THE AQUATIC CITY

Post-Oil Phase of The Caspian Sea

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Abstract

In the midst of all the political struggles in the Caspian region the only thing that is certain is that the resources will be exploited one day. All five regional countries (Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan) are hoping for a secure access to a largely untapped reservoir of oil beneath the seabed. Nevertheless, they are not the only interested parties. The United States and the European Union and multinational oil companies are also eager to exploit the opportunities the Caspian offers. Rigs will be installed, pipelines will flow, and the oil will be sold. Yet as this process moves inevitably forward, it is also becoming clear that the petroleum economy and its associated operations will have a limited lifespan. Beyond that moment when the last barrel of oil leaves the seabed, the Caspian will remain. A wasteland of what once was a unique eco-system. Is it possible to plan for this moment by extending the momentum generated by the oil operations into the post-oil phase of the sea, rather than passively anticipating a post-industrial wasteland?

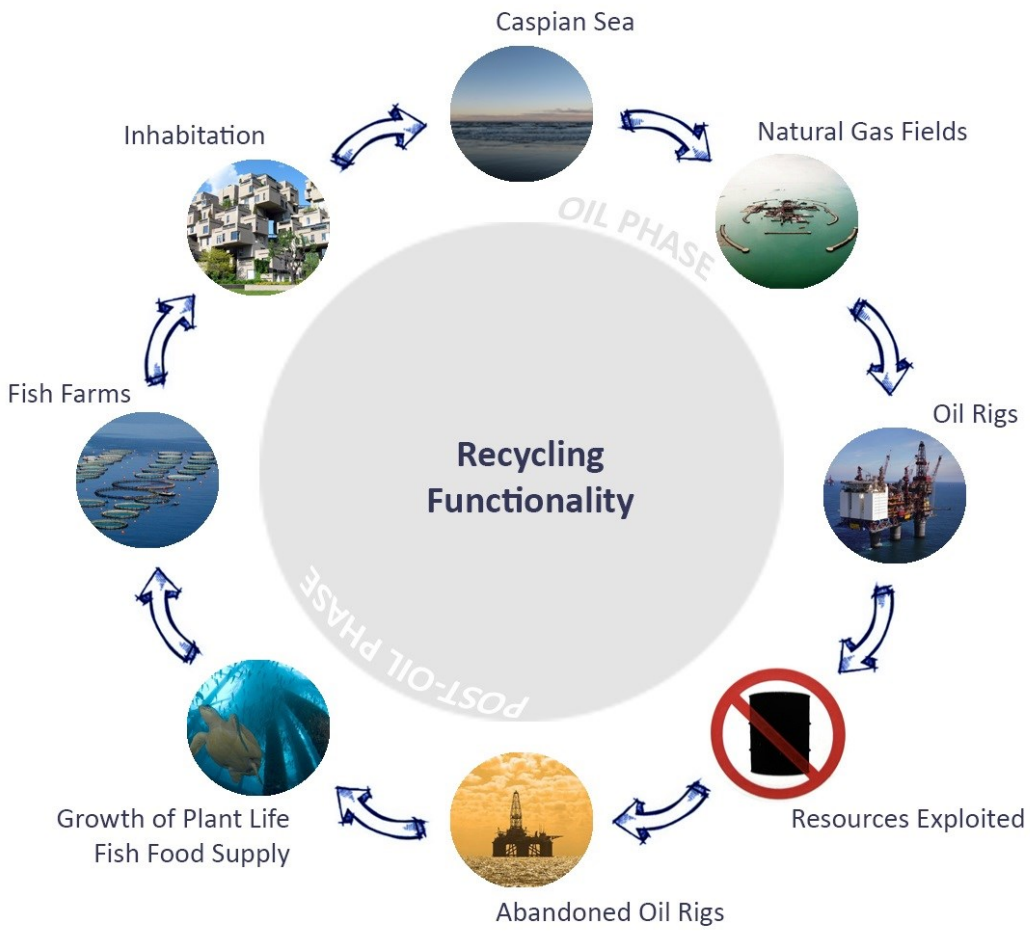

Figure 1

The oil rigs have created new territory for the Caspian fish. The sea is home to a variety of fish species, including sturgeon, from which more than 90 percent of the world's caviar is harvested. As inland spawning grounds and coastal habitat are degraded by development and poaching, the offshore oil installations have become an important alternative sanctuary. Acting as artificial reefs, the structures provide surfaces that support the growth of plant life, which in turn supplies food for the fish. Taking a cue from the adaptation of these existing sea-dwellers, this thesis proposes to develop a strategy for post-oil reactivation of the Caspian Sea, specifically in Iran (which can be applied to other offshore platforms in the region), by reviving abandoned offshore platforms; a plan that identifies potential new resources and establishes activities that will form the basis for ongoing occupation of the sea.

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Introduction

The countries of the Middle East[1] together produced 38.8 percent of the total world oil output in 1974. Although this number dropped down to 22 percent in 1986, the region contained 57.6 percent of the world's proved oil reserves and 25.5 percent of the world's proved gas reserves by the beginning of the 1990s and has remained stable well into the 21st century[2]. Most of these are located in the so-called "Iraq-Iran-Arabia Basin". Iran's economy as one of the founding members of Petroleum Exporting Countries (OPEC) is based on oil. Today Iran holds the world's fourth-largest proved crude oil reserves and the world's second-largest natural gas reserves. Iran also ranks among the world's top 10 oil producers and top five natural gas producers. Iran produced 3.2 million barrels per day of petroleum and other liquids in 2013 and more than 5.6 trillion cubic feet of dry natural gas in 2012.[3]

Figure 2 – OPEC members

[1] The Middle East, as recognized here, consists of the countries of the Arabian Peninsula together with Turkey and Iran.

[2] Beydoun, Z. R. The Middle East: Regional Geology and Petroleum Resources. (Beaconsfield, Bucks, U.K: Scientific Press, 1988.)

