oceanography.

Chemical Oceanography is the study of the behavior of the chemical elements within the earth's oceans. The study of history and structure of the ocean's floors is summarized in Geological Oceanography, or Marine Geology. Biological Oceanography focuses on marine organisms and their relationship to ocean circulation, nutrients and the bio-geochemical cycling of elements, while Physical Oceanography focuses on the physical properties and dynamics of ocean processes.

Research Labs Worldwide

The growing interest to explore the world ‘s oceans over the past years has led to the formation of new research centers worldwide. The majority of them are situated in Europe and the USA.

Besides mainland institutes, research ships sail around the world to obtain more knowledge, data and understanding of the vast undiscovered territories of the oceans.



Oceanography

Life of an Oceanography researcher

Marine researchers usually have two workplaces, a working desks on a mainland office and expeditions on research vessels that sail the oceans for data collection. For most young students pursuing degrees in marine science, working on board of research vessels is one of the main reasons to start.

In the offices onshore, the marine researchers develop new expeditions, or work out material samples and research reports from previous expeditions. The research ships belong to different universities and institutions. Marine researchers must apply to obtain a research vessel for a certain period of time to operate their expedition. Expeditions are rather expensive, the average cost of a research vessel is approximately € 20.000 per day. The expeditions, to a certain degree, founded by scholarships and research grants received from various public and private institutions.

As mentioned above each expedition starts with an idea or particular interest area that is perceived of needing further or entirely new empirical evidence.

After an expedition is permitted and the necessary funds are obtained, the leading marine researcher forms a team that is going on the expeditions. Usually, it is a mix of senior researchers and scholars together with students.

Since every expedition has a different goal, focusing either on Chemical, Geological, Biological, or Physical Oceanography, the equipment needed varies. An expedition pursuing to explore sponges of the deep sea,for example, needs different equipment from an expedition searching for sediments on the ocean floor. Thus universities and institutes usually own huge warehouses, where hundreds of robots, machines, and other marine research equipment is stored.

As marine researchers depend on special instruments and computers, a preference goes out to the development of such by themselves. Just like an architect likes to choose his program or a painter choose his brush, an oceanographic researcher chooses his instrument, as previously mentioned sometimes built or modified on his own. If a marine researcher goes on a research expedition, the equipment gets packed and brought on the vessel. For this reason, besides others, many research universities and Institutes are situated right next to the sea.

On average, a marine researcher gets on one to three expeditions annually. For that, many of them are creative with packing their instruments. Packing and unpacking is a time consuming process. Often they are integrated in a travel box, already equipped with the necessary energy and water connections. Like this, unpacking is not necessary and the instruments are fast ready to use.

After the instruments and the crew is on board, the vessel leaves main land for about a month or two, to collect material samples, fishes, water samples, situate measure instruments, maintain measure instruments, measure by their own and scan the ocean floor. Using the labs and measure devices on board is just doable to a certain point. A ship in motion on a dynamic sea is seen as undesirable for the highly sensible instruments of marine research.

Mesurement Instrument
At the IOW in Warnemünde

After coming home from a expedition, the materials have to be worked out, expedition reports have to be written, and the next expedition can be planed.


Heidolph

Offices and Laboratories

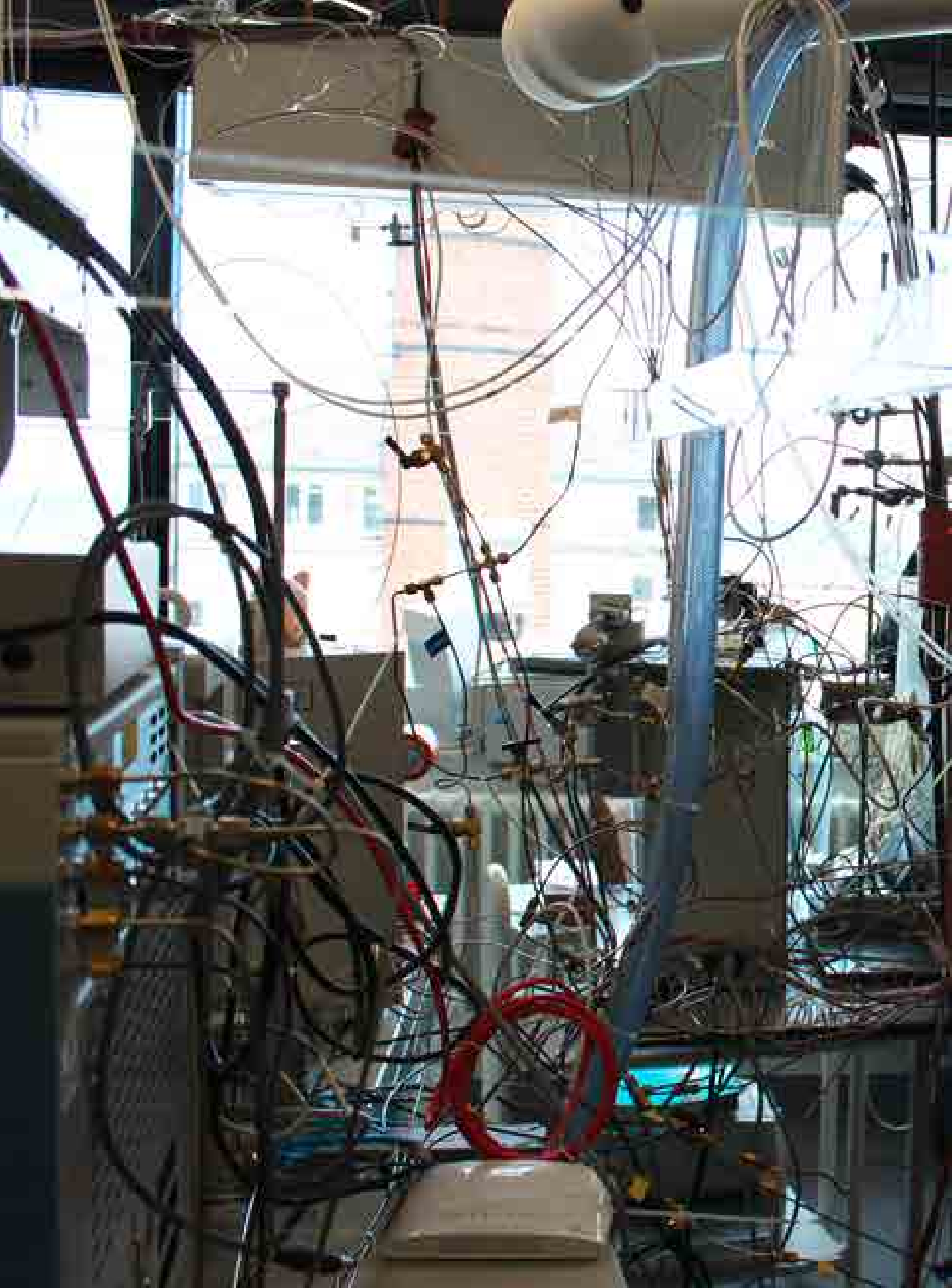
As previously mentioned, marine researchers spend the majority of their time in offices at different universities and institutes. As oceanography is a relatively new science, the universities and institutes housing the facilities, are also often quite new. Nearly all facilities are situated right next to the water, or are as close as an hour away. To have a direct connection to the research vessels and the sea is perceived as a great advantage. Some Research Institutes even extend their research into sea. The Marine Science Centre in Warnemünde, situated in the north of Germany, has a seal station set on a ridge into the sea, where seals live in natural salt water, and their reproductive behavior can be researched. Visitors are allowed to visit the station and even swim with the seals.

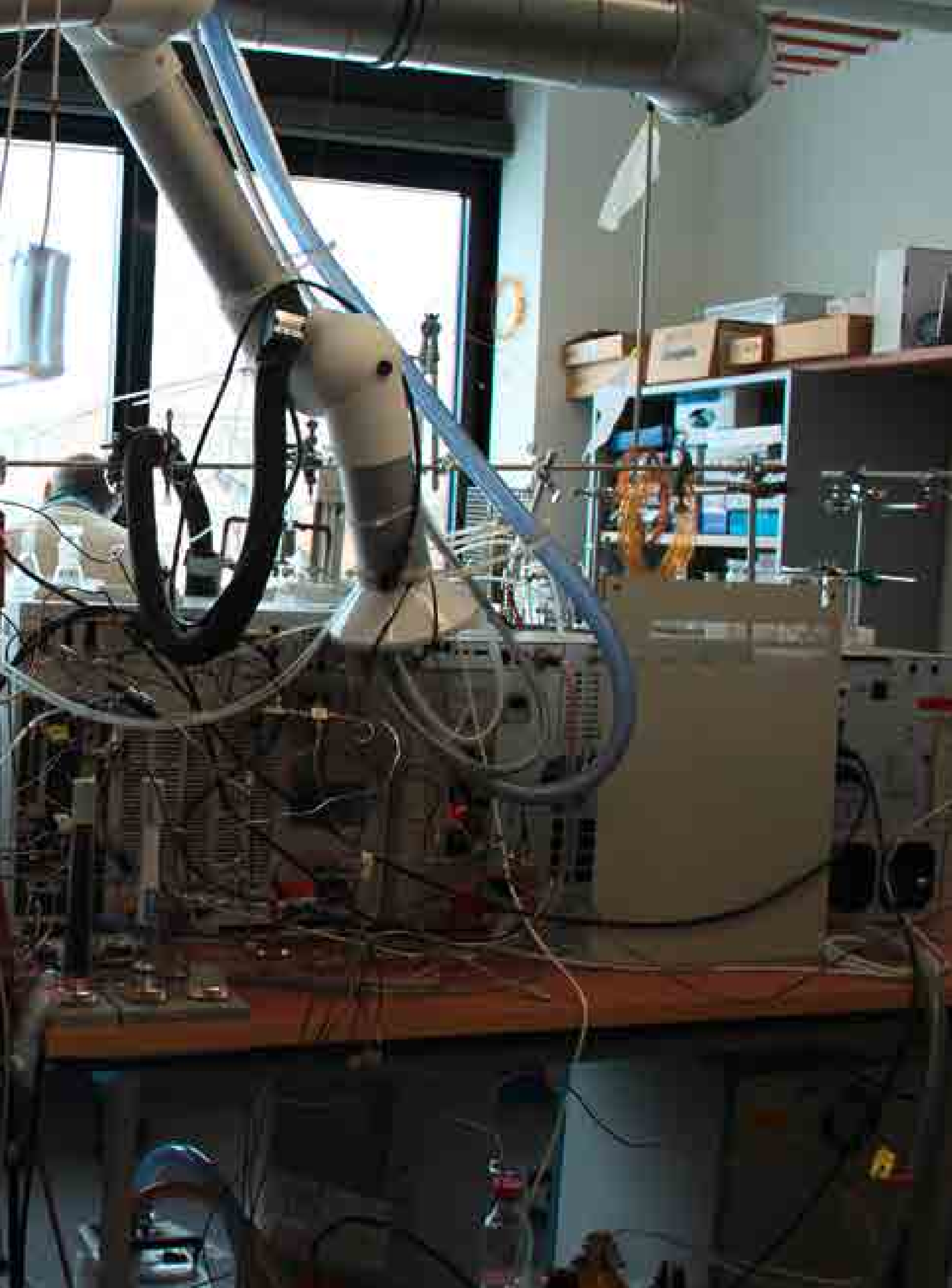
On main land the marine research facilities are; office desks; laboratory desks; and special laboratories. Each leading marine researcher has one office and a laboratory desk. The offices are often single offices, between 12–20 m^2, equipped like any other office: some shelves, a desk with two visitor chairs for meetings, and a computer.

Next to an office desk, each marine researcher has one permanent desk in the general laboratory. Usually three to six people share one room. The desks are equipped with the basics laboratory equipment. As mentioned before, oceanography researchers use their own instruments; therefore today's laboratories are modified for that. The walls of the general laboratory desks are design for a modular system, to clip in the different instruments each researcher needs.

The special laboratories host specific equipment. For some measurements, special humidity, temperature, or light conditions are needed. Each field of oceanographic research has its own needs, and therefore different special laboratories. Biological Oceanography has, for example, vacuum chambers, an isotope laboratory and a molecular laboratory; Physical Oceanography needs a fine mechanics workshop and a calibration lab. Therefore they vary in size and design in terms of temperature or light conditions. Depending on the housed equipment they vary in size between 10–200 m^2.

Most of the time, the marine research facilities are not built for communicative purposes. The offices and labs are often single ones, connected via long narrow dark hallways. The social aspect of meeting somebody by accident is important for the social life at work. Often the built environment does not provide space for spontaneous meet ups and the small cafeteria is the only place to meet people.





The research vessels can be seen as mobile expedition laboratories, and they are as much as important like the ones on mainland. The expeditions are great possibilities to explore new species, sediments and many more.

Life on board

On average a research vessel holds the capacity for approximately 30 people. Only a few ships, like the research vessel, named ATLANTIS, have space for up to 60 people. Often, there are only 15 beds, enough to fit half of the crew.

The personnel work in shifts, with two people sharing one bed. Being on a research vessel is not just exciting and adventurous. Leaving family and friends for a number up to 135 days a year is the bitter side of being a marine researcher. With age, it becomes increasingly difficult to leave the family. Yet again, like on the oil rigs, the international crew, meeting new people and a family-like atmosphere on board helps to keep the crew motivated and in a good mood.

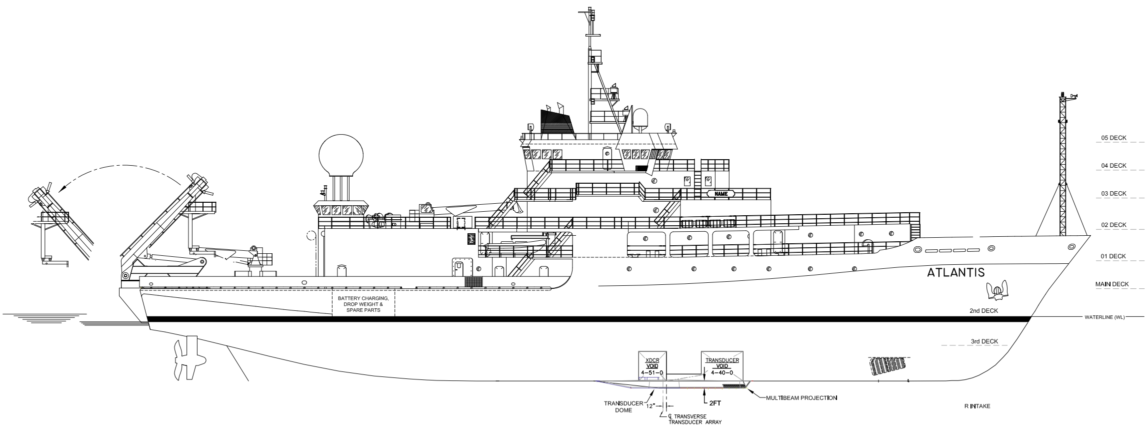
As mentioned before, the main activities on board include collecting data such as material samples, fishes, water samples, situating measure instruments, maintaining measure instruments, measuring by their own and scanning the ocean floor. The problem of working on the ship is that the vessel is constantly moving. Most of the sensitive marine research instruments can not be utilized under these conditions. Research in the labs of the ship is limited. Without a lot of recreation space or other things to do, life on board can sometimes be boring and frustrating.

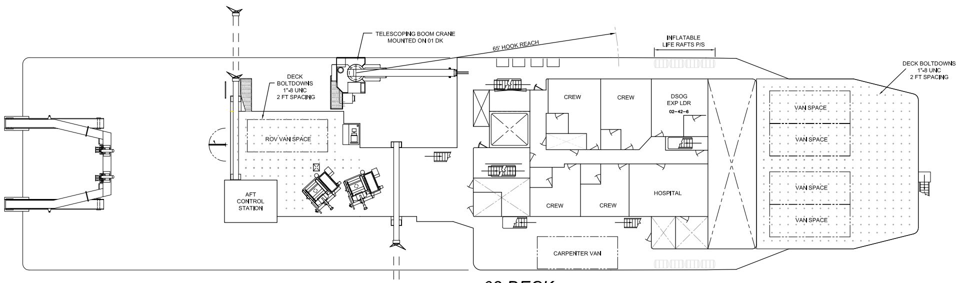
ATLANTIS
Atlantis is owned by the US Navy and operated by the Woods Hole Oceanographic Institution

The Vessel

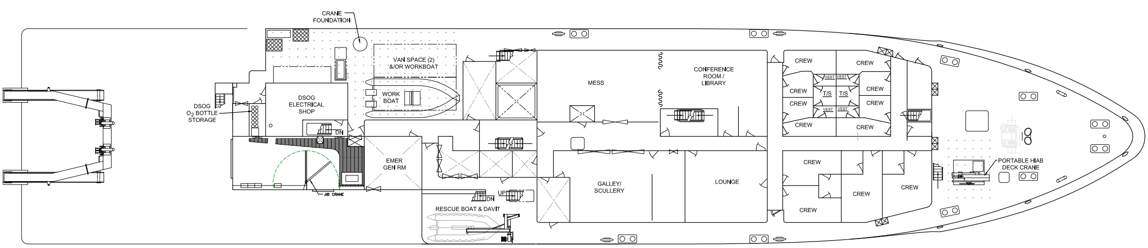
On the research vessels, space is limited and focused on labs and research facilities. They are well equipped, with labs, cranes, and smaller boats. Recreation and sleeping space usually takes up the smallest space.

The distribution of space can be seen in the ground floor plans on the following page: the vessel is well equipped with a computer lab, biological/analytic lab, hydro-graphical lab, wet lab, and storage room. The recreation room forms one lounge.


05 DECK
04 DECK
03 DECK
02 DECK
01 DECK
MAIN DECK
2nd DECK
WATERLINE (WL)
3rd DECK
ATLANTIS
NAME
BATTERY CHARGING, DROP WEIGHT & SPARE PARTS
XDCR VOID 4-51-0
TRANSDUCER VOID 4-40-0
TRANSDUCER DOME
12"
2FT
℄ TRANSVERSE TRANSDUCER ARRAY
MULTIBEAM PROJECTION
R INTAKE



02 DECK, *R/V ATLANTIS*



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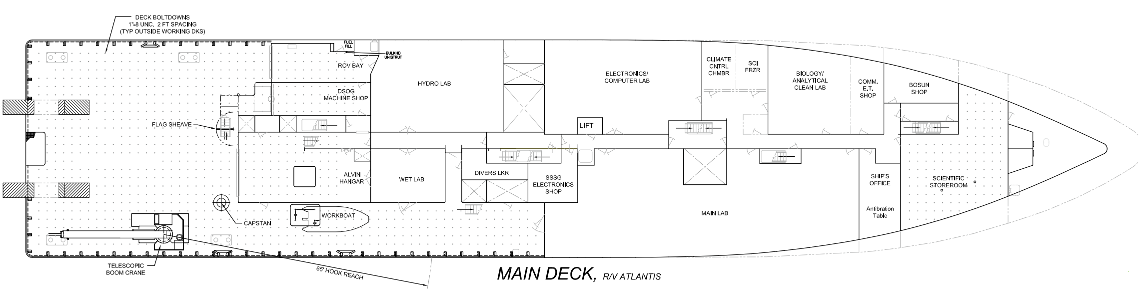


MAIN DECK, *R/V ATLANTIS*

Equipment

The most important equipment to research, especially in the deep sea, are underwater vehicles, named ROVs, AUVs, and HOVs. Remotely Operated Vehicles, short ROVs, and Autonomous Underwater Vehicles, short AUVs, are unmanned underwater vehicles. Human Occupied Vehicles, short HOVs, can carry one to three people.