[3] Iran's oil exports not expected to increase significantly despite recent negotiations, US Energy Information Administration, (Accessed November 2014) http://www.eia.gov/todayinenergy/detail.cfm?id=14111

Human workings for petroleum in Iran date back to antiquity. Commercial oil was first discovered in 1908 in "Masjid-Suleiman[4]" and soon after became the Anglo-Iranian Oil Co. From 1957 onwards and after the establishment of the National Iranian Oil Company (NIOC), a series of principally offshore agreements (in the Persian Gulf) were signed between the NIOC and various US and European companies to further develop this industry. Since the establishment of the OPEC in 1960, Iran's oil production has varied greatly. Iran averaged production of over 5.5 million barrels per day of oil in 1976 and 1977, with production topping 6.0 million barrels per day for much of the period. However, with the Islamic Revolution, all partnerships and service contract agreements were terminated by 1980 and NIOC assumed all operations in the country. [5]Since then a combination of war, limited investment, sanctions, and a high rate of natural decline of Iran's mature oil fields has prevented a return to such production levels. Moreover Iran's domestic consumption has increased dramatically in the past decade. Iran consumed 9.6 quadrillion British thermal units of energy in 2012. With these margins it is clear that Iran needs to be producing more oil rather than less and less each year.[6]

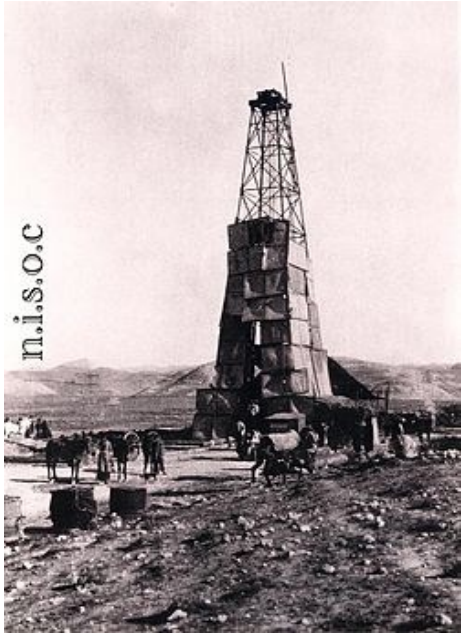

Figure 3 – First oil well in Masjid Suleiman

[4] A city in the province of Khuzestan,Iran

[5] Beydoun, Z. R. The Middle East: Regional Geology and Petroleum Resources. (Beaconsfield, Bucks, U.K: Scientific Press, 1988.)

[6] IRAN, US Energy Information Administration, (Accessed November 2014) http://www.eia.gov/countries/cab.cfm?fips=ir

The Persian Gulf, handle almost all of Iran's crude oil exports. Iran's largest gas field is South Pars, a non-associated gas field located 62 miles offshore in the middle of the Persian Gulf. South Pars reserves account for roughly 40% of Iran's total gas reserves, and the field is also estimated to hold 17 million barrels of condensate in place. Other major gas fields in Iran include: Kish, North Pars, Tabnak, Forouz, and Kangan. Iran is also estimated to hold 2 trillion cubic feet of proved and probable natural gas reserves onshore and offshore in the Caspian basin. [7]

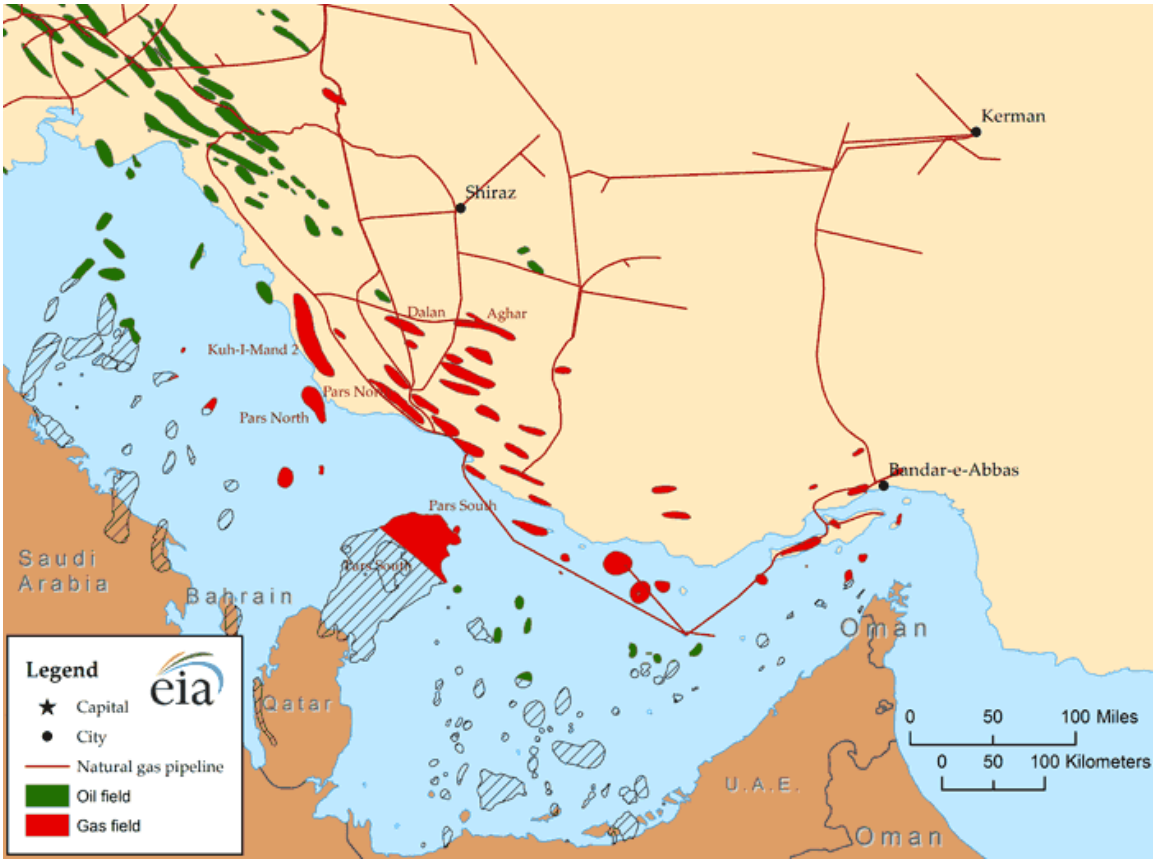

Figure 4 - Iran's major gas fields in the Persian Gulf

The Caspian Sea region is one of the oldest oil-producing areas in the world and is an increasingly important source of global energy production. The area has significant oil and natural gas reserves from both offshore deposits in the Caspian Sea itself and onshore

[7] IRAN, US Energy Information Administration, (Accessed November 2014) http://www.eia.gov/countries/cab.cfm?fips=ir

fields in the region. Most of the offshore oil reserves are in the northern part of the Caspian Sea, while most of the offshore natural gas reserves are in the southern part of the Caspian Sea. However, while developments have been relatively smooth in the Persian Gulf, there have been various setbacks in the Caspian Sea due to lack of regional cooperation between the countries and few export options. Moreover, in recent years, a series of sanctions targeting the oil sector have resulted in cancellations of new projects by a number of foreign companies, while also affecting existing projects.

Although developments have slowed down in this section, investments in the Caspian's oil and gas reserves seem inevitable. Nevertheless, due to the tight economic atmosphere of Iran following more strict sanctions in the past few years, the government has started to explore other opportunities in the Caspian Sea, one of which is tourism. Establishing and launching special docks in northern harbors of the country for berthing cruise ships and providing some facilitate for transportation of passengers are taken into consideration. Meanwhile, with several countries gaining access to valuable hydrocarbon deposits after the collapse of the Soviet Union, each has taken diverging approach to developing the energy resources of the area which has eventually resulted in the pollution of the Caspian Sea. Although there is an uneven distribution of pollution sources over the sea perimeter, which leads to uneven pollution of its separate parts, there are specific features of the hydrological condition of the sea due to which the pollution of one of the sea parts invariably leads to pollution of other water areas. In general, the Caspian is one of the most polluted seas and thus, tourist industry won't be a success in such conditions.