For energy and information transmission, the ROVs are connected to the ship with cables. ROVs and AUVs are easy to differ from the outside. While ROVs do not have to save energy, they are built as frame or framework with all kinds of components in it, with a variety of drive propellers. AUVs carry their own batteries and are not connected to the ship. They collect data and transmit the data via satellite. They have to save energy, therefore they are built with a low resistance formed outer skin such as submarines or torpedoes have. The underwater vehicles vary in size and function. ROVs can weight between 1,5 kg and 20 t. HOVs are manned underwater vehicles, carrying a maximum of three people, one pilot and two scientists.

Nowadays, they can reach nearly every trench. “Alvin” is today’s most famous underwater vehicle, specialized on researching the deep sea. One dive lasts six to ten hours. Sensors measure currents, temperatures, and chemicals. With 3 000 sensors spread worldwide, the ocean gets covered more and more every day.

ROV
An underwater vehicle collecting data at the ocean’s floor

Collecting data

HOV
Manned underwater vehicle
exploring the deep sea

Letting marine sensors
into the ocean

Calypso

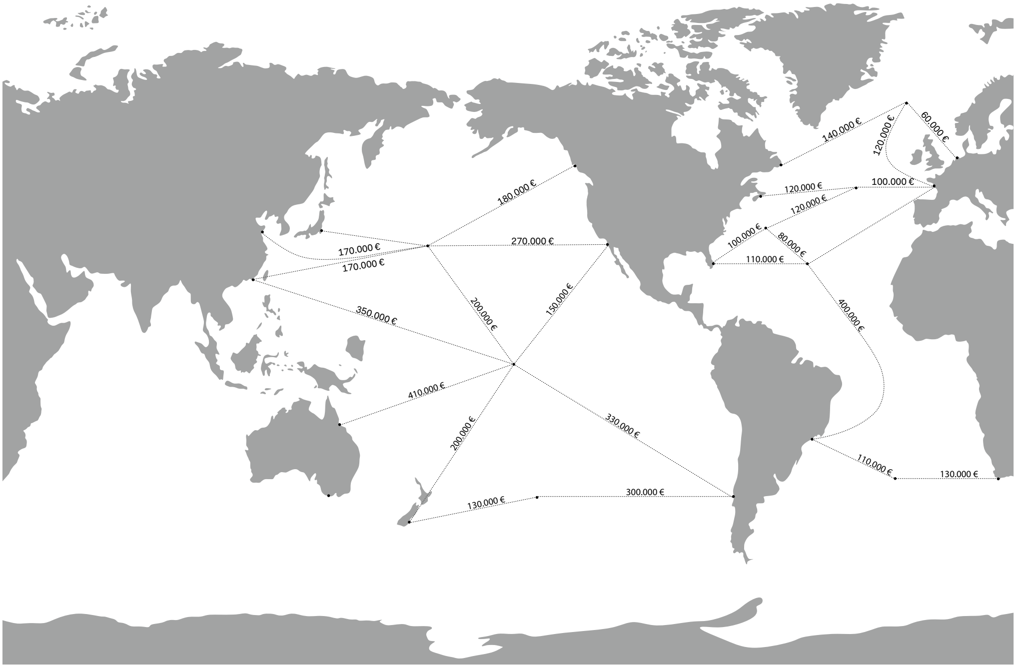
Research vessels have always been essential for marine research. New techniques and innovations have eased the marine research and led to many discoveries the past decades. Rising costs of oil and fuel makes the expeditions more and more expensive.

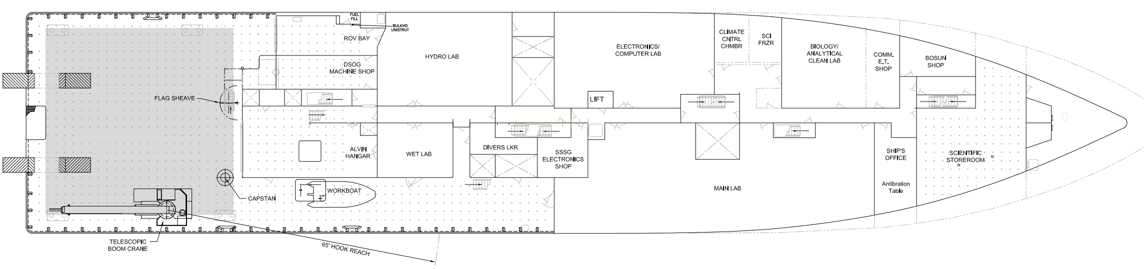
Crew and fuel costs are the two largest single components of the total research vessel operating costs. For example, the operational costs of a research vessel are around € 20.000 per day. Since research areas can be far from the main land, getting there, alone already costs a lot of money.

Awareness regarding the state of the world's oceans and its effects on global warming, possible natural resources, global weather, and many more increasing. The interconnectedness and complexity of the problems faced today are contributing to the way research is done. The different fields of oceanography research are starting collaborate on certain issues. Nowadays, expeditions are single investigative. The rapid development of technologies used for research, impose another issue of the building of suitable vessels. ROVs, AUVs, HOVs, sensors, and other research equipment will change in the future in terms of size, weight, and usage.

A general research vessel can be used for up to around 30 years. Technical developments, however, are rapidly changing on a much faster basis and therefore impose problems for the vast adjustments of such vessels and ships used for research. Currently, research vessels usually carry one to a maximum of two underwater vehicles. Often, a ship is built or adapted to this special equipment. The marine research vessel ATLANTIC, for example, is especially used to transport the HOV ALVIN. Often, some sensors or special equipment is even integrated in the ship, and therefore complicated and expensive to modify or replace. The need of future research, require the ability to carry more instruments and equipment, therefore the design of the oceanography research ships will have to change. The trend of the research vessel design is to keep the main deck as empty as possible of fixed and integrated ship or research equipment. This is in order, to carry a wide range of multiple devices and underwater vehicles, even if they change over time in size and weight.

The flexibility of using a range of instruments leads to longer expedition cruises and more crew members. Nowadays, researchers usually stay a month on a vessel. With longer cruise time, people will need more comfort to be able to work effectively and concentrated on the ship.

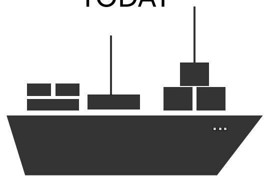


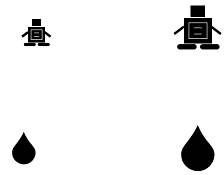


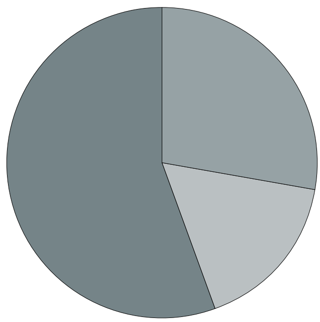
ATLANTIS

Main deck of the research vessel
and space for equipment

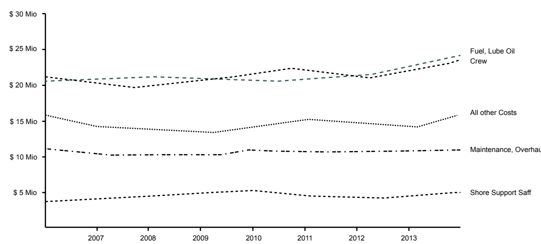
TODAY

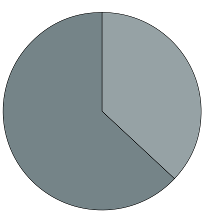




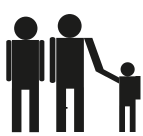


- 100 Days -
- 200 Days Port,- Maintenance time
- 60 Days Expedition





- 135 Days Research vessel
- 230 Days Home



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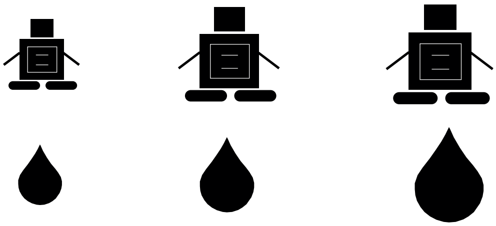
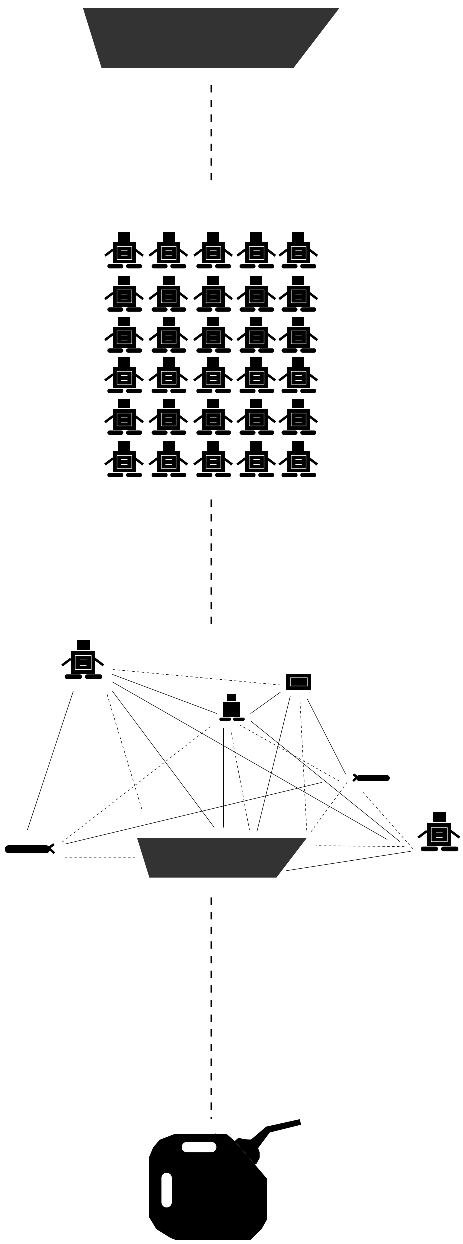




Re-using semi-submersible

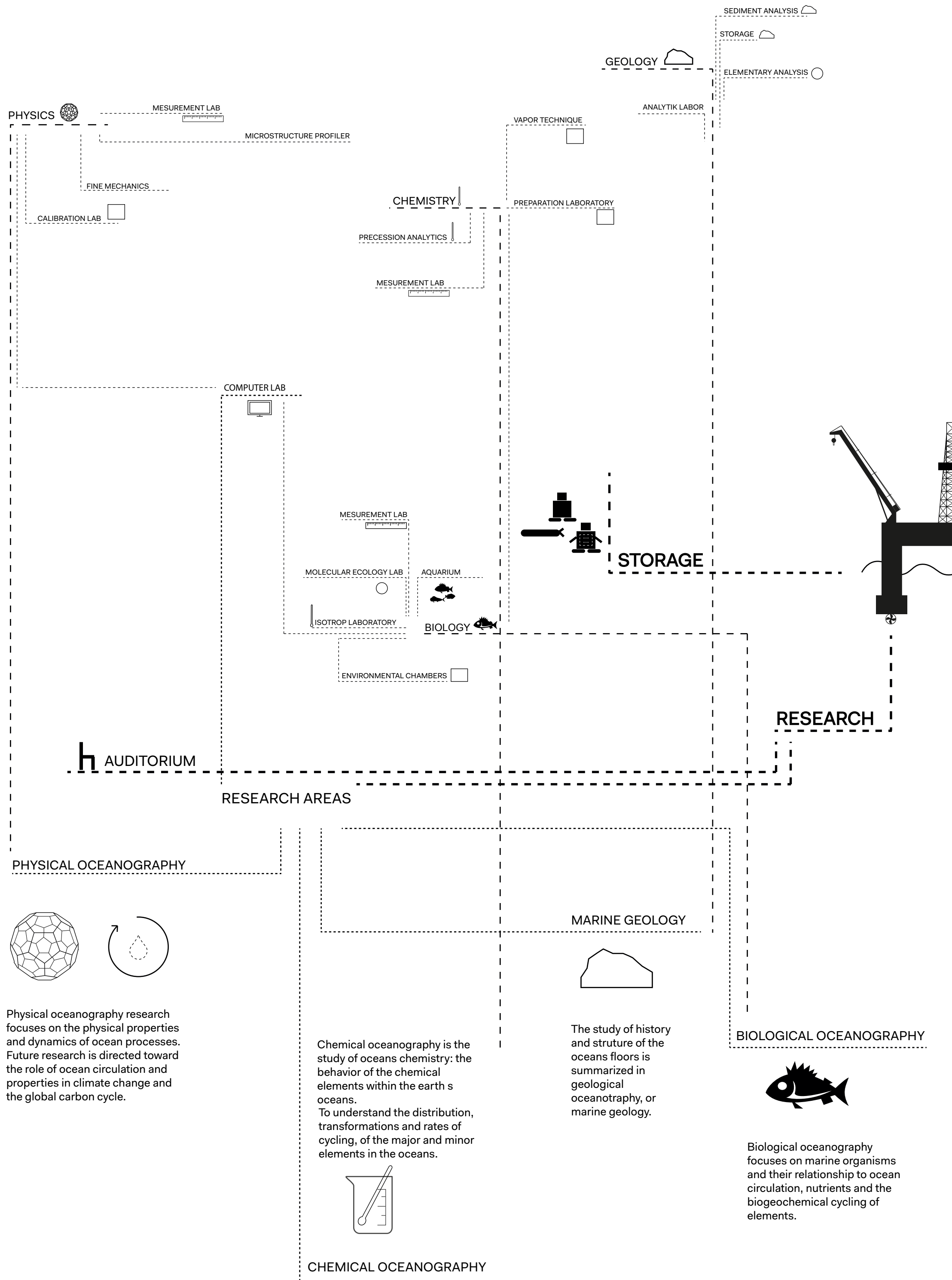
Re-using a semi-submersible oil platform as a deep sea research facility. Semi-submersible oil rigs are high-end technical “machines”, developed with a great amount of knowledge and money.

Nowadays it is the most resistible of all oil platforms, usually made to withstand lifelong hurricane conditions. In addition, semi-submersibles are not limited on water depth or soil texture, because they can adjust their position automatically via dynamic positioning (see chapter: The chosen platform). As mentioned before the trend of future research vessel is to design them bigger and as kind of a platform to transport a variety of research equipment. Re-using a semi-submersible oil platform would provide for that. Floating oil platforms could be seen as huge ships with higher safety conditions bigger in size and less motion, which is currently a problem on research ships (see chapter: Research vessel). Next to vessels semi-submersible oil rigs are the only types of oil platforms that are not limited on water depth.

Functions

The Calypso holds the capacity to accommodate up to 100 crew members in a rotating 6 month cycle. Depending on the research objective, it can be a mix of all fields of studies such as, chemists, physicist, biologist and geologists. In this 6 month period, the crew will live and work on the platform. Next to living and working facilities, a huge storage place for the variety of equipment is necessary as well as a means for the delivery of supply and for the production of energy.

Since, living under such “extreme” condition can be exhausting and stressful, next to living, working and storage facilities the focus is on sport and recreation areas.