On the other hand the coastal wetlands of the Caspian basin include many shallow, saline pools which attract a variety of bird life and biodiversity. The Caspian Sea is also rich in marine fish of commercial value. The sea is world famous due to the presence of a unique species of sturgeon which is of commercial value due to its black caviar and very tasty meat. These fish species are now on the verge of extinction due to reduction of reproduction grounds, overfishing and water pollution by pesticides, heavy metals and oil products. [8]

[8] Zendedel, Hasan. North and The Coastline of The Caspian Sea [شمال و سواحل خزر](Irangardan, Tehran 2008)

Overall, without access to the high seas it is already clear that the Caspian Sea cannot play the same role as the Persian Gulf for Iran. With the ever- increasing pollutants in the water and the dying eco-system, tourism seems like a lost cause for the Iranian government.[9] Furthermore, the sanctions have dramatically decreased international investment in the petroleum industry slowing down the development of this section in Iran. Thus, Iran has erected some structures in the Caspian Sea which are either not producing at full capacity due to lack of investment and technology or abandoned due to lack of marketplace (sanctions prohibit other countries from buying Iran's petroleum product). Although Iran's current policy regarding the Caspian Sea is unclear (due to secrecy and international politics), the inevitable outcome of all this is that Iran will be left with abandoned offshore platforms and a wasteland of what was once a unique eco-system.

This thesis tries to unfold all the socio-economic issues surrounding the Caspian Sea in order to find a suitable new programming for the existing abandoned platforms at the Sea to address both the economic issues Iran is facing and the environmental situation of the Caspian Sea. Although this thesis explores the socio-economic situation of Iran in this matter, the idea of re-programming the platforms can be acknowledged and studied in other neighboring countries and applied to other platforms all over the Caspian Sea.

[9] Hutzinger, O. The Handbook of Environmental Chemistry, volume 5, Water Pollution, Part P (Berlin; London: Springer, 2005.)

1. Caspian Sea

The Caspian Sea, the largest inland body of water (the area of the sea exceeds 390,000 km2), is located in the Eurasian continent and accounts for 40 to 44 percent of the total lacustrine (lake) waters of the world.[10] The sea is 200 to 400km wide extending over 1,030km from north to the south. With respect to the physico-geographical conditions and the character of the bottom topography, the sea can be subdivided into three parts: the North, Middle, and South Caspian. Because of the Caspian's great extension, the sea finds itself within several climatic zones. Its northern part lies in the zone of a temperate continental climate, the western coasts feature a moderately warm climate, while the southwestern and southern regions of the sea refer to the subtropical zone. The eastern coasts of the sea are characterized by a desert climate.[11]

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[10] Croissant, Michael P., and Buelent Aras. Oil and Geopolitics in the Caspian Sea Region. (Westport, Conn: Praeger, 2000.)

[11] Hutzinger, O. The Handbook of Environmental Chemistry, volume 5, Water Pollution, Part P (Berlin; London: Springer, 2005.)

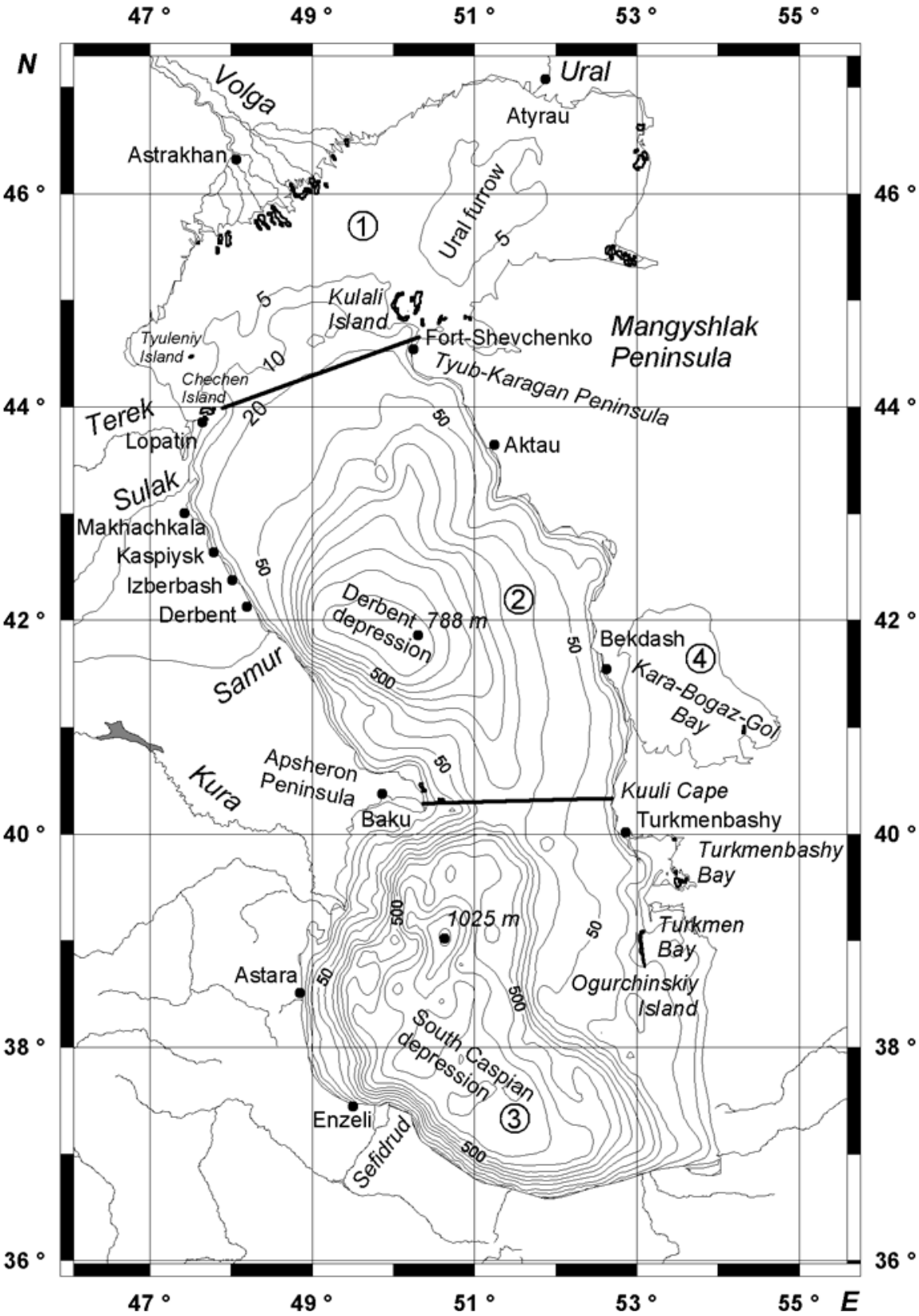

Figure 5 – Main parts of the Caspian Sea 1. North Caspian 2. Middle Caspian 3. South Caspian