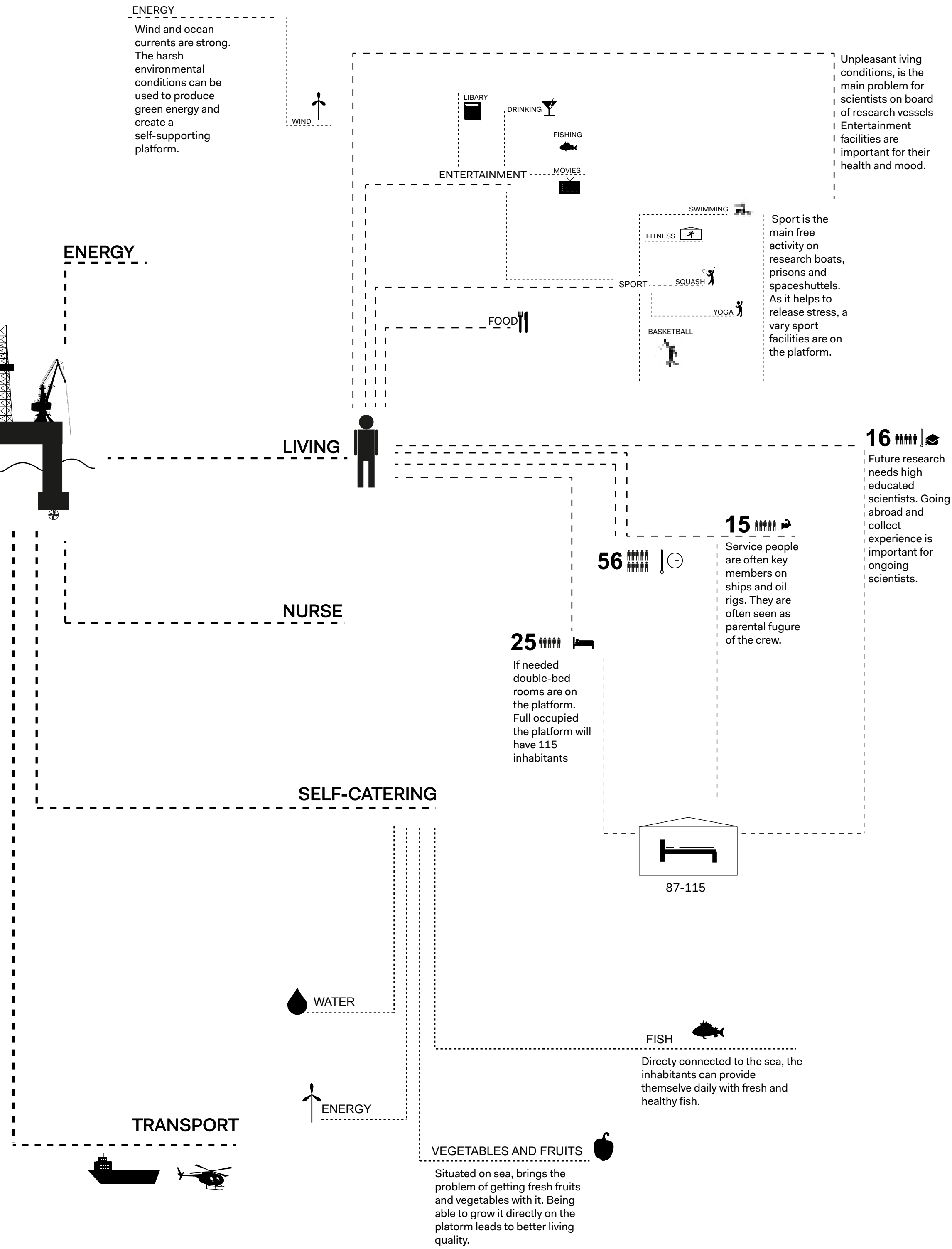


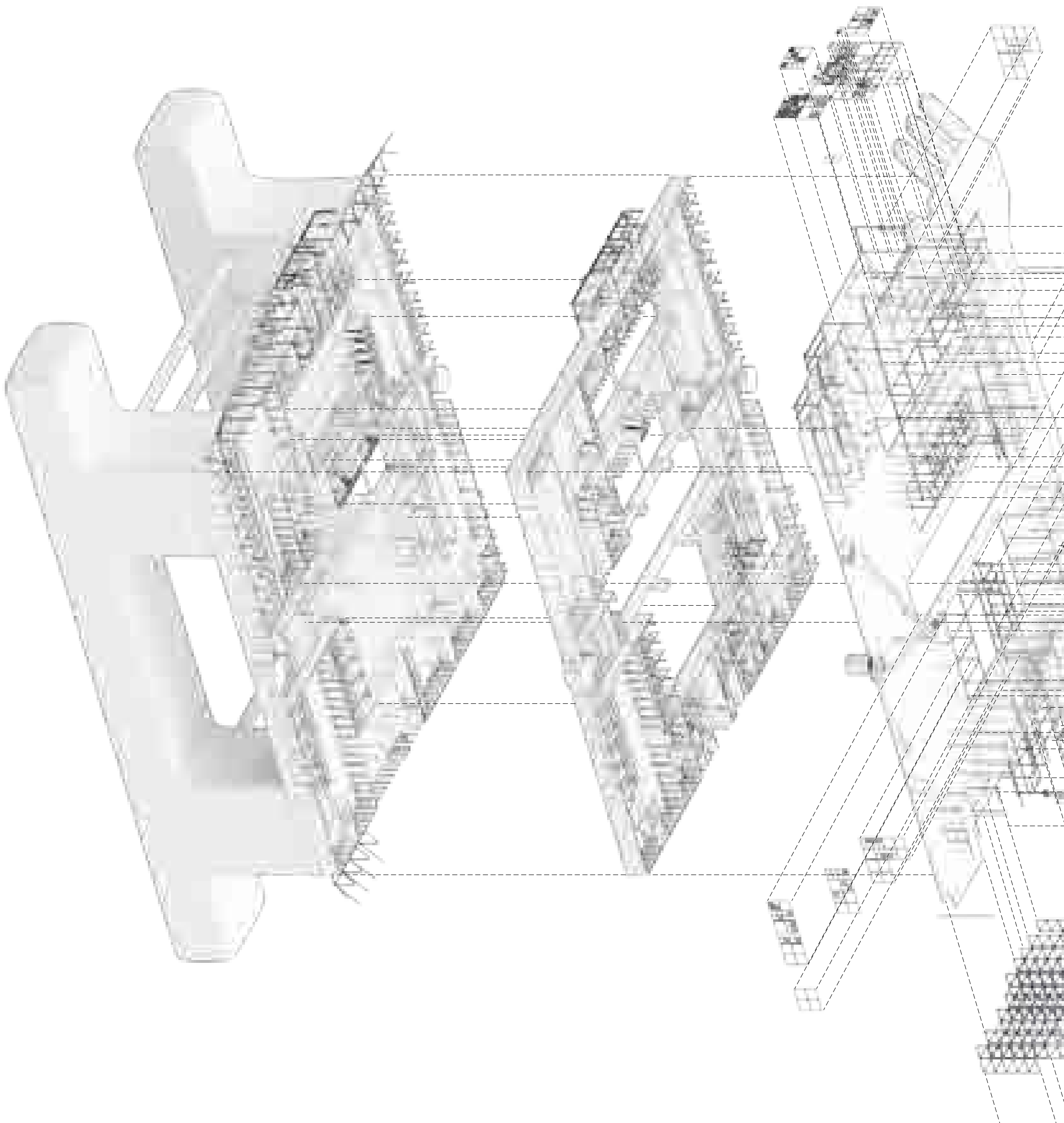
Physical oceanography research focuses on the physical properties and dynamics of ocean processes. Future research is directed toward the role of ocean circulation and properties in climate change and the global carbon cycle.

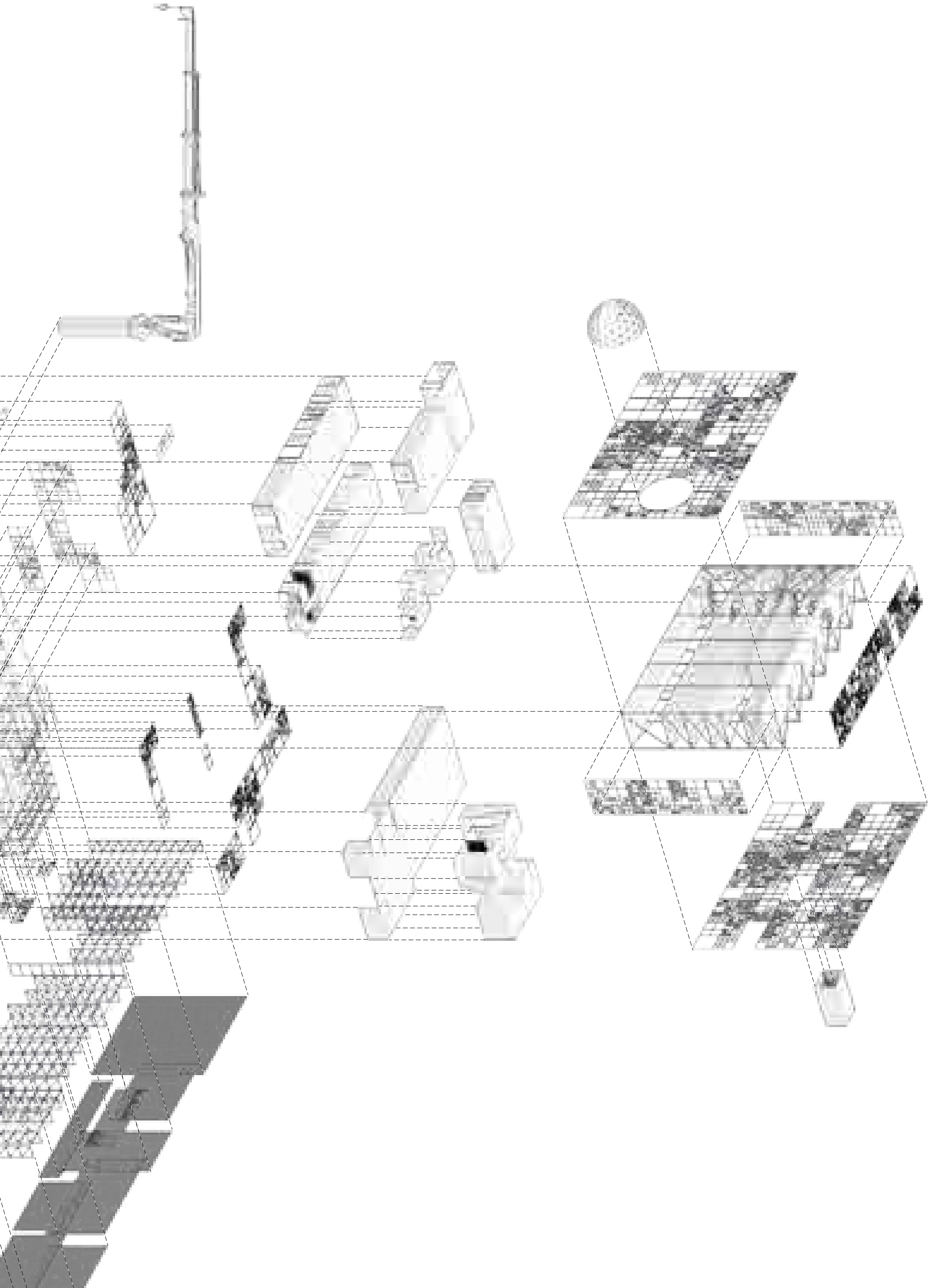
Chemical oceanography is the study of oceans chemistry: the behavior of the chemical elements within the earth s oceans.
To understand the distribution, transformations and rates of cycling, of the major and minor elements in the oceans.

The study of history and struture of the oceans floors is summarized in geological oceanotraphy, or marine geology.

Biological oceanography focuses on marine organisms and their relationship to ocean circulation, nutrients and the biogeochemical cycling of elements.


ENERGY
Wind and ocean currents are strong. The harsh environmental conditions can be used to produce green energy and create a self-supporting platform.
WIND
LIBARY
DRINKING
FISHING
ENTERTAINMENT
MOVIES
Unpleasant iving conditions, is the main problem for scientists on board of research vessels Entertainment facilities are important for their health and mood.
SWIMMING
FITNESS
SPORT
SQUASH
YOGA
BASKETBALL
Sport is the main free activity on research boats, prisons and spaceshuttels. As it helps to release stress, a vary sport facilities are on the platform.
FOOD
ENERGY
LIVING
16
Future research needs high educated scientists. Going abroad and collect experience is important for ongoing scientists.
15
Service people are often key members on ships and oil rigs. They are often seen as parental fugure of the crew.
56
25
If needed double-bed rooms are on the platform. Full occupied the platform will have 115 inhabitants
NURSE
SELF-CATERING
87-115
WATER
FISH
Directy connected to the sea, the inhabitants can provide themselve daily with fresh and healthy fish.
ENERGY
TRANSPORT
VEGETABLES AND FRUITS
Situated on sea, brings the problem of getting fresh fruits and vegetables with it. Being able to grow it directly on the platorm leads to better living quality.

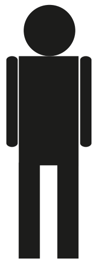




Crew

Next to the marine researchers, enought service staff is need on the bord to creat pleasant living conditions for the crew.

On research ships and oil rigs, the service personnel is often seen as parental figure of the platform, therefore they are as important as the rest of the crew. Next to a doctor and cooks, crane opertors, cleaning personnel, gardeners, platform operators, IT personnel and a general housekeeper is on board of the platform. In total 15 people form the service crew.



16

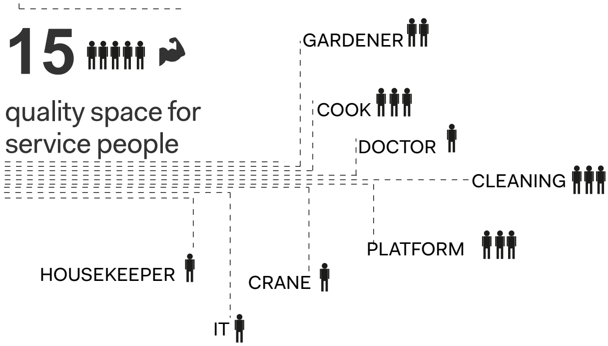
16 apartments and working spaces are reserved for students

56

56 apartments and working spaces are reserved for scientists

15

quality space for service people

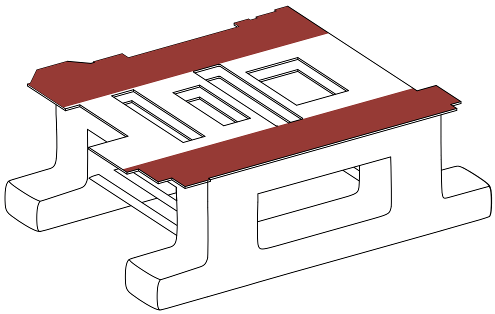


25

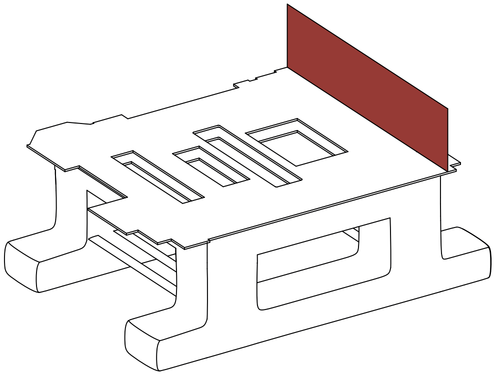
offering additional berthing for visiting investors or a bigger crew, provides space up to 115 people

Key elements of the platform

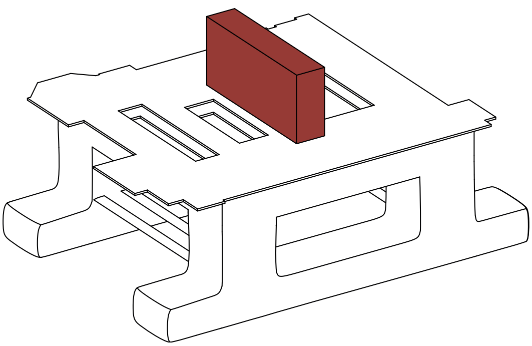
The design of the platform contains key elements in terms of design and function. The following pages describe the individual elements as; the stripes; the energy wall; the vertical greenhouse and die built environment in detail.



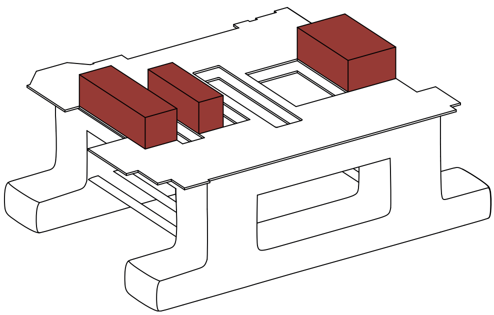
Three stripes



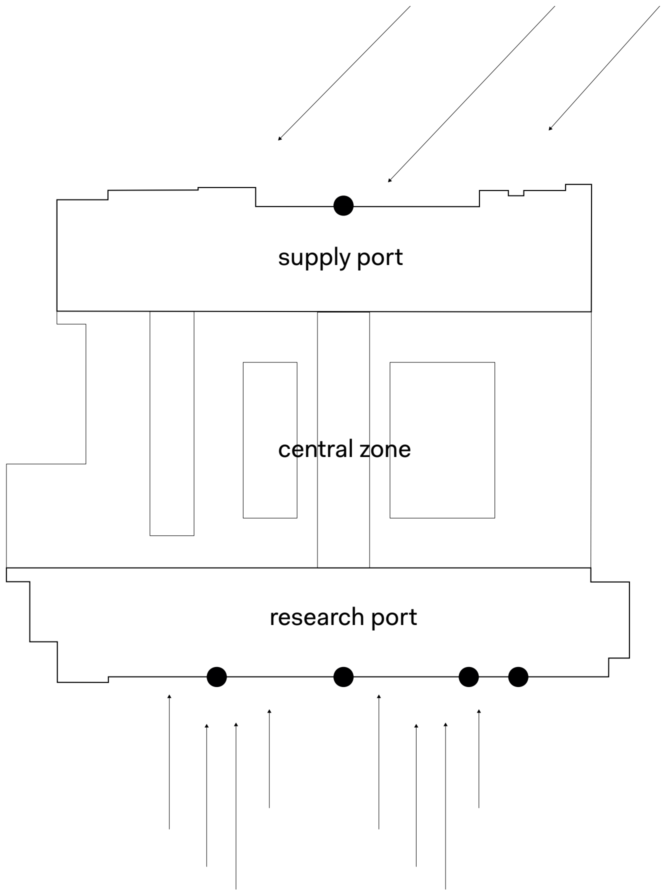
The energy wall



The vertical greenhouse



The central zone


supply port
central zone
research port

Three stripes

Different to a conventional research vessel, the platform Calypso will not be shipped to a port to be equipped but rather get the necessities via a supply ship. A certain space for delivering the ISO-containers has to, therefore, be provided. On the other hand, the researchers need a vast amount of space on the main deck to store underwater vehicles and sensors. Space is also needed to facilitate the dynamics of towing the equipment in and out of the ocean.

Therefore, the main deck is divided in three zones, or rather stripes. A port with heavy lift cranes delivering supplies to the platform, a research port with four small cranes that lift the underwater vehicles and sensors in the ocean, and the middle area, that hosts living, working and recreational facilities.

Dividing the main deck in three stripes is also necessary because of the safety requirements. The two port areas can be dangerous zones due to the cranes lifting and placing ISO-containers; underwater vehicles and sensors. Therefore the access system is as well divided in three zones. In contrary to the two ports, the central zone is accessible to all inhabitants. Because working with the research equipment and cranes needs a special training, just certain staff is allowed to stay and work in the area of the two ports.

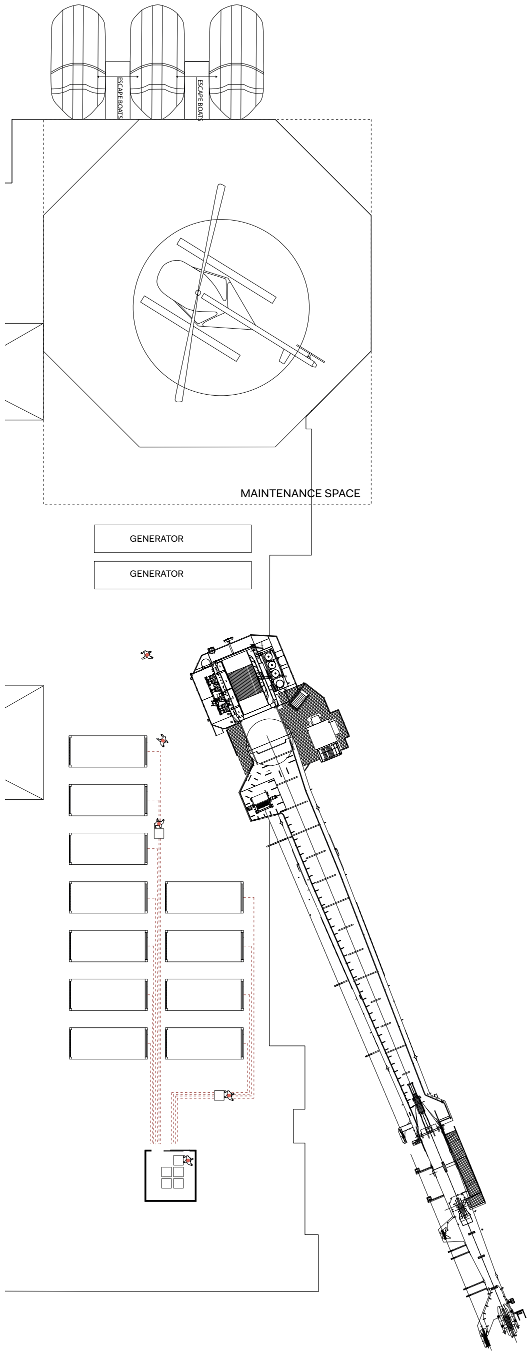
The devision also has aesthetic and social thoughts. The four holes situated in the central zone, give the flat main deck a third dimension. With the visual connection to the two lower floors the area gets more alive and creates a city-like atmosphere.

Supply port

Supply ships will foster the need of basic amenities such as food and clothing, but also equipment and additional tools. Depending on the distance to the mainland, the platform will get supplies every three to six months. Therefore, enough space at the main deck is needed to lift up the ISO-containers, to unload them and store the goods on the platform.

In addition, the main deck has to offer enough space to repair all main elements on the platform in case of damage. Furthermore, two emergency generators are in this area. In case of an emergency situation, three escape boats are able to evacuate the 100 inhabitants present at the time.

A direct connection with the elevator to the huge storage space underneath the port provides enough space to store food, equipment for the vertical greenhouse, and replacement equipment.