The length of the coastline of the Caspian Sea at a sea level of about 27 meters below the ocean level reaches approximately 5,360km (not taking into account the coastline of the islands), which is shared by Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan. Settlements on the Caspian shores vary greatly. The greatest share of the population is concentrated in the 5-km-wide coastal zone in Azerbaijan and Turkmenistan, which is due to widespread extraction of hydrocarbons. Among the cities the largest are the Azerbaijan capital, Baku, with a population of 1.8 million; it is followed by such Russian cities as Astrakhan, the center of the Astrakhan Region, and Makhachkala, the capital of the Republic of Daghestan, with populations of 484,000 and 391,000 respectively. The southern coast of the Caspian is populated by small cities on the Iranian coast, the largest of which are Anzali with a population of 554,000.[12]

Today the Caspian Sea is known to readers thanks to its oil and gas resources, sturgeon and caviar, significant sea-level variations, socio-economic and political problems.

1.1.Caspian Politics

For more than 250 years the Caspian Sea was shared by two states: Russia (the Soviet Union) and Persia (Iran). After the disintegration of the USSR in 1992, the new independent states of Azerbaijan, Turkmenistan and Kazakhstan radically changed the political and economic situation in the region. In addition to Russia and Iran, who had determined the situation on the Caspian for a long period, Azerbaijan, Turkmenistan and Kazakhstan are now interested parties, beginning a new stage in the historical development of the Caspian region.

The Caspian Sea region is one of the oldest oil-producing areas in the world and is an increasingly important source of global energy production. The area has significant oil and natural gas reserves from both offshore deposits in the Caspian Sea itself and onshore fields in the Caspian basin. The US Department of Energy reports that the total resources

[12] Aldis, Anne, and Shirin Akiner. The Caspian: Politics, Energy and Security. (Abingdon, England; New York, N.Y: RoutledgeCurzon, 2004.)

of the Caspian region are estimated at 100–200 billion barrels of oil (which exceeds North American oil resources as a whole) and 7.9 trillion cubic meter of gas. This makes the region the world's third largest for natural gas reserves.[13]

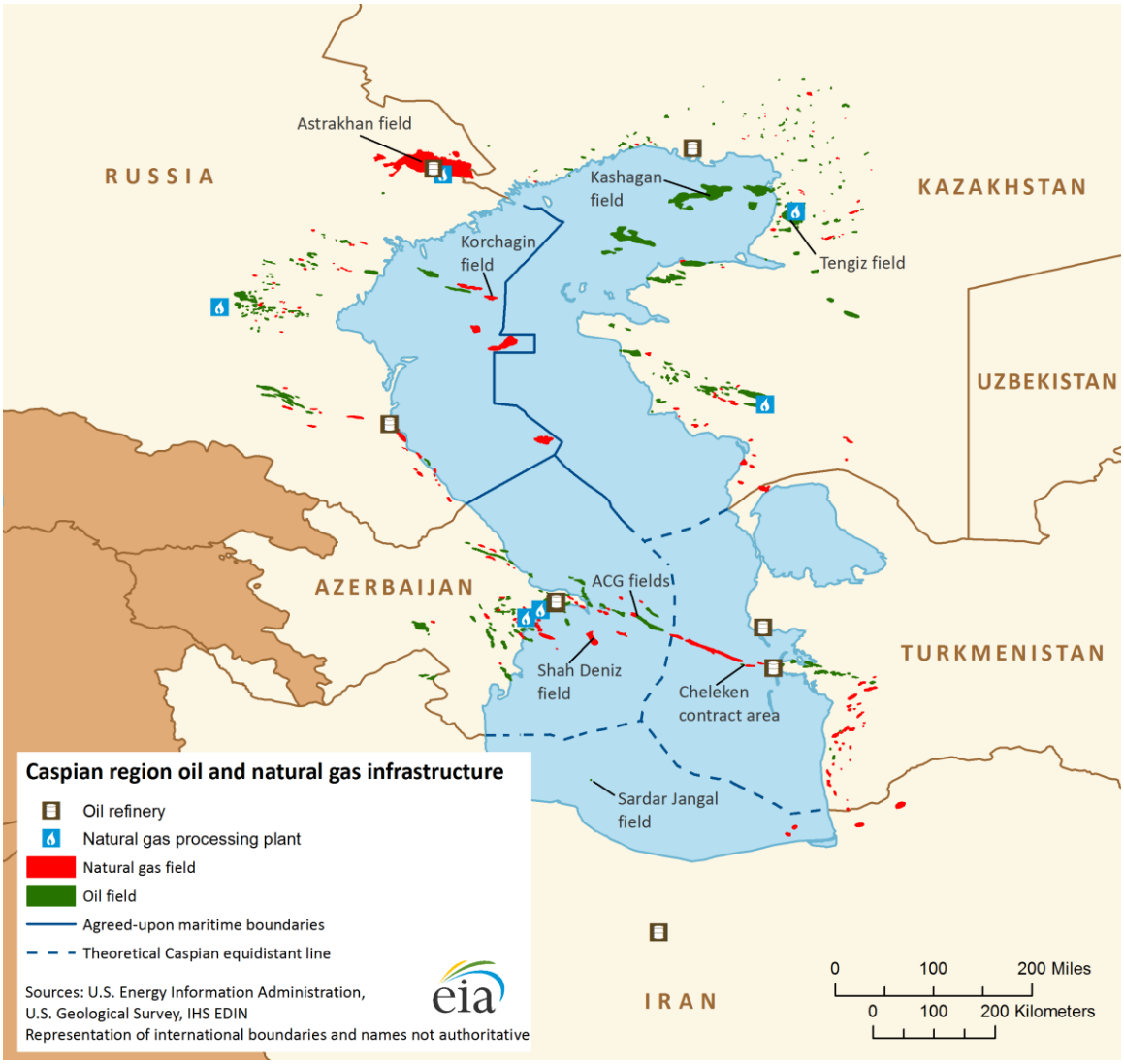

Figure 6 – Caspian Sea lack of regulation and clear borders

Traditionally an oil-producing area, the Caspian area's importance as a natural gas producer is growing quickly. Aside from Azerbaijan's oil production, the Caspian Sea largely was untapped until the collapse of the Soviet Union. With several newly independent countries gaining access to valuable hydrocarbon deposits, the different

[13] Zonn IS, Kostianoĭ AG and Kosarev AN. The caspian sea encyclopedia. (Berlin; London: Springer; 2010.)