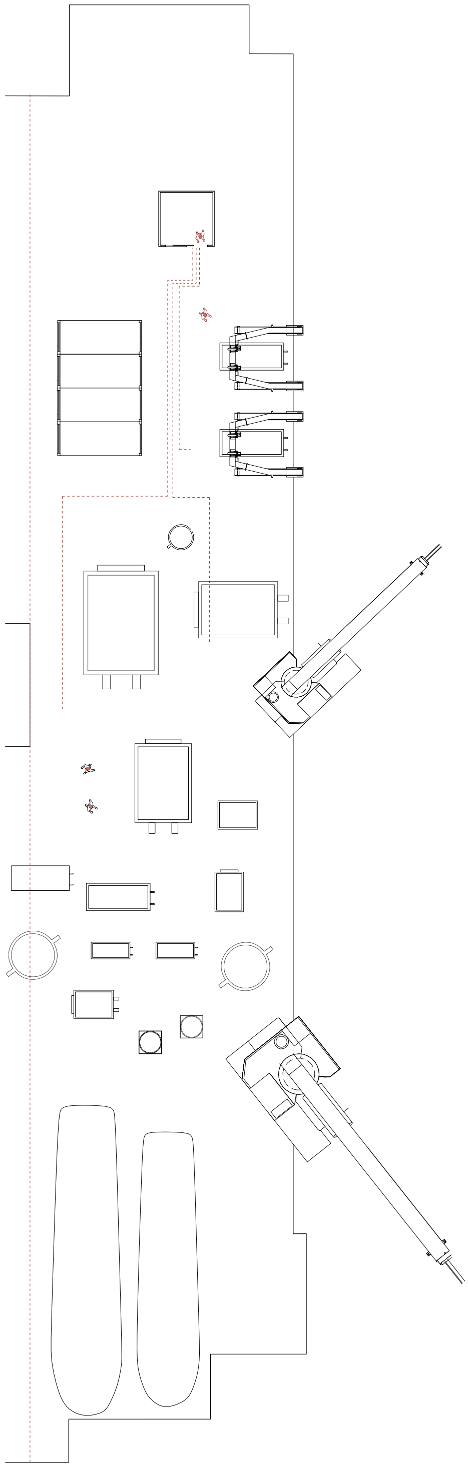

ESCAPE BOATS
ESCAPE BOATS
MAINTENANCE SPACE
GENERATOR
GENERATOR

Research port

The port for the marine researchers is at the opposite side of the support port. On both sides ships or underwater vehicles are in the ocean. Dividing the two ports provides an undisturbed workflow on both sides.

On the research port, four cranes can lead small research vessels, underwater vehicles, and other equipment, into the ocean. As the technology of the underwater vehicles is changing at an increasing speed, usually the controlling system comes in ISO-containers. Easy to ship and lift, they can travel with the underwater vehicles. The main deck provides enough space for 15–20 underwater vehicles and their controlling containers as well as for two small research ships.

Like the support port, the main deck is connected directly with the storage space below. Smaller vehicles, sensors, and other marine research equipment can be stored.

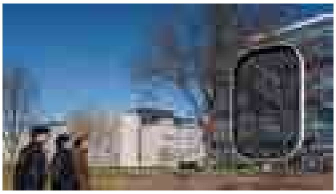


Central zone

With the huge two port areas, only a small part is left to cover the main deck with working, recreation, and living facilities. To cover the middle area with these facilities has not just practical and functional reasons. The four holes makes the two lower levels visible, the topside which seems as a massive plinth opens up and gives views to the happenings below the main deck. With this the topside loose the aesthetic of a flat platform and gets more three-dimensional.

Another aspect of living offshore brings with it the problem of the fact that the previous steady view of sea can turn from beautiful to frightening after have spent a number of time at sea. It is a constant reminder to be locked and not able to escape. For that, different to the two ports, this area is packed with different typologies and functions.

Energy wall

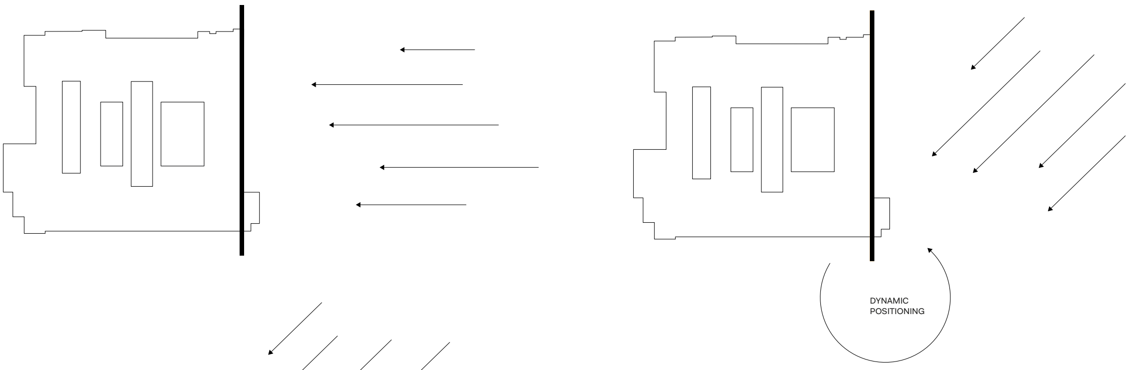


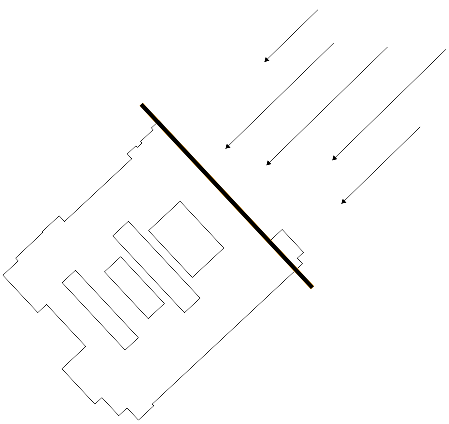
EWICON
Installed at the campus TU Delft

As the platform is cut from mainland it has to be self-sufficient in terms of water, energy and to a certain degree of food. Two of the major problems on the platform are producing energy as well as strong winds. Offshore winds are usually static in terms of speed and direction; in contrast to the mainland, as they can blow very strongly (see chapter: Weather and winds). Working on the platform and being outside can be a problem, with certain strengths of incoming winds. Nevertheless, wind is also the most efficient method to get energy offshore.

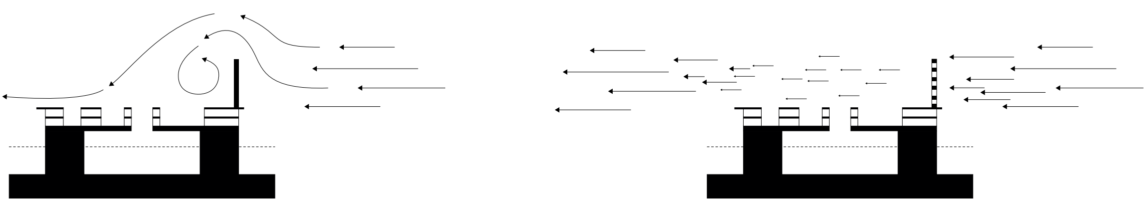
Creating a “wall” that blocks the wind but at the same time generating energy, solves both problems with one element. A new method of getting energy out of wind contains, not as usually turbines, a wall made out of horizontal tubes (see chapter: Energy) This construction can be seen as a porous wall, which minimizes the wind evenly on the whole main deck. If it were to be totally blocked, the wind would speed up. Wind eddies and high wind speed would make being outside on the platform impossible.

While the semi-submersible is able to adjust itself with dynamic positioning, creating a wind fence one side of the platform is enough; in case of the wind direction changing, the platform can rotate itself, the wind wall towards direction of the wind.





Rotating
via dynamic positioning the platform rotates towards the wind



Porous wind blocking wall

Vertical greenhouse

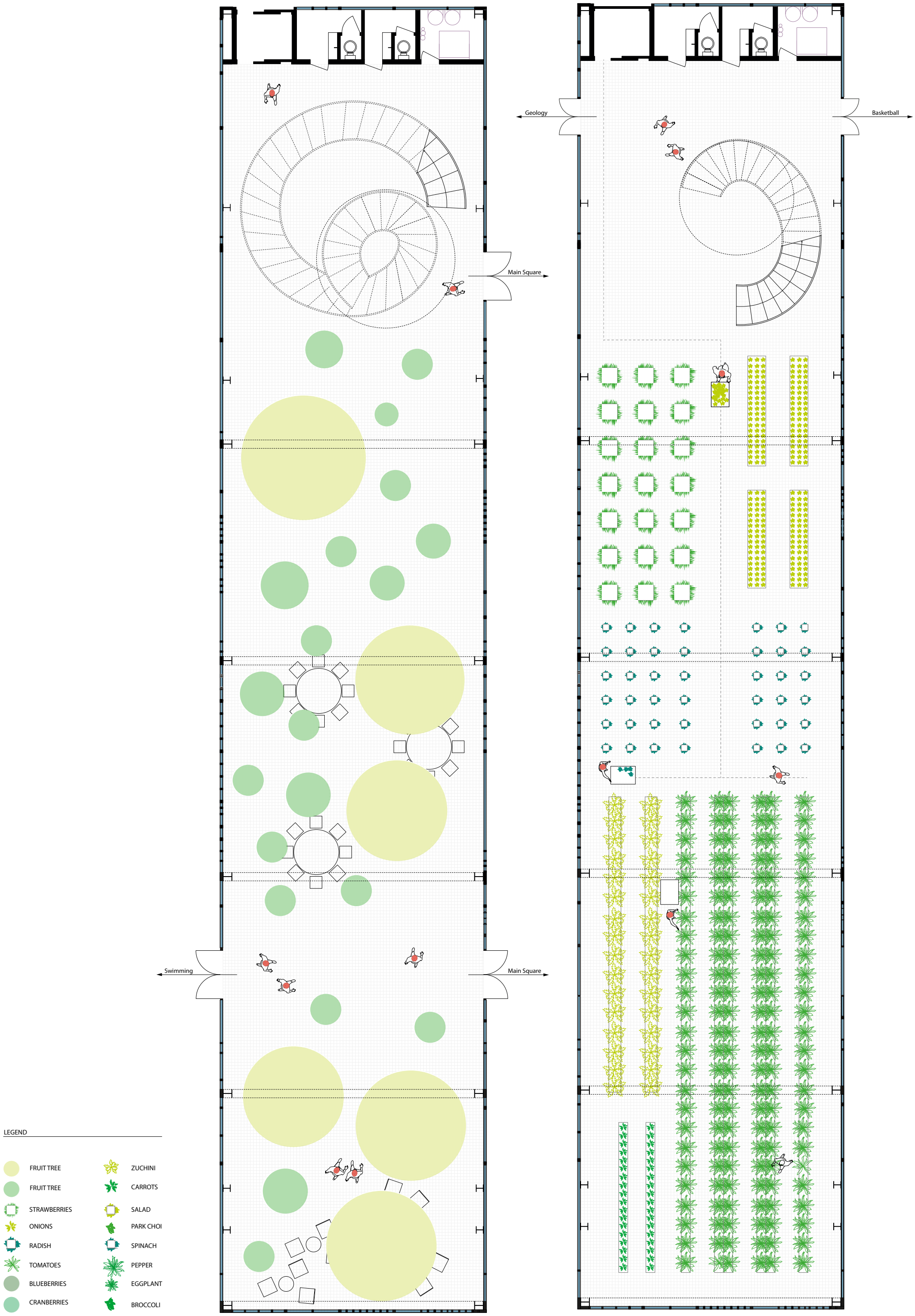
One of the major problems with living offshore is the absence of green as well as having fresh fruits and vegetables. The moonpool, the middle and biggest hole of the four ones on the platform, was actually used to drill for oil. It hosts the most important equipment, the driller and is the key element of every drilling oil platform. This is both functional as well as aesthetic. The whole platform adjusts itself around this tower and hole, therefore it can be seen as the heart of the platform.

Originally used to drill for oil, I suggest using the hole to keep the aesthetic key element; the vertical middle, to grow vegetables and fruits for the inhabitants of the research platform, as well as create a vertical garden. As mentioned before, after six month the view of the wide ocean, could become more frightening than beautiful. The vertical element is a visual cut trough the middle of the platform.

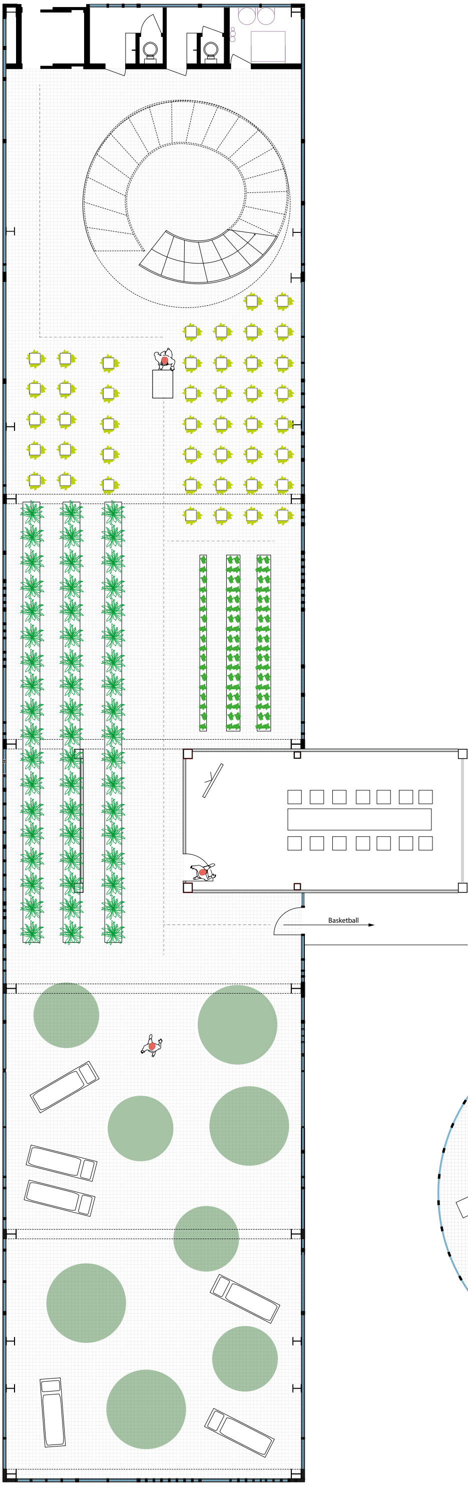
Garden

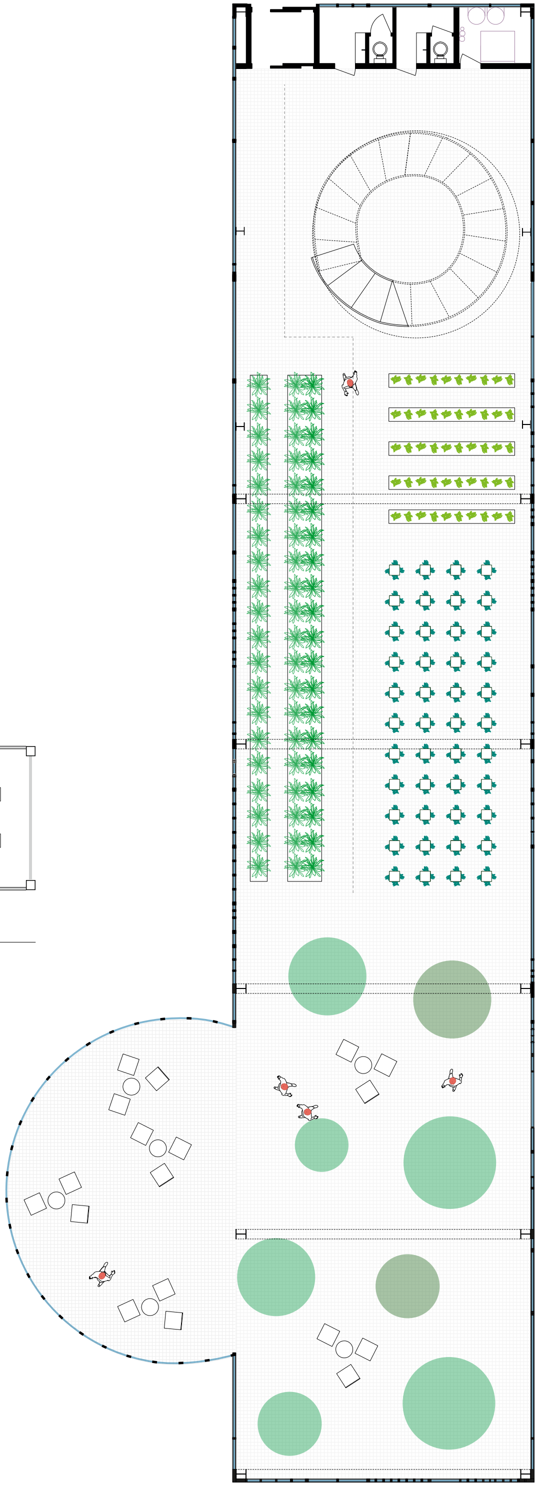
Peppers, tomatoes, oranges, strawberries, and all the other fruits and vegetables grown in the green tower, have different smells and colors. The variety of the plants and therefore ground floor patterns creates a different atmosphere and walkable ways on each floor.

One meeting box and one café, penetrating the tower and provides space for the inhabitants. The surrounding area of the café and the meeting box hosts plants like blueberry bushes or apple trees. This creates a park-like atmosphere in some parts of the vertical greenhouse.



Geology
Basketball
Main Square
Swimming
Main Square
LEGEND
FRUIT TREE
FRUIT TREE
STRAWBERRIES
ONIONS
RADISH
TOMATOES
BLUEBERRIES
CRANBERRIES
ZUCHINI
CARROTS
SALAD
PARK CHOI
SPINACH
PEPPER
EGGPLANT
BROCCOLI


Basketball



Greenhouse

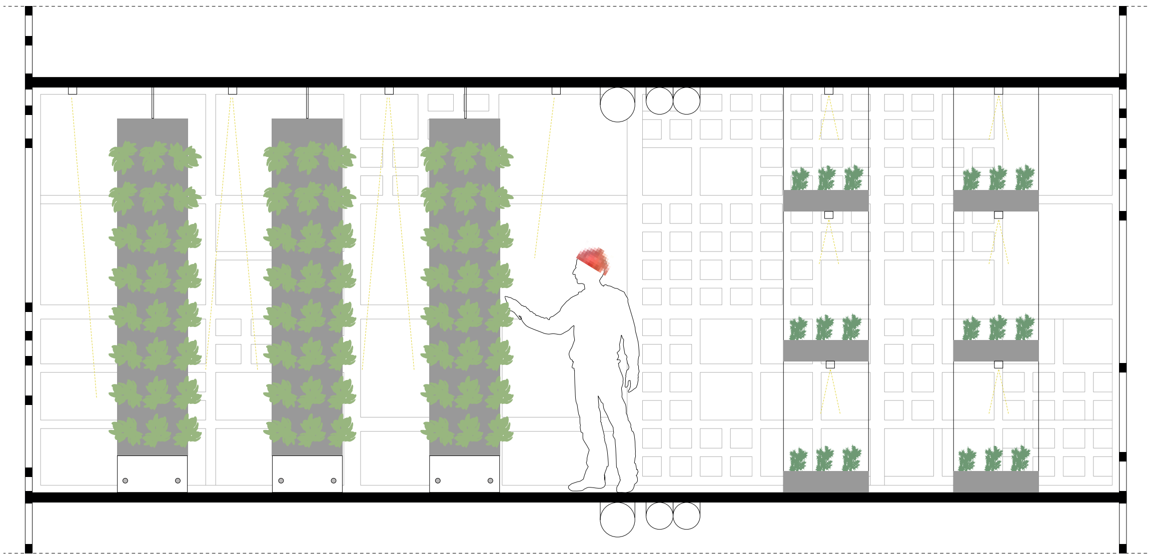
A lot of fruits and vegetables have to be fresh to eat them, like celery, cucumbers, lettuce, radish, sprouts, apples, grapefruits, lemons, oranges, and many more. Being delivered just every three to six month, certain fruits and vegetables have to be grown on the platform. To provide this amount of fruits and vegetables, hydroponic gardening is used. Hydroponic gardening methods “include growing plants in containers of water, sand, crushed rock, gravel, and vermiculite.”[32] It is water saving and productivity is increased by 25–50 %, in addition the full ceiling height can be used efficient.