countries have taken diverging approaches to developing the energy resources of the area. However, the initial euphoria and optimism that accompanied the initial involvement of foreign investors in the region has been tempered by difficult operating conditions, both geological and political. Complications such as lack of regional cooperation between the countries' governments, under-developed transport infra-structure and complex geological conditions mean that the region has at times struggled to attract the foreign investment it needs.[14]

Moreover the geographic reality was that The Caspian Sea is a lake and thus without access to the high seas. This meant the issue of export pipelines became a key constraint both in terms of politics and the cost of exporting. Moreover, perhaps less obviously, no ocean access would dramatically increase the cost of operations. Thus, rigs either had to be transported in small bits to the Caspian and reassembled or built in situ in a context where although the construction yards existed, their technology was at least 20 years out of date. Thus, the international oil companies operating there faced enormous political problems at global and local level plus growing concerns over the commerciality of their investments.[15]

All political and geographical facts and figures point to a single fact; "hydrocarbon resources of the Caspian are great, but the Caspian is not the Persian Gulf and it cannot claim the role of a complete alternative source for the world oil market."[16]

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[14] Aldis, Anne, and Shirin Akiner. The Caspian: Politics, Energy and Security. (Abingdon, England; New York, N.Y: RoutledgeCurzon, 2004.)

[15] Crandall, Maureen S. Energy, Economics, and Politics in the Caspian Region: Dreams and Realities. (Westport, Conn: Praeger Security International, 2006.)

[16] Zonn IS, Kostianoĭ AG and Kosarev AN. The caspian sea encyclopedia. (Berlin; London: Springer; 2010.)

1.2.Caspian Environment, An endangered ecosystem

The other and historically essential natural resource of the Caspian is its biological resource. The Caspian ecosystem is a closed basin, with its own sea level history that is independent of the level of the world's oceans. The coastal wetlands of the Caspian basin include many shallow, saline pools, which attract a variety of bird life and biodiversity. Over 400 species are unique to the Caspian. The Caspian Sea is rich in marine fish of commercial value (about 123 fish species and subspecies) and other renewable bioresources. At the same time the Caspian Sea is a place of prospecting and utilization of non-renewable resources, such as hydrocarbons. New projects of hydrocarbon transportation are developed and realized here.[17]

The Caspian Sea suffers an increasing anthropogenic impact (human impact on the environment). The most important pollutants are oil and oil products. The chemical pollution grows with the intensification of the human activity on the sea coasts and in the sea proper and represents one of the most hazardous kinds of anthropogenic impact on the Caspian ecosystem. The main sources of pollution of the Caspian natural environment are transborder atmospheric and water transfer of pollutants from other regions, washing off with river flows, discharge of untreated industrial and agricultural wastewaters, municipal–domestic wastewaters from cities and settlements in the coastal zone due to the insufficient number of treatment facilities and oil and gas operations on land and offshore. The increased concentrations of pollutants are characteristic of the near-mouth areas of the rivers. The landlocked nature of the sea and volume of the river flow are the main sources of pollution here. Accordingly the degree of pollution of the eastern shelf of the Caspian Sea is lower than that of the western shelf because, in the latter case, the amount of pollutants is reduced due to the small number of rivers and industrial enterprises.[18]

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[17] Aminmansour, Morteza. Pars Times: Ecosystem and environment Caspian Sea, (Accessed February 2013) http://www.parstimes.com/environment/caspian_ecosystem.html

[18] Hutzinger, O. The Handbook of Environmental Chemistry, volume 5, Water Pollution, Part P (Berlin; London: Springer, 2005.)

Figure 7 – Anthropogenic impact on the Caspian Sea eco-system

Environmental problems of the Caspian have been shaped in the course of economic development of the sea, coastal territories, and watershed basins of the rivers flowing into the sea. With the increase in the economic potential of the Caspian countries due to hydrocarbon extraction, construction of new sea ports, rehabilitation of existing ports, revival of the merchant and tanker fleet, enhancement of the navy component, and construction of oil and gas pipelines this environmental stress may grow.

In 1992 the Volga River basin and coastal territories of the Caspian were officially recognized as "zones of environmental catastrophe". The northern Caspian region is considered the most polluted section of the sea due to its shallow depths and the high concentration of rivers flowing into the sea. Nevertheless, waters of the South Caspian could be considered just as heavily polluted. The highest values of oil product pollution are in the areas near major cities, ports and industrial regions, which in this case are reported near Baku (capital of Azirbaijan), on the edge of the southern Caspian region.

The most heavily polluted areas of the Caspian Sea also include the water area near Apsheron Peninsula, which receives industrial effluents and domestic water of the major industrial centers in Baku, and as a result has turned it into a dead zone.[19] Although relatively clear coastal waters can be seen further south, near Sefidrud River (Iranian coast), the natural environment of the Caspian Sea is a balanced system that functions and responds to external impacts as a single unit.[20]

Figure 8 – Location of the Volga River basin

The likely outcome of the oil and gas scenario of the development of Caspian riches will affect, first of all, the fishery and fish industry. This threat is especially great because of excessive development of the fuel-power industries, drawbacks of legal foundations of

[19] Zonn IS, Kosti͡anoĭ AG and Kosarev AN. The caspian sea encyclopedia. (Berlin; London: Springer; 2010.)

[20] Hutzinger, O. The Handbook of Environmental Chemistry, volume 5, Water Pollution, Part P (Berlin; London: Springer, 2005.)

nature conservation activities, restricted application of nature-saving technologies, and a low ecological culture, which increases the risk of technogenic catastrophes. In general, the shaping situation in the Caspian region urges taking concrete actions for saving the Caspian ecosystem.

1.3. Sturgeon; The Symbol of The Caspian Sea

One of the most catastrophic aftereffects of the anthropogenic intervention into the Caspian ecosystem is related to the population of sturgeon. Aside from their tasty meat, sturgeon are valuable for their caviar, an expensive delicacy in high demand on the world market. The world market price of stellate sturgeon caviar varies up to USD 1,500/kg. One kilogram of black caviar may cost upward of USD 10,000. The main countries producing caviar are Russia, Iran, and Azerbaijan.

Sturgeon is one of the Caspian's large fishes. Individuals are as long as 200–210 cm with a maximum mass of 60–65 kg (The average individual is 36 to 150 cm in length and 3 to 15 kg). Sturgeon is a long-living fish with a maximum age of 45–50 years. Sexual maturity of the male Sturgeon is not until after they are 8–9 years old, while females do not mature until the age of 10–12 years. The breeding power of the mature female sturgeon varies from 50,000 to 800,000 eggs.[21]

[21] Zonn IS, Kosti͡anoĭ AG and Kosarev AN. The caspian sea encyclopedia. (Berlin; London: Springer; 2010.)

Figure 9 – Beluga Sturgeon

In the past century, their catches were at its peak in the middle 1970s. (The Caspian supplied more than 80% of the world's sturgeon stock.) After the disintegration of the USSR and the formation of new independent states, a non-controlled fishery has started in the sea. As a result, the commercial resources have multifold decreased as compared to the 1970s.[22] Diminishing catches in the Caspian have led to a drop in caviar production. In 1989 the Soviet Union produced 1,365.6 t of black caviar and Iran 282 t. By the late 1990s Russia produced only 40 t/year, other new sovereign Caspian states (excluding Turkmenistan) 34.8 t, and Iran about 150 t. Already, even before full-scale production of hydrocarbons in the Caspian Basin has begun, the situation of the sturgeon in the Caspian Sea is catastrophic, so much so that some experts speak in terms of the Caspian losing its fishery significance.[23]

[22] Hutzinger, O. The Handbook of Environmental Chemistry, volume 5, Water Pollution, Part P (Berlin; London: Springer, 2005.)

[23] Zonn IS, Kostianoĭ AG and Kosarev AN. The caspian sea encyclopedia. (Berlin; London: Springer; 2010.)

These fish species, which are living fossils, are now on the verge of extinction. among other reasons (overfishing and water pollution), due to reduction of reproduction grounds since construction of oil wells started in the Northern Caspian in their spawning grounds and on the paths of their migration. Recently sturgeon landings have decreased dramatically from 30,000 tons in 1985 to only 5,672 tons in 1995. The majority of sturgeon population is now supported artificially. The Caspian countries will lose about US$6 billion every year just due to deduction of sturgeon catches. In addition, the caviar business, the annual turnover of which is several billion dollars, was damaged by over 90%.[24]

Figure 10 – Caviar

[24] Environmental Issues, Caspian Environment Program. (Accessed February 2014) http://caspian.iwlearn.org/caspian-1/environmental-issues/environmental-issues

2. Iran's Northern Lowlands

Iran is the only country adjacent to the southern coasts of the Caspian Sea. The entire extension of the southern coast of the Caspian Sea is rimmed by the Alborz Mountains. At places, these mountains approach the coastline by two to five kilometers while mostly they are located 30–50 km away, giving place for coastal lowland (Iran's Northern Lowlands). Unlike the frozen north coast of the Caspian, the industrial west and the deserted east coast, the warm and humid subtropical climate of this area has made it quite picturesque.[25]

Iran's northern lowlands, with approximately 38,700 square kilometers of area (roughly 4 percent of the whole country), is located along the Caspian Sea, separated from the southern regions and Tehran province by the Alborz Mountains. The unique geographic conditions (mountains to the south and Caspian Sea on the north side) of the region create an immediate shift in the climate. The Alborz Mountains Stretch against the coastline of Caspian Sea throughout the northern region of Iran, blocking the Caspian Sea climate to reach further south and thus creating a different vegetation and scenery between the two sides. More than 37 percent (14,540 square kilometers) of the northern Alborz Mountains and the plains are covered with woods which are home to several animal species, namely the Persian leopard. The lowland strips' pleasant climate, beautiful natural landscapes and most importantly, proximity to Tehran, have led it to be one of the main recreational and tourism areas of Iran. Located only four hours drive from Tehran, the northern plains is a holiday destination for the seven million population of the capital.[26]

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[25] Hutzinger, O. The Handbook of Environmental Chemistry, volume 5, Water Pollution, Part P (Berlin; London: Springer, 2005.)

[26] Zendedel, Hasan. North and The Coastline of The Caspian Sea [شمال و سواحل خزر](Irangardan, Tehran 2008)

Figure 11 – Iran's Northern lowlands (known as "shomal" amongst Iranians)

Being located between the Caspian Sea and the Alborz Mountains, the northern plains has a humid subtropical climate. The Caspian climate is blocked off by the tall mountains of Alborz from reaching out further south, making the northern plains one of the most humid regions in Iran. The humidity percentage is highest during late fall and early winter months (86%), and lowest during late spring and early summer months (74%). The temperature is moderate throughout the year due to the high percentage of moisture in the air.[27] The humid climate prevents sharp drops in temperature during winter while providing a moderate weather during the summer months. The closer you are to the coast, the more moderate the temperature.[28]

[27] Vadiyi, Kazem An Introduction to the Natural Geography of Iran [مقدمه¬ای بر جغرافیای طبیعی ایران] (Akhtar Shomal, Tabriz 1960)

[28] The average temperature in January (coldest month of the year) is 6.6 degrees Celsius with a minimum of 2 degrees. The temperature doesn't change drastically in the summer with the average being 25.1 in July (and a maximum of 30.2 degrees Celsius). With an average rainfall of 1000 to 1500 millimeters a year, the region is not comparable to the other parts of the country. It has, by a large margin, the heaviest

The geographic position and land fertility in the northern lowlands has made it the main rice cultivation region in the country. Rice, grain, fruits, cotton, tea, tobacco, sugarcane, and silk are also produced in the lowland strip along the Caspian shore. With Caspian Sea at its doorstep, fishing is the other main occupation in the Northern provinces.[29] The proximity to Tehran (the capital of Iran) and the everyday growing of industrial cities in the region along with farming and trades activities has led to substantial economic development in the region during the past ten years. Furthermore, the large amount of gas and oil reserves lying at the depth of the Caspian has made the lowland strip along the shore an important political-economical zone in the country.

Comparing to the other countries in the region Iran has the greatest number of ports along the Caspian coast. Nevertheless, lack of a clarified regulation in Caspian Sea's legal system and strict sanctions against the country has decreased Iran's share in shipping industry both in tourism and transportation sections. Establishing and launching special docks in northern harbors of Iran for berthing cruise ships and providing some facilitate for transportation of passengers are taken into consideration. Following the agreements which have been reached with the other Caspian Sea regional countries, Iran hopes to increase the number of national ships with support of the government in the near future.[30]

Considering the large amount of oil and gas resources in Caspian Sea, the government is determined that more development should be made in this section. In December 2011, the *Khazar* Oil Company discovered the giant *Sardar-e Jangal* field approximately 150 miles offshore in the Caspian Sea. According to preliminary estimates, the gas reserves of the field are estimated at 50 billion cubic feet, which equals Iran's total gas consumption over a 10-year period. The first phase of the field was expected to become operational within

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rainfall in Iran with a maximum of 2,368 millimeters reported throughout one year. With only 4 percent of the country's total area, the rainfall in the northern plains is equal to more than 40 percent of the whole country. The highest amount of rainfall is during fall months when it sometimes continues for 45 to 60 consecutive days. Because of the moderate temperature the average snowfall doesn't exceed 7 days a year while most of it is a mix of rain and snow. (Sahami, 2007)

[29] Sahami, Cyrus. Sociological Geography of Northern Iran [پژوهشي پيرامون جغرافياى انسانى شمال ايران] (Zavieh, Mashhad 2007)