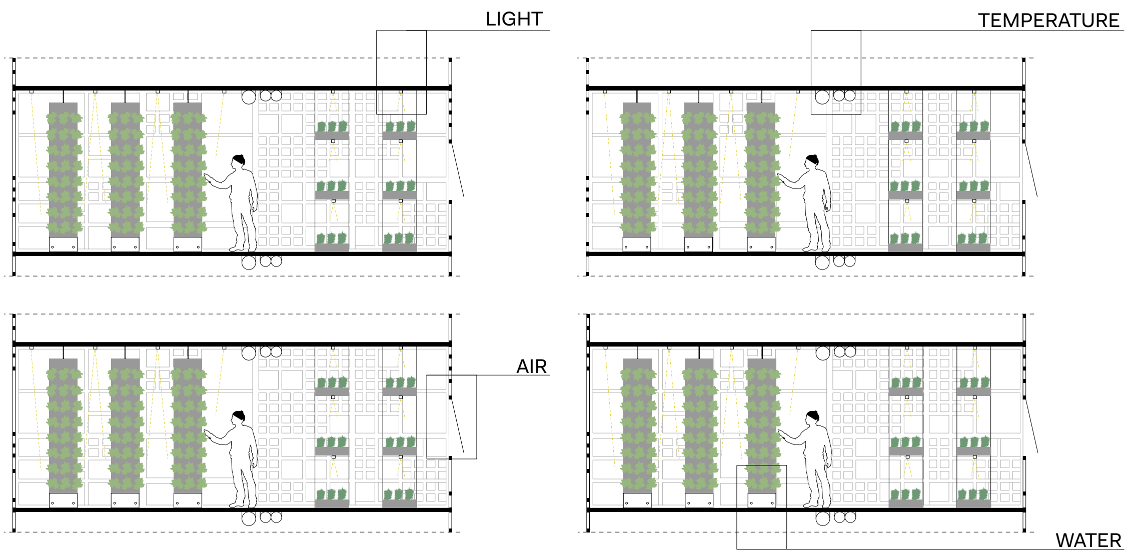
Directly connected to the big storage space in the platform, the gardeners can access each floor by elevator, care for the plants, and pick them. They can be stored in the storage rooms within the platform. Since the storage rooms are directly connected to the kitchen, they could be picked and cooked right away.

On one side of the elevator, all technical equipment such as pipes for water, air, and to regulate the temperature, is lead up to the last floor. The access for gardeners and inhabitants of the platform is split, so that a productive growing of food is possible, and the people can still use the greenhouse as a garden in their free time.

Depending on the fruits and vegetables used, three methods of growing could be applied; vertical towers; horizontal beds; or up from ground with wires that hold the plants vertical. As seen in the figure on the previous page, these three methods creates different growing patterns and therefore a changing ground pattern on each floor.

Most fruits and vegetables need the same temperature and sun conditions, therefore no separate sections are needed and the tower is one huge greenhouse, accessible for the inhabitants of the platform. Because the platform can sit in any location, the air temperature can vary between 0–35° C. The tower has to be self-acting, in terms of controlling the temperature, humidity, watering the plants, and ventilation.



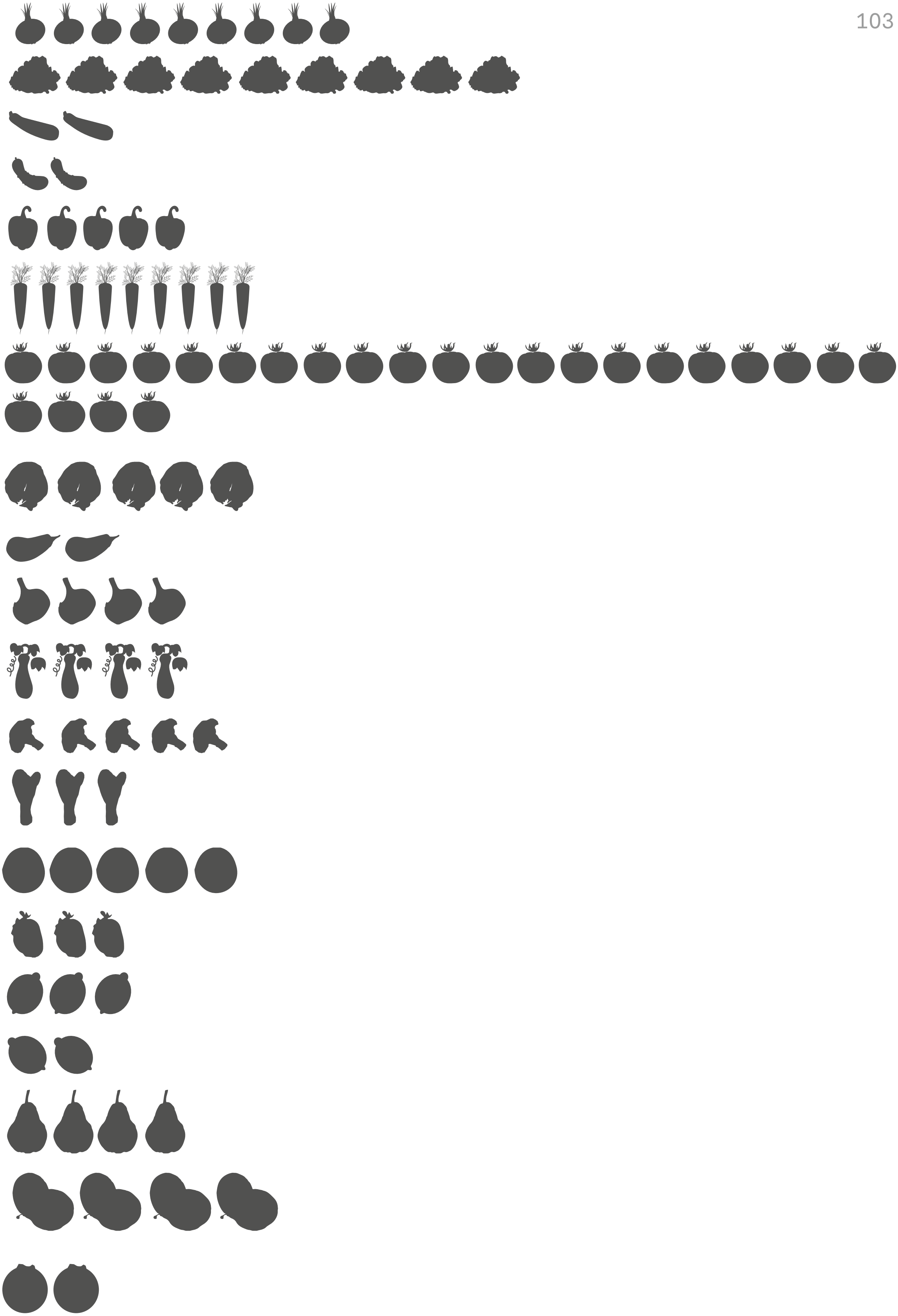

LIGHT
TEMPERATURE
AIR
WATER

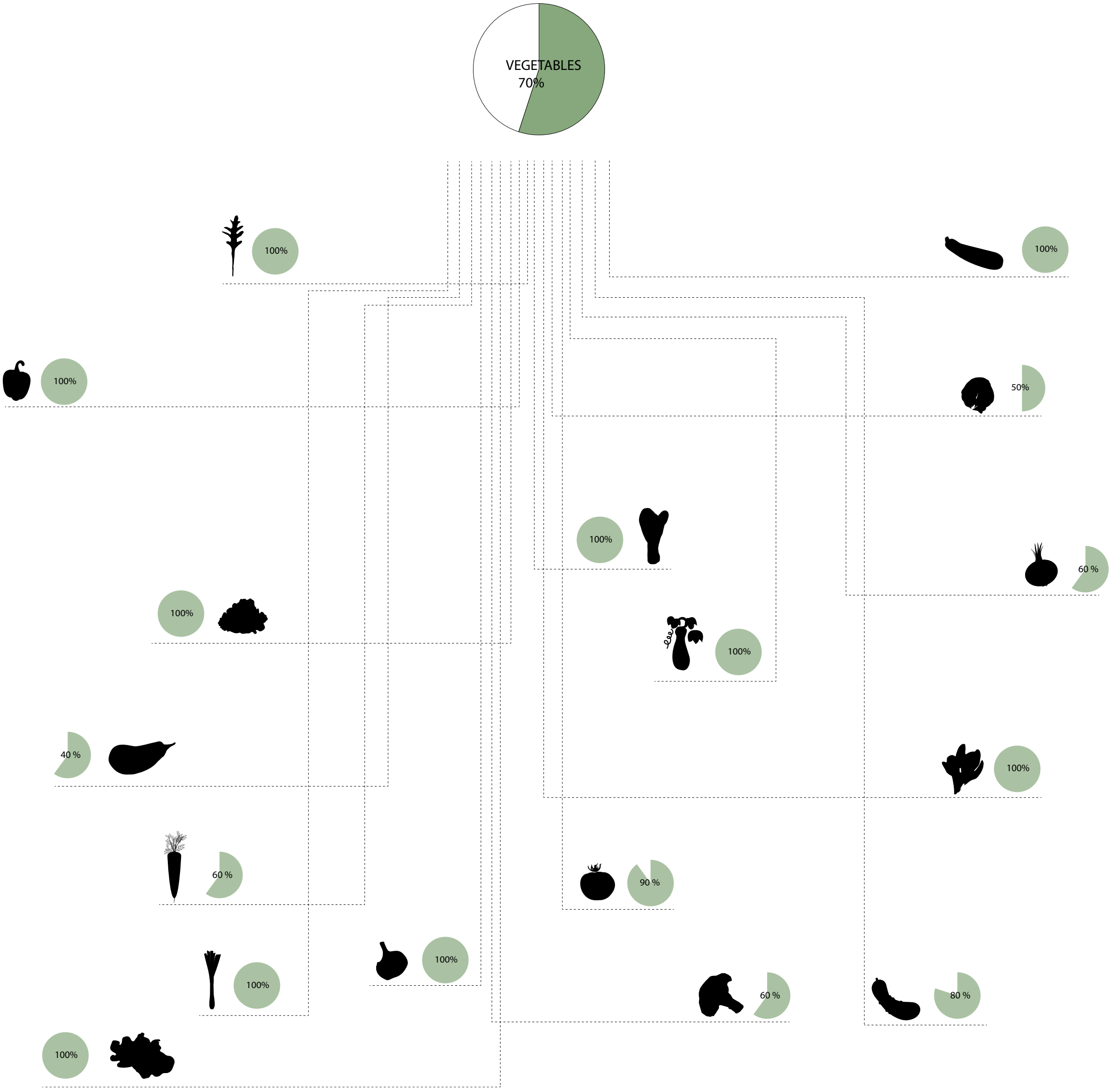
Self-sufficient

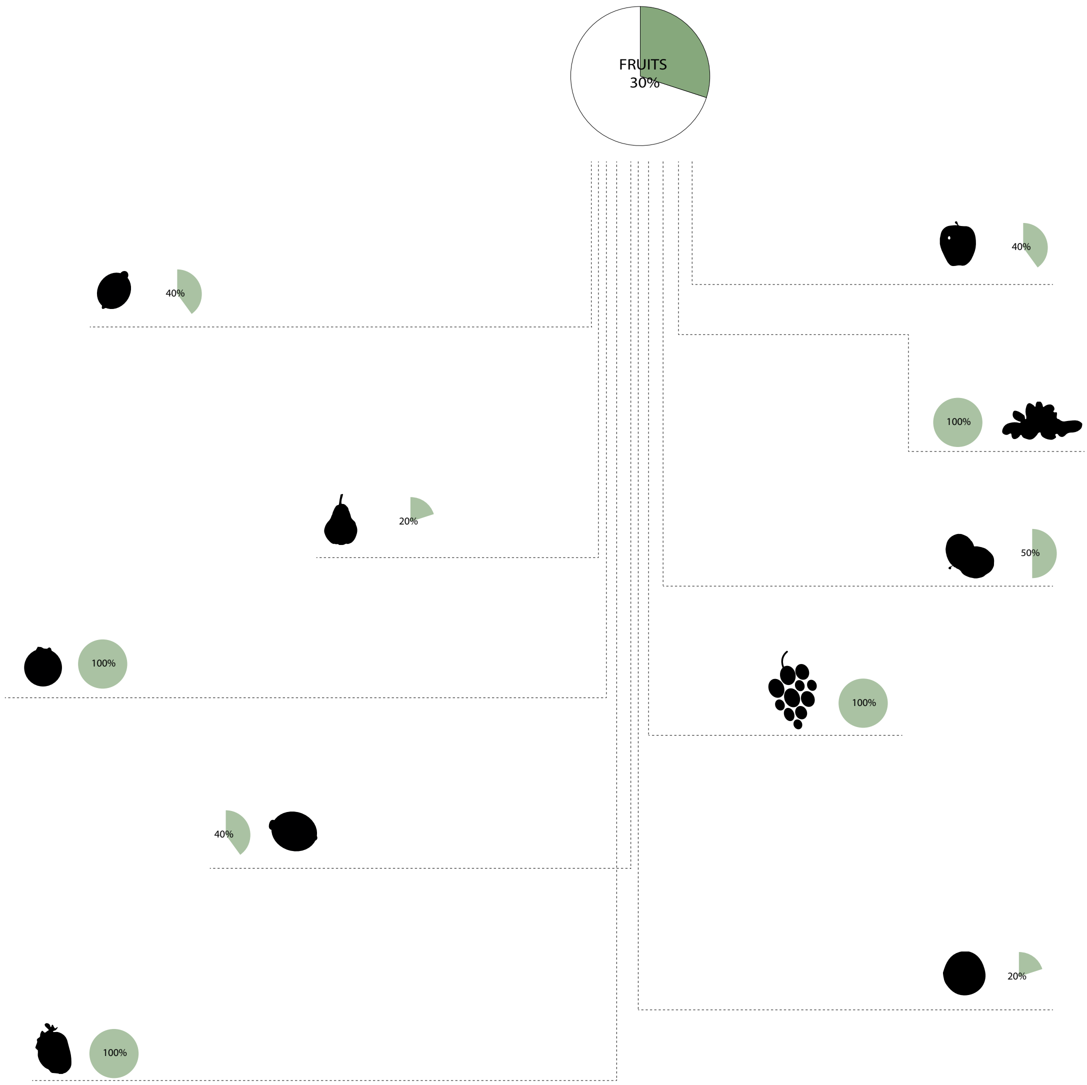
On average, a person eats about 124 kg of vegetables and 47 kg of fruits per year. As some fruits do not necessarily need to be fresh, the main focus on the platform is on the non frozen fruits and vegetables.

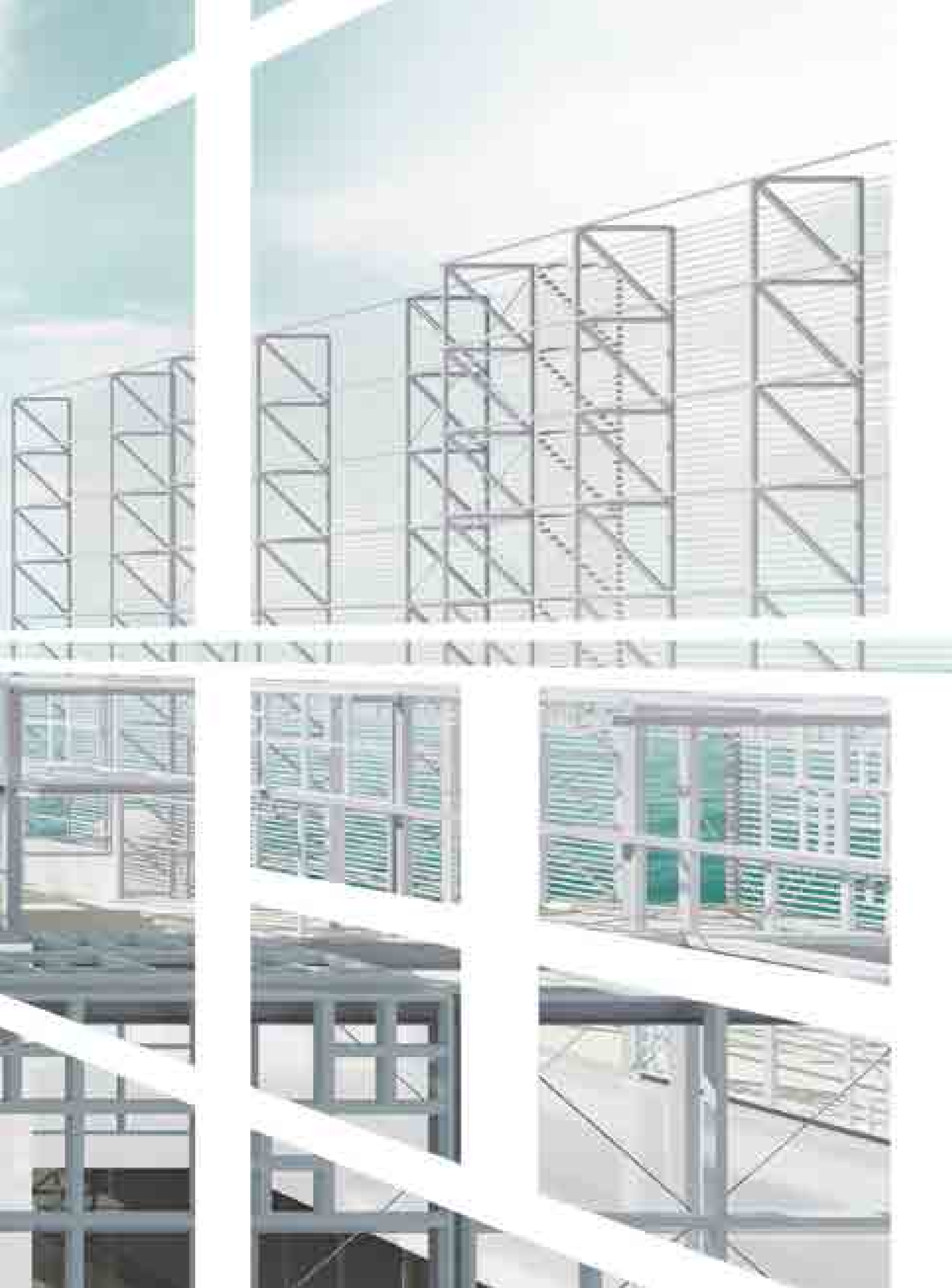
The figure to the right hand shows how many vegetables a person consumes annually on average. With the vertical greenhouse on the platform, 70 % of the needed vegetables and 30 % of fruits will be provided. Most non frozen fruits or vegetables can even be provided by 100 %.

One icon represents one kg.




VEGETABLES
70%
100%
100%
100%
50%
100%
60 %
100%
100%
40 %
100%
60 %
90 %
100%
100%
60 %
80 %
100%


FRUITS
30%
40%
40%
100%
20%
50%
100%
100%
40%
20%
100%



Built environment

As mentioned before, after using two great parts of the platform for the support port and the research port, just a small area for facilities as living, working and recreation is left. The two levels below the main deck and the central zone forms one unit.

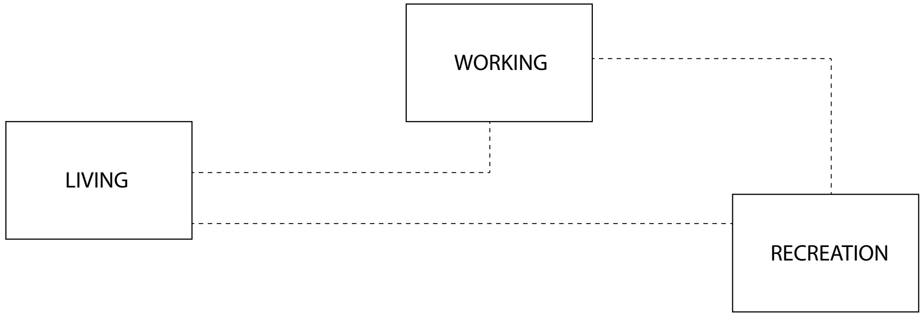
With 80 by 80 meters the platform is quiet small, for living isolated for six month period of time. As the two ports accessible just for certain trained personnel, the platform gets even smaller. How the functions; working; living; sport and entertainment are distributed can make the platform feel bigger, but as well smaller.

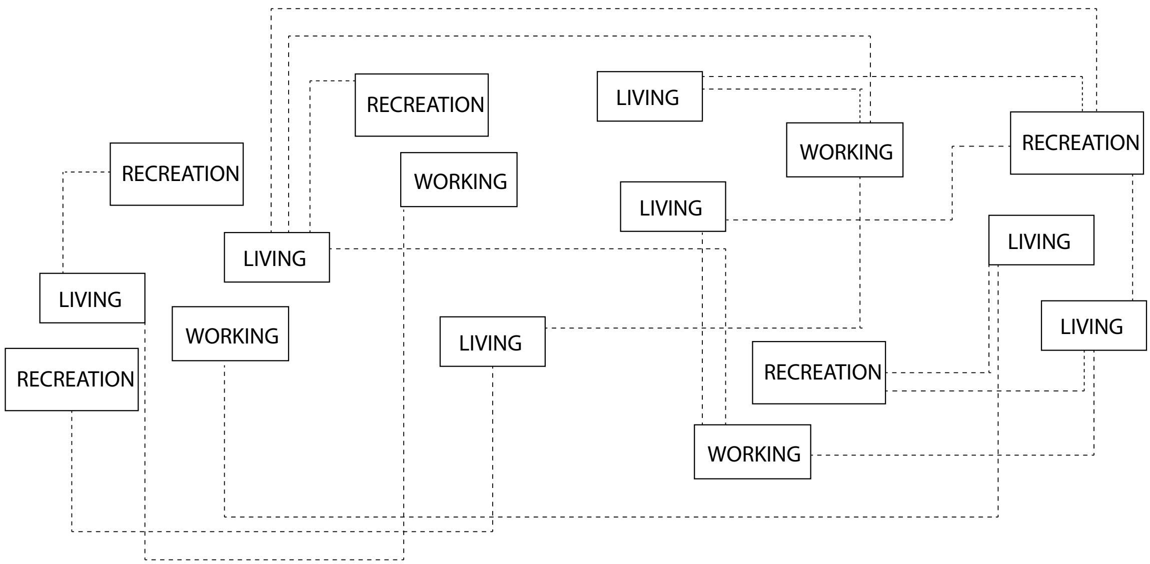
Decentralization

One hundred people living and working for six month on an 80 by 80 meter platform can get quite tight. With apartments, working facilities, and gardens, the platform becomes like a small village, where inhabitants can not escape for six months.

The problem of isolation and being locked up can be analyzed on the platform's original function – the oil rig. Mainly for safety reasons, the living quarters on an oil platform are always in one block, situated at one side of the oil rig. The left part of the platform is packed with technical equipment and therefore with the different working spots of the workers. This arrangement makes a small place feel even smaller. The workers have daily the same routes, and due to the safety regulations, they are not allowed to go to other working stations. They walk from their room to their working station and back, on a daily basis. Kitchen and recreation areas are usually in the living block as well. Therefore the ways are always the same and often short

Comparing the platform with a city, de-centralisation would make the platform mentally bigger, at least in the inhabitants' perceptions. It would lead to longer distances between the functions and therefore more walking paths. With mixing the arrangement of the functions, the inhabitants are able to access almost all parts of the platform.


WORKING
LIVING
RECREATION


RECREATION
LIVING
LIVING
RECREATION
WORKING
RECREATION
WORKING
LIVING
LIVING
LIVING
WORKING
RECREATION
RECREATION
LIVING
LIVING
RECREATION
WORKING
LIVING

Distribution of space

The four holes in the platform are aesthetic and functional interesting elements. With no visual connection to the ocean, and sunken into the platforms' topside the space has another quality than the upper deck built environment.

Like in cities, where different squares often have a vary atmosphere, the holes in the platform offer different activities for the inhabitants. The hole hosts, from right to left, the main square, the vertical greenhouse, swimming area and relaxation area.

The vertical garden situated in the central hole, is connected with the square to the left. This square could be seen as the main square of the platform as it is surrounded by the kitchen, the dining hall and the library. In this area the inhabitants can eat, meet up, chat, project movies play games and hang out. Covered by trees the area is shaded in hot climates.

The square at the other side of the vertical greenhouse is directly connected to the sport pool and sauna areas. The three small holes that were once used for drilling, are now three small outdoor pools. The third hole is the most quiet and secluded area of all four of them, it can be used to take some time alone and relax.

Even the researcher will work interdisciplinary, each field of research needs his own enclosed zone. Therefore the chemical, physical, geological and biological oceanography areas are forming each one area. For greater social interaction, the four fields surround the vertical tower and the main square. The access system usually leads trough both areas, like this, the researcher of the different fields will meet up unplanned and spontaneous. These kind of social interactions is often missing in the nowadays research facilities (see chapter: Offices and laboratories) as well as the research facilities, sport, recreation and living facilities are distributed mixed.

Functions in Detail

Since every expedition usually consists of a new crew, most of the inhabitants will not know the people they have to live with for the upcoming six months. Usually an expedition is important and great for the marine researchers, yet being away from home and therefore leaving family, friends, and familiar surroundings still can be tough.

The unusual and often unpleasant living conditions on the research ships are doable for about a month (see chapter: Life on board); the marine researchers often come home tired and stressed. As future expeditions will lengthen, the living conditions should improve. Besides research facilities, the project focuses on the living and recreation areas. The following pages will discuss the concept of the three functions and social aspects in terms of the isolated living situation on the platform.

Social aspects

The unusual conditions on the research platform contribute to social problems. The isolated living situation, the unusual environment and being away from family and friends can lead to psychological stress.

Comparing the situation on the research platform with being prison a spaceship, an oil rig, or a research vessel can aggravate stress and aggression. Usually in situations where people have to live in a small space for a certain period of time, sport is the main free time activity. It helps to release stress, is perceived as healthy, and can be a way of social interaction. In conclusion, providing different sport facilities on the platform creates a better overall mood of the small community. Therefore the platform hosts a vary of sport facilities. To strengthen the social structure the focus is on group sports. In addition qualitative living and work spaces are important to make the people feel comfortable and safe.

Work Facilities

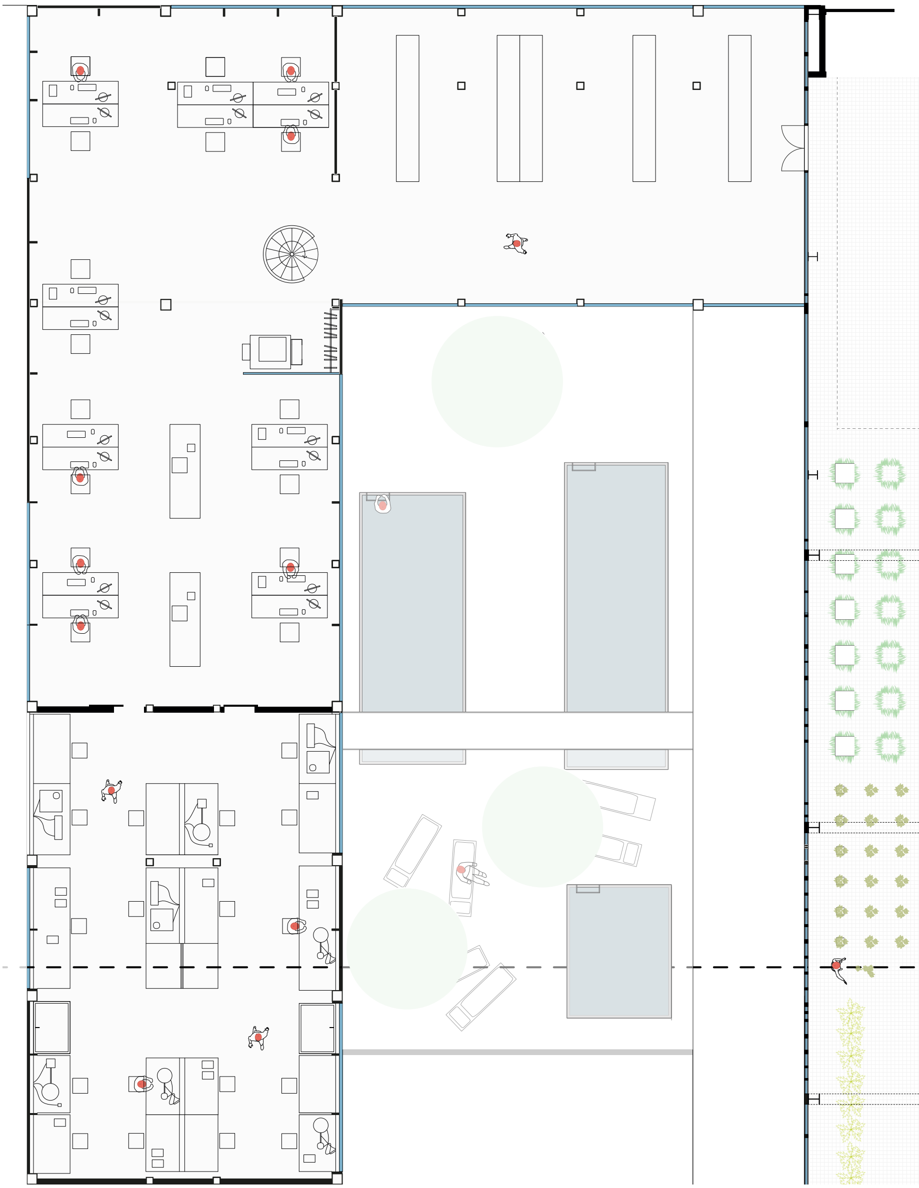
There are offices, general laboratories and special laboratories (see chapter: Offices and laboratories). The four fields and their facilities are sitting each, on one side of the platform, therefore they surround the main square and the vertical greenhouse.

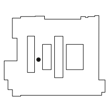
In future, the four fields of oceanography; chemistry, physics, geology and biology will work more interdisciplinary than today, therefore enough space for each field is necessary.

Each field has space for 14–16 researchers. As the laboratories and offices are planned generous in some offices up to 20 would fit. On a usual research expedition, all four branches are on board. As the general labs and working desks are all equal, there is also the possibility to just have a, for instance, biological expedition, with 64 biology marine researchers attending.

The general lab space and working desks are similar in all four branches of oceanography, but they vary in need of special laboratories. The laboratories such as, pressure chambers, measurement lab or calibration lab vary in size and number. Some of these labs have special needs in terms of light penetration, temperature and air humidity.

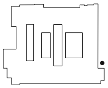
In contrast to the laboratories on main land, where each oceanography researcher has his own office, the researchers on the platform work together in one room. Mainly from a social point of view, but also because it is a temporary work space. The following pages show the office,- and laboratory facilities of the geology department, as well as office,- laboratory,- and special laboratory facilities of the marine biology department of the platform closer.



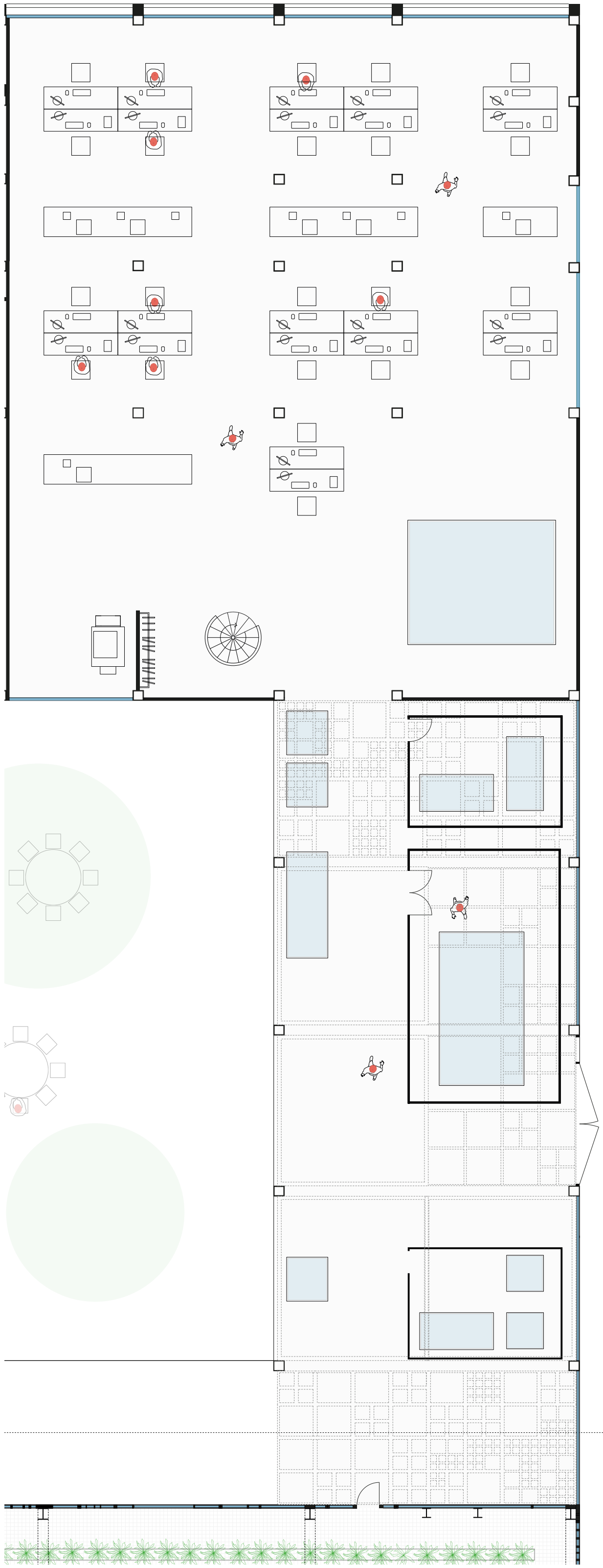


Geology department
Office and laboratory facilities
orientated to the vertical greenhouse
and the chemical department

Laboratories
Lower level
1_200



Biology department
Office, laboratory facilities and
special laboratories
orientated to the energy wall and
the research port



Offices
Main deck
1_200

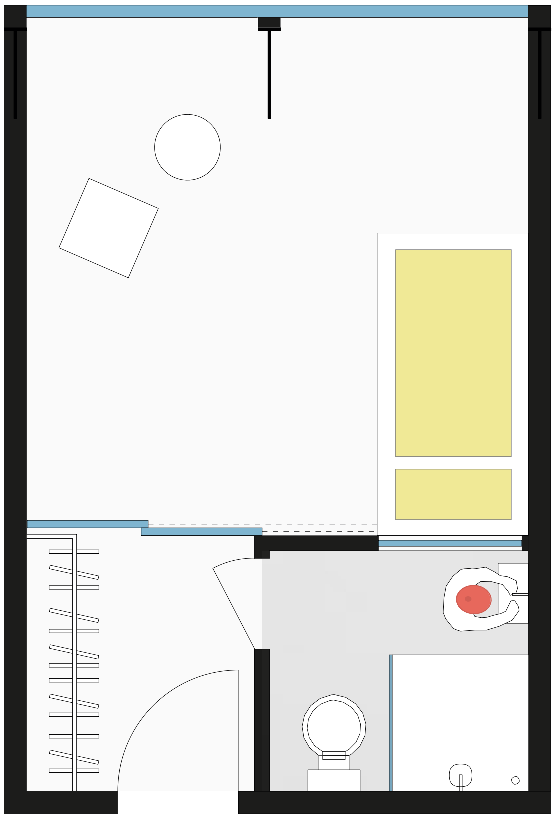
Living

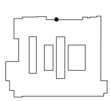
The inhabitants will live and work for six month on the platform. At marine research expeditions usually the team is international and often don t know each other.

As seen on oil rigs, keeping the hierarchy low helps to prevent stress fight and bad mood. To foster a better community feeling, doctors, cooks, nurses, cleaning personnel, and marine researchers, will all have the same standard of living. As the rooms are situated in different areas of the platform they vary in quality. The platform rotates with the wind, therefore no steady orientation is given. A room which is oriented south could be east at the next day.