[30] Sadeghioon, Ladan M. Payvand Iran News: Iran's Share in Caspian Sea Shipping is Little, (Accessed February 2014) http://www.payvand.com/news/07/apr/1024.html

two years which would create job opportunities for 6,000 people. Natural gas accounted for about 59 percent of Iran's total domestic energy consumption in 2010, with oil consumption at 39 percent of total energy use. Iran had marginal contributions from coal and hydropower. Although there have been a few setbacks due to lack of international investment and sanctions made against Iran's Oil industry and oil exports, since the country relies almost entirely on its oil and gas reserves both internationally and domestic, one way or another the development in this section is inevitable. The government is determined to increase investments in this industry especially in the Caspian region. Iran discovered 13 new oil and gas fields with in-place reserves of 14 billion barrels of oil and 45 trillion cubic feet of natural gas during in 2009-2010.[31]

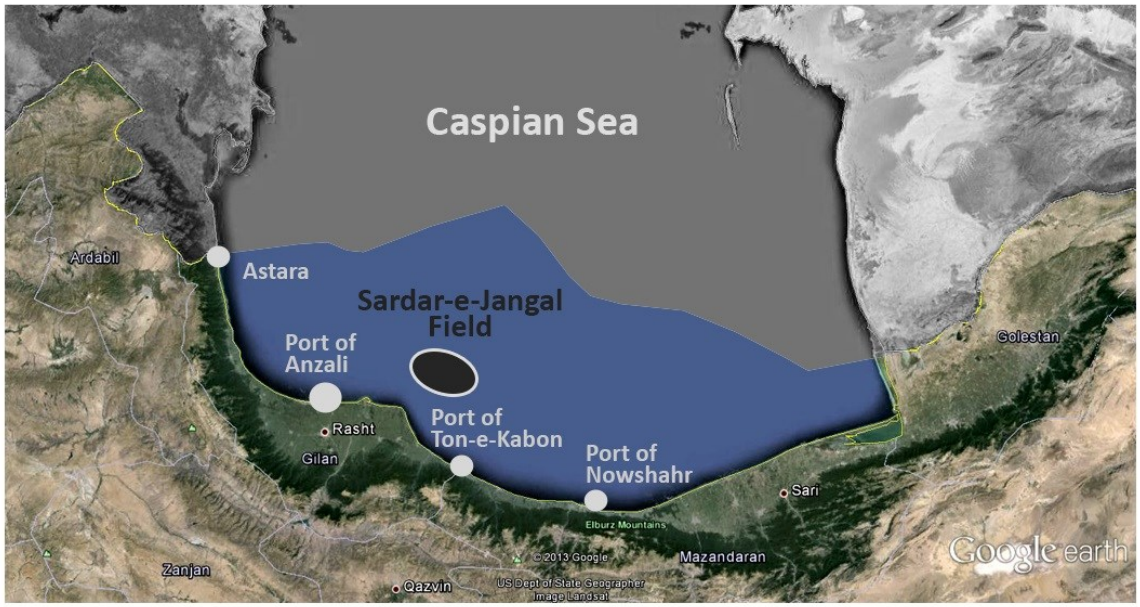

Figure 12 – Approximate location of the Srdar-e-Jangal gas field off the coast of Anzali

Nevertheless, tightening of sanctions[32] by the United States and the European Union brought Iranian oil exports to a near standstill in the summer of 2012. Thus, the government might have to put an early stop to its petroleum associated projects in the Caspian and find the economic comfort it is looking for elsewhere.

[31] IRAN, US Energy Information Administration, (Accessed November 2014) http://www.eia.gov/countries/cab.cfm?fips=ir

[32] In 2010 the US government put a set of more strict sanctions on Iran to force the country to stop its nuclear developments.

3. Iran and oil, politics and economics

Stretching from Turkey and Iraq to Turkmenistan and Pakistan, Iran is the world's 17th largest country in terms of territory, including more than 1.6 million square kilometers. It is one of the world's oldest continuous major civilizations with a population of more than 75 million. Apart from petroleum, the country's other natural resources include natural gas, coal, chromium, copper, iron ore, lead, manganese, zinc and sulfur.[33] In terms of traditional measures of economic power, Iran is the largest and arguably the most influential state within the Middle East. Iran has the second largest economy in terms of gross national product (GDP) and the second largest population in the region. The proven oil and gas reserves of the Islamic Republic are the second and third largest in the world respectively and collectively represent approximately 26%of total global reserves.[34]

[33] The national currency is the Rial (IRR). Although the "Toman" is no longer an official unit of Iranian currency, Iranians commonly express amounts of money and prices of goods in Tomans. One Toman equals 10 Rials. Despite this usage, amounts of money and prices of goods are virtually always written in Rials.

[34] "OPEC annual statistical bulletin" Organization of Petroleum Exporting Countries, 2013. (Accessed February 2014)
http://www.opec.org/opec_web/static_files_project/media/downloads/publications/ASB2014.pdf

Figure 13 – Iran's location on the world map

Figure 14 – Iran amongst other Middle-Eastern countries

Estimates of macroeconomic data on Iran‘s economy and petrochemical industries are uncertain. There are major difficulties in getting accurate data from Iran, and Iran often issues politicized and opaque data. It is possible, however, to investigate and evaluate trends over time, and some of the costs of sanctions for Iran‘s economy are clear. Iran‘s currency, long held artificially high by a regime that could afford to subsidize it, has nose-dived since the implementation of more strict sanctions which prohibited the Islamic Republic from selling petroleum and gas. Sanctions against Iran’s oil industry (the main source of wealth in the country) amongst other sanctions resulted in the immediate loss of the country’s currency. Iranian Rial has lost 80% of its value against the dollar during two years since 2011. In a single day, on October first 2012, it dropped by 15%, and after a brief stay, resumed its trend downwards in early 2013. Finally it was trading at around 37,500 Rials to one dollar in February 2013, up from 13,000 in September 2011. The value of oil to the country’s economy and future investments becomes more clear if we look into the Geneva agreement between The Islamic Republic and the member-states of Group 5+1 (the five permanent UN Security Council members plus Germany). In November 2013, after five days of difficult and intensive talks and more than a decade-long standoff, the two sides reached an agreement regarding Iran’s nuclear program which resulted in dropping some of the sanctions made in 2011. As of January 2014 and as a direct result of the agreement, Rial has gained close to 40% of its value and is currently trading at 25,000 Rials per US Dollar.[35] To completely understand the role of the oil-industry in Iranian’s economy it is necessary to briefly discuss Iran’s economic environment during three different political stages.

[35] "Iran Overview" The World Bank, Last updated: Oct 01, 2013 (Accessed February 2014), http://www.worldbank.org/en/country/iran/overview

3.1.The Pahlavi Monarchy and the Pre-Revolution Economy of Iran (1960-79)

The state of the Iranian economy in the two decades preceding the 1979 revolution was one of substantial growth and prosperity. Inflation averaged below 3.7% with an annual real growth rate of 9.6% for the period of 1960 to 1977. All sectors of the economy experienced significant growth and expansion as billions of dollars in oil revenues fueled government investment in urbanization, infrastructure, industry, and agriculture. Though the government exerted control in oil, defense and other key industries, the private sector exercised an increasingly active role in the economy.

Figure 15 – Shah's White Revolution

The 1975 Law for the Expansion of Ownership in production enterprises – as one of the principles of Shah's (Mohammadreza Pahlavi) White Revolution – provided for the sale of shares to workers and private investors. As a result of Shah's (Mohammad-Reza

Pahlavi, last king of Iran) policies, significant private investments, and soaring oil revenues, the national output of Iran grew by nearly 1,800 percent from 1960 to 1978. This period was also marked by improvements in health and education with decreases in infant mortally, and undernourishment. The Pahlavi government's emphasis on rapid growth, modernization, social welfare reform and expansion into the global economy appeared to produce remarkable gains to the benefit of the entire Iranian community, due to land redistribution programs, job growth, higher standards of living, and low to moderate inflation. However, the social health of Iran was not as alive as its economy. The policies of the Pahlavi regime rewarded the sociopolitical elite thus increasing the gap between the lower and upper classes, using the military and secret security force (SAVAK) to repress the voices of the middle class and a growing opposition and socialist movements.[36]

Figure 16 – Shah's friendly relationship with the US

Despite Shah's state rescue and recovery programs, unemployment in construction and unskilled labor industries compounded the problems facing the Pahlavi regime. Critics of

[36] Amuzegar Jahangir The Dynamics of the Iranian Revolution: The Pahlavis' Triumph and Tragedy (State University of New York Press , 1991)

the Shah's regime and the force of opposition movements gained strength and popular support as the economic situation failed to improve. Shah's desire to achieve regional military superiority, emerge as a major industrial power within a generation and create a Western European style welfare state had proved to be overly ambitious, ultimately resulting in the fall of the Pahlavi regime in 1979. The return of Ayatollah Khomeini (Leader of the Revolutionists who was exiled by Shah to live in Paris away from Iran) to Iran on February 1st, 1979 marked the end of the longstanding kingdom of the Pahlavi family after 54 years. Khomeini gained the trust of the worker class in the country to force Shah to step down. (Some say it was the pressure from the oil-industry workers that forced Shah to leave the country.)[37]

Figure 17 – Revolutionists gathering in the Azadi Square in Tehran to welcome their new leader

[37] Amuzegar, Jahangir Iran's Economy under the Islamic Republic (New York, NY: St.Martin's Press, 1997)

3.2.The Islamic Republic of Iran (1979)

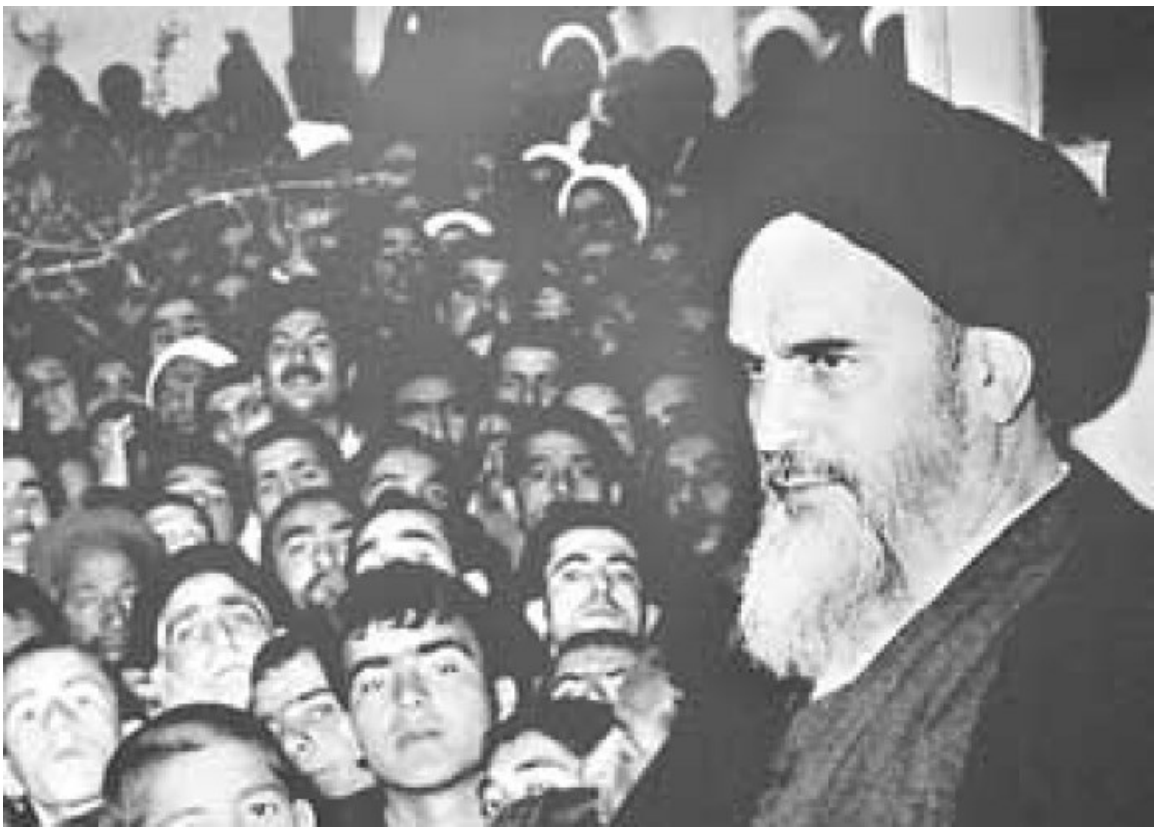

Figure 18 – Ayatollah Khomeini

In the wake of the 1979 Islamic Revolution, Iran was changed from a largely secular pro-Western monarchy into a theocratic state in which the fundamental law of the nation became that of Sharia Law (religious law of Islam). The most influential leaders of the state in turn became the religious clerics of the Shi'a (second largest domination of islam) Islamic religion, with primary power over the state in hands of the Supreme Leader. In the decades following the revolution there has been constant tension within the political landscape of the Islamic Republic comprised of the conservative right, namely Ali Khamenei (Supreme Leader of Iran since 1989) and Ahmadi-Nejad (president 2005-2013), the pragmatic right or centrists (like Hashemi-Rafsanjani, president 1989-1997),

and the reformists of the Islamic left, namely Khatami (president 1997-2005), Mir Hossein Mousavi and Karroubi (Leaders of the 2009 Green Movement[38] in Iran).

This political tension has directly affected the country's foreign relations over the years and resulted in different stages in the economy of the country. The traditional hardliners of the conservative right have wanted to maintain the Islamic principles that formed