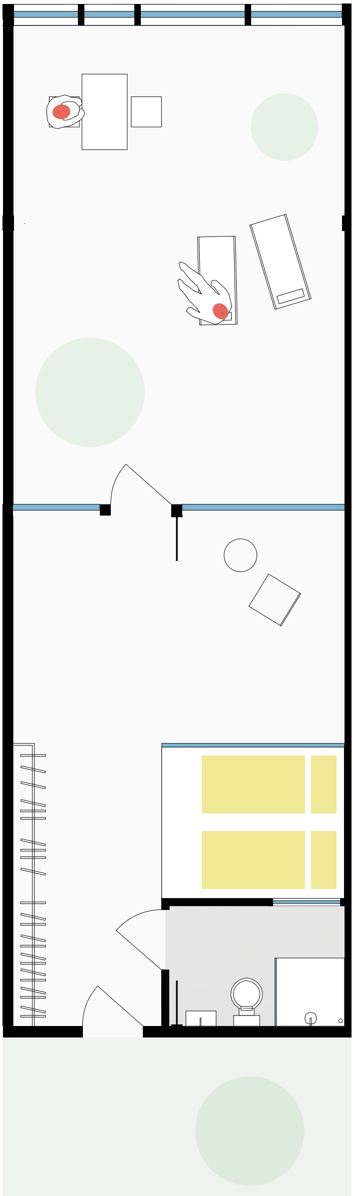
The apartments in the platforms are situated on topside, at the main deck, behind the energy wall, oriented towards the ocean; another building; the green tower or toward one of the two ports. The view to the ocean could get frighten in bad weather conditions or in a light storm. The different locations, and therefore orientations are important for the inhabitants comfort. Depending on taste and level of fearfulness the inhabitants will accommodate in the several apartments.

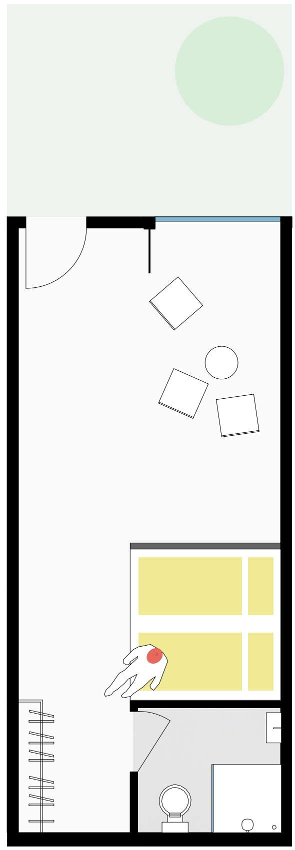
The rooms are average 17 m^2 big and each is equipped with a bathroom, a bed, a relax area and a closet. The ground floor plan is cut simple. The rooms are flexible to a certain part, most have sliding doors to create a separation of living, sleeping or entrance area. In case more researchers joining the expedition, investors come to visit or couples are on board, some rooms are bigger and for two people.

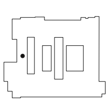




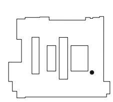
Apartment Type Nr.1
With an ocean view
1_50



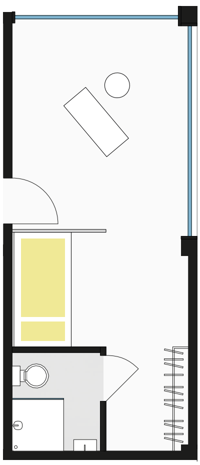


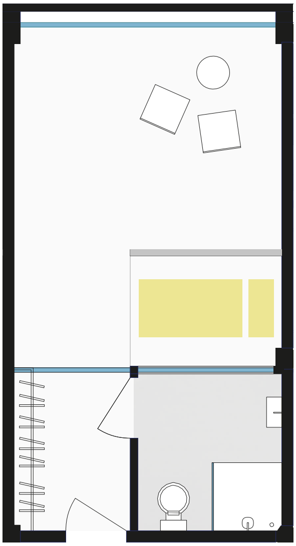


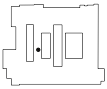
Apartment Type Nr. 2
With an ocean view
1_100



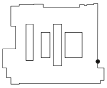
Apartment Type Nr. 3
oriented to the main square
1_100







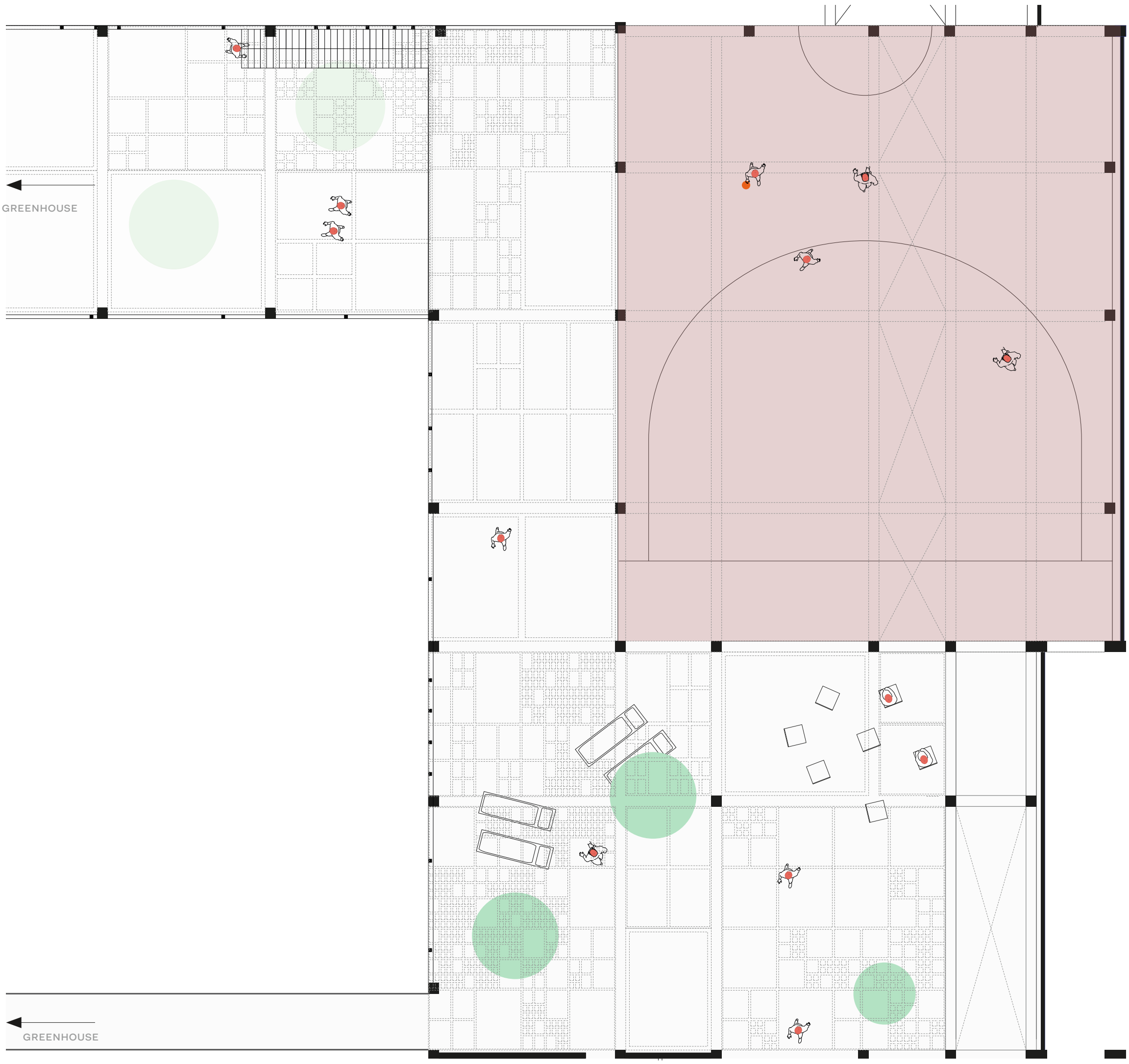
Apartment Type Nr. 4
Oriented to the greenhouse
1_100

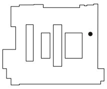


Apartment Type Nr. 5
Oriented to the energy wall
1_100

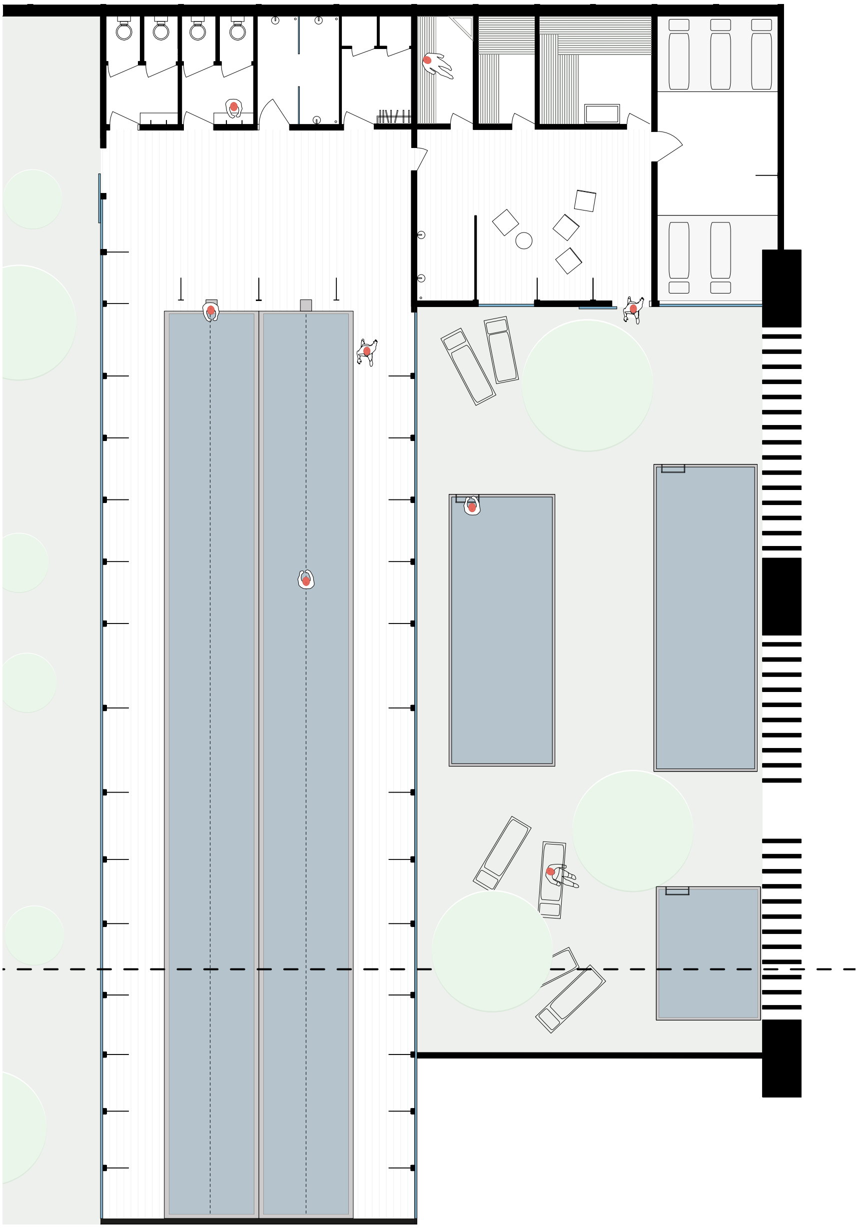
Recreation and Sport

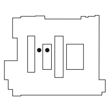
As mentioned earlier sport is important to release stress as well for the social structure. A indoor sport swimming area connected to one outside, a basketball area, indoor fitness, squash, a climbing wall and a yoga area can be found in the platform. As well as the other functions the sport and recreation areas are spread over the platform. A café situated in the vertical greenhouse, a auditorium which can be used as a cinema as well and a library are on the platform. The following pages show the basketpall place, directly connected to a little green area and the vertical greenhouse. As well as the swimming and sauna facilities and the libary connected to the main square.



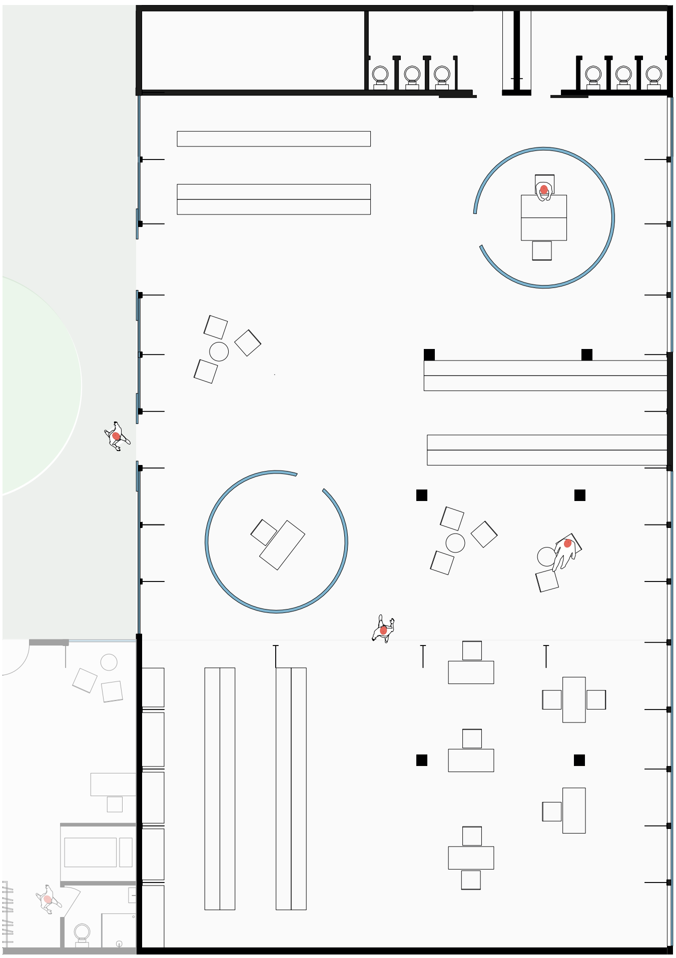


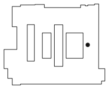
Basketball
1_200





Pool and sauna area
1_200





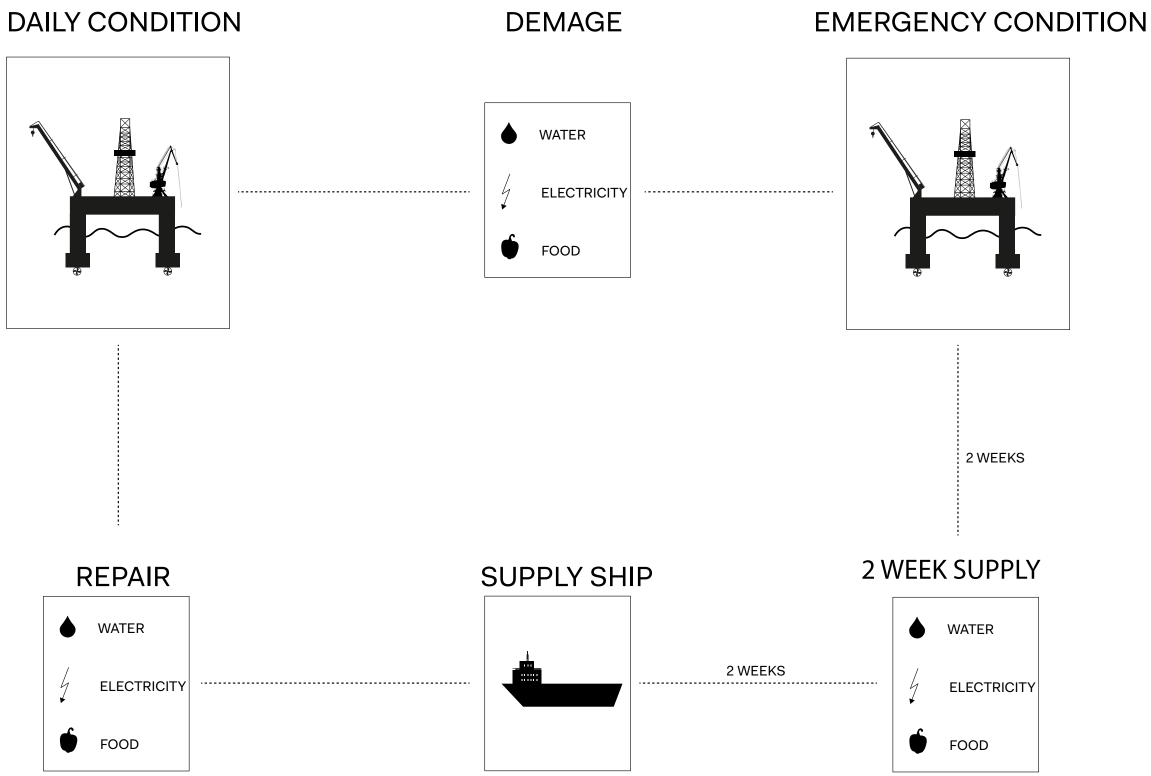
Libary
1_200

Water and Energy
Operational and Emergency Condition

As the platform can be situated all over the world, the distances to mainland may therefore greatly vary. The largest distance unveiled to mainland is about 7.000 km. This the platform is situated middle of the Pacific. An average supply ship would need approximately one week to reach the platform. Bad weather conditions or technical problems can extend the time up to two weeks.

Water, electricity and food are needed for the crew to survive on the platform, as well as to keep the platform working. Two conditions are developed, operational and emergency conditions (see figure on the right)

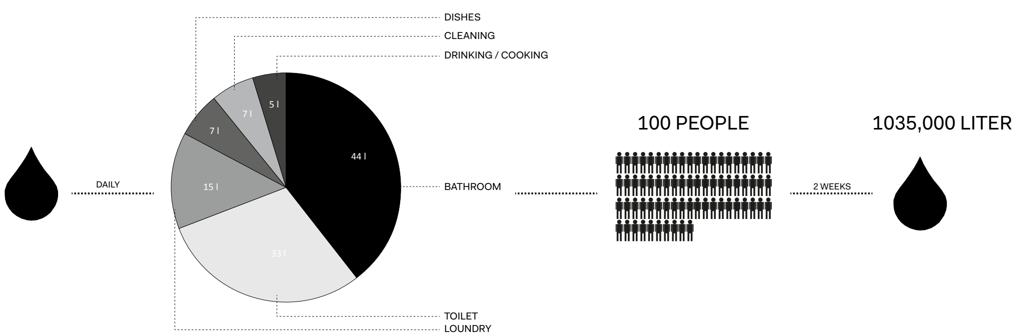
On operational condition, a situation where everything works well, which means no damage to the technical equipment or the platform itself. Equipment that is necessary for survival can break or be damaged by high waves or strong winds. For this reason, there is an emergency condition. Additional water supplies, emergency energy generators, and enough food is providing that the people on the platform can carry on working and living until a supply ship arrives or the damaged equipment is repaired or replaced, meaning for at least two weeks. In case of hurricane season,the research platform will be shut down and no inhabitants will be on the platform.


DAILY CONDITION
DEMAGE
WATER
ELECTRICITY
FOOD
EMERGENCY CONDITION
2 WEEKS
REPAIR
WATER
ELECTRICITY
FOOD
SUPPLY SHIP
2 WEEKS
2 WEEK SUPPLY
WATER
ELECTRICITY
FOOD

Water

In an operational condition a sea-water distiller will produce the water for the research platform. One person in an average household utilities about 111 Liters of water daily. Since a lot of equipment on the platform is cooled by sweet water, the amount has to be at least tripled. For 100 people, a daily need of 33.300 Liters of water is assumable.

In case of damage of the water distiller, the emergency condition for water provides tanks with sweet water with a two week supply about 517.500 Liters. This amount of water needs a volume of 517 m^3.



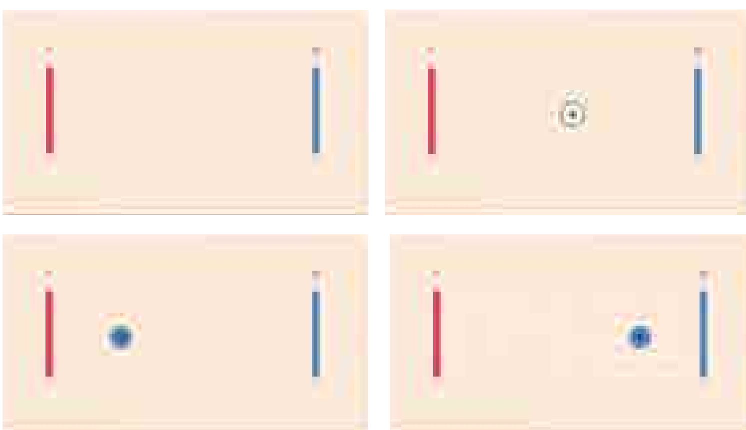
EWICON
installed at the campus
TU Delft

Energy

One person consumes an average of 10 kw/h daily. Due to the dynamic positioning of the platform, all the research equipment, water distiller, and food tower consume a lot of energy, the amount can be at least quadrupled. For 100 people on the platform, 3.000 kw/h daily are needed.

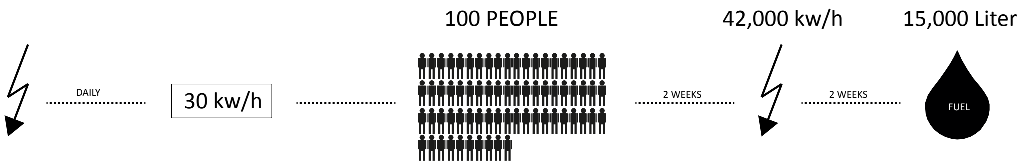
In operational condition the EWICON system will provide the platform with energy. Developed at the TU Delft, this method is based on “the principle that the wind transports electrically charged particles or charge carries in an electric field.” Like pushing a rock up against a mountain, the charged particles get forced against the direction of the electric field by the wind.

Offshore wind is the best way to produce energy. Speed and direction do not change that fast, the most consistent latitudinal wind patterns are found over the world’s oceans. To produce energy out of wind, steady speed and direction is important; this is hard to get in cities or on the mainland because of the buildings or changing terrain, while it is quite easy offshore. Nowadays, wind turbines are the common way to produce energy out of wind. The noise, the aesthetic, the resulting shadows, and the danger of killing bird migrations, makes wind turbines unpopular. More and more experimental methods of extracting energy from the wind are being thought of, one of them is EWICON.



System of EWICON
charged water droplets

The platform is powered by wind energy. No wind, too strong wind for a long period of time or damage on the wind producing equipment would lead to the emergency condition. Emergency energy generators powered by diesel fuel will supply the platform with enough energy to keep on working and living for at least two weeks.



Sections and ground floor plans

Section B
1_400

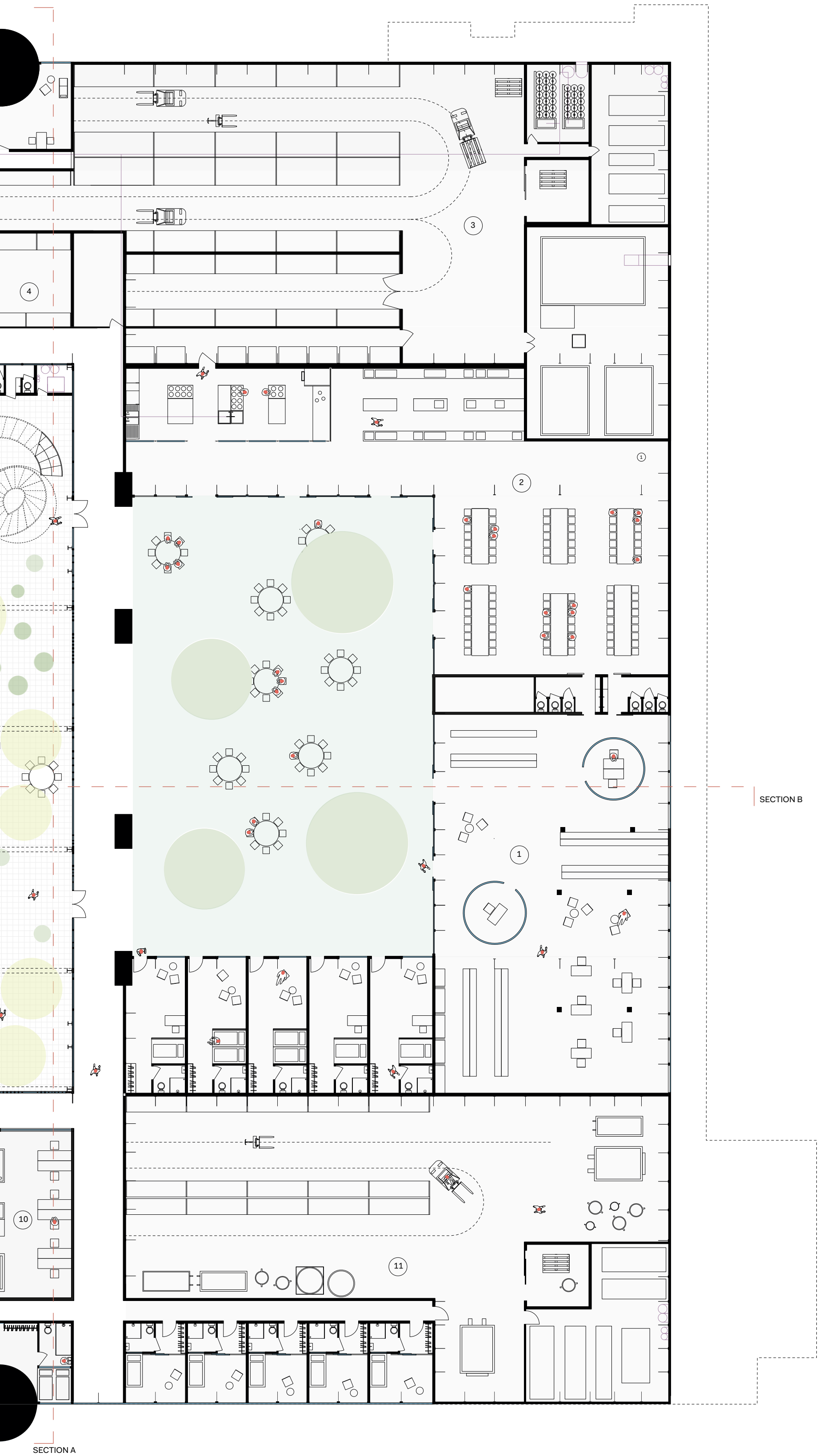

CHEMISTRY
GEOLOGY


BIOLOGY

1st Floor
1_400

1	LIBRARY
2	KITCHEN & DINING
3	SUPPLY STORAGE
4	GREENHOUSE STORAGE
5	SPORT POOL & SAUNA
6	AUDITORIUM / CINEMA
7	SQUASH
8	CLIMBING
9	ENGINE
10	FINE MECHANIC WORKSHOP
11	RESEARCH STORAGE

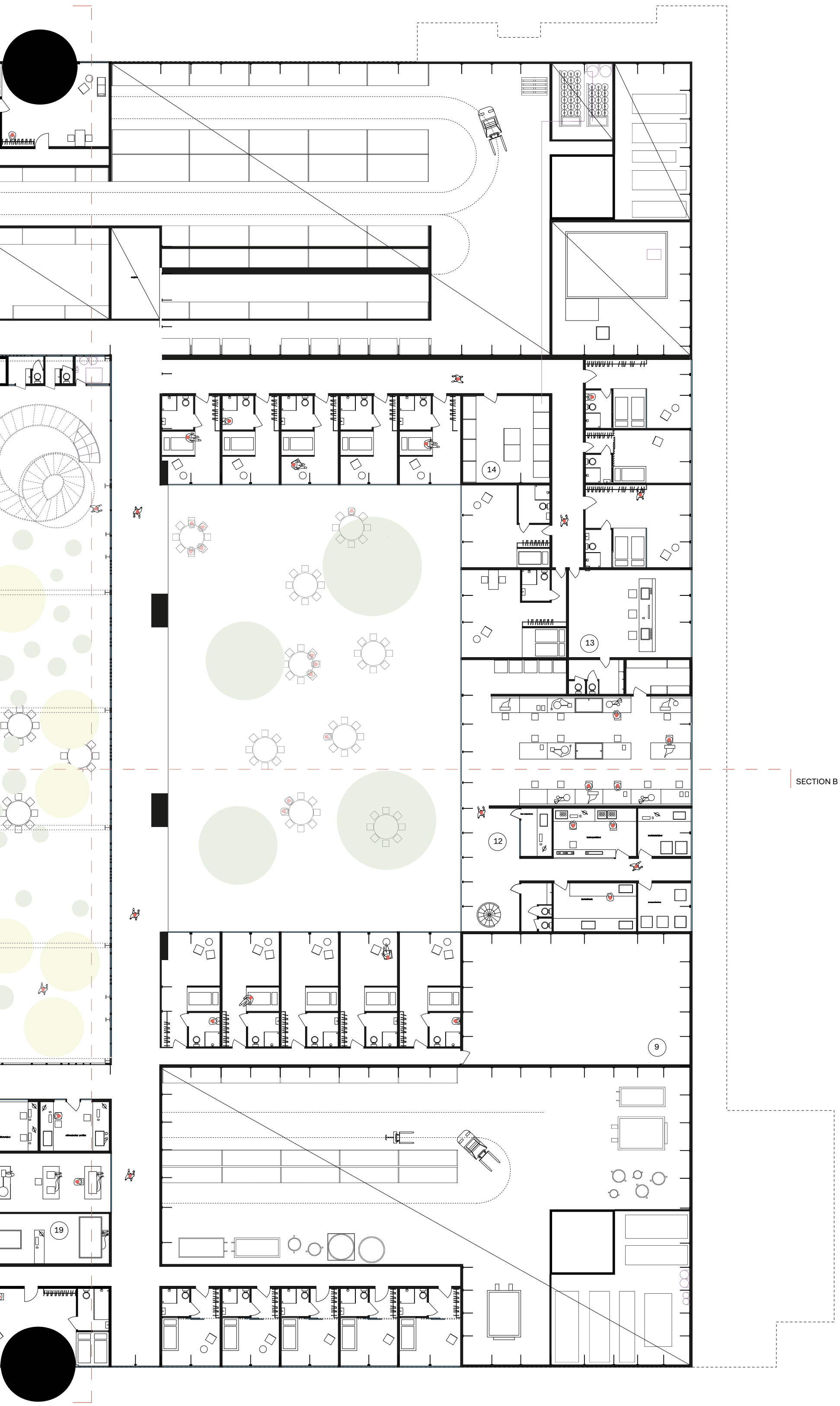

engine
5
3
3
7
8
6
9


3
4
2
1
10
11
SECTION B
SECTION A

2nd Floor
1_400

12	BIOLOGY LABS
13	CONTROL ROOM
14	WASHING
15	FREE
16	YOGA
17	INDOOR FITNESS
18	PHYSICS LABS & OFFICES
19	PHYSICS LABS


15
16
17
storage
18


14
13
12
9
19
SECTION B
SECTION A

Main Deck
1_400

20	WORKSHOP
21	GREEN
22	GEOLOGY LABS & OFFICES
23	NURSE
24	CHEMISTRY OFFICE & LABS
25	FISHING
26	BIOLOGY AQUARIUM & OFFICES


23
22
24
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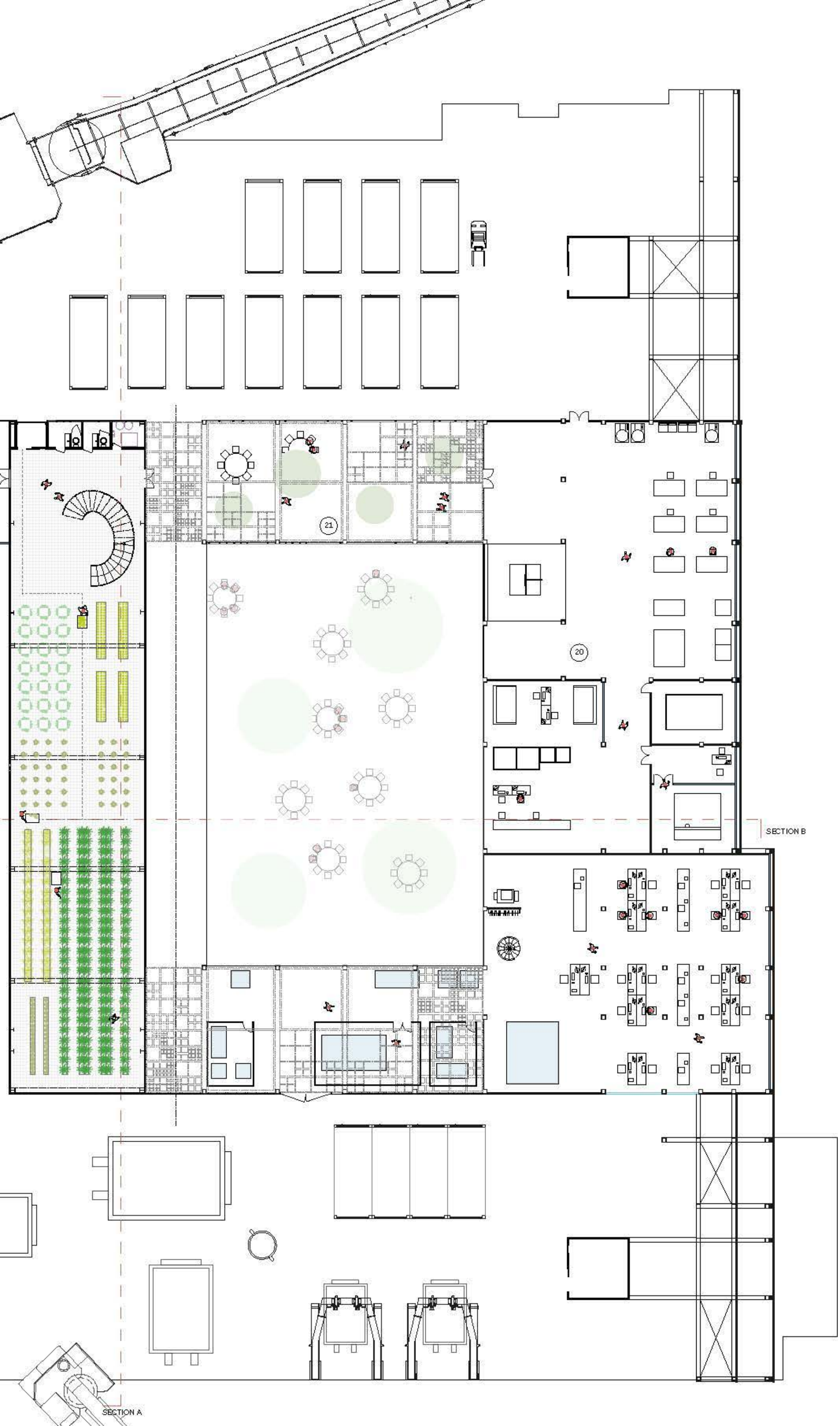
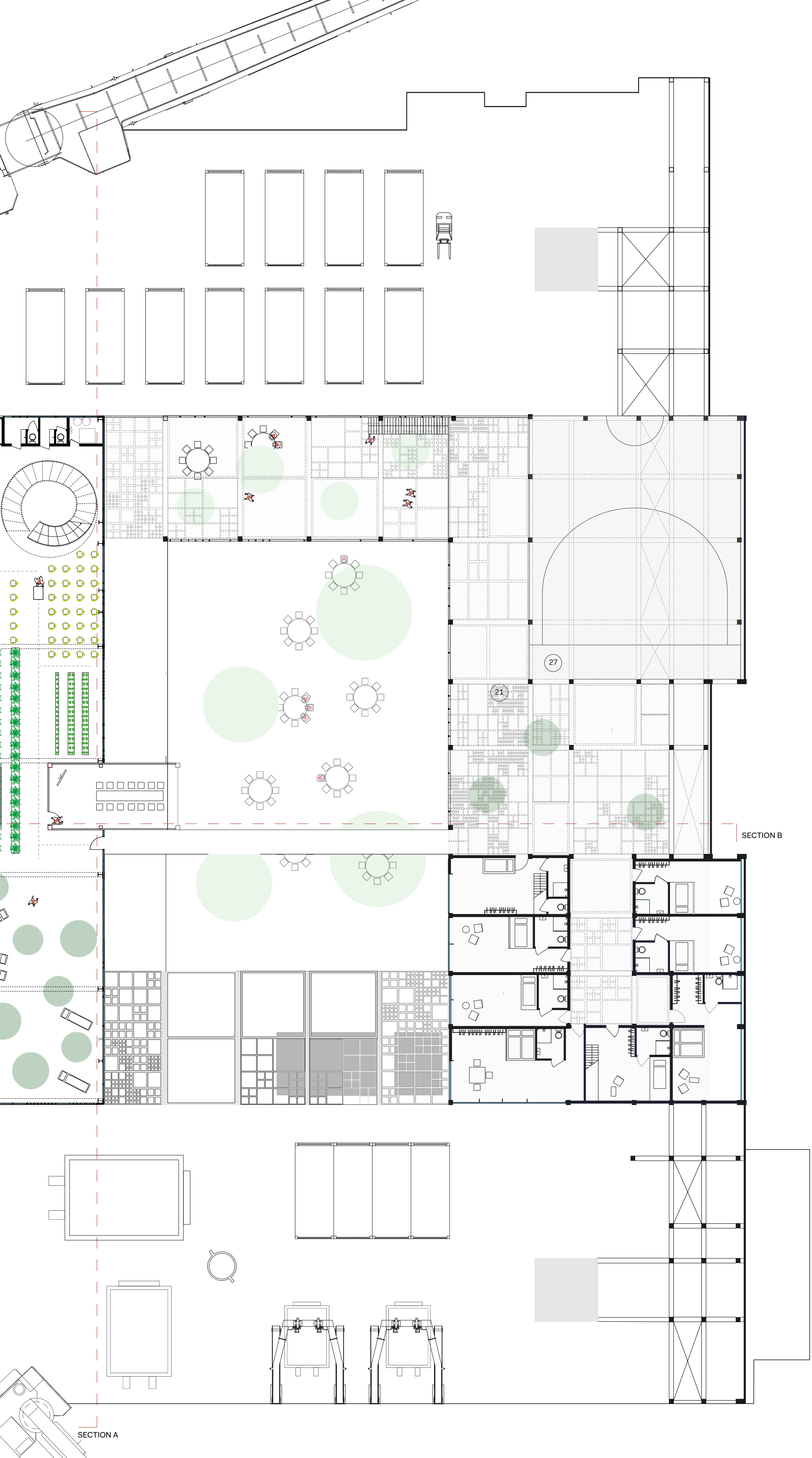

21
20
SECTION B
SECTION A

3rd Floor
1_400

27	BASKETBALL
28	GEOLOGY LABS
29	BRIDGE
30	CHEMISTRY LABS


29
28
30
21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21
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SECTION A

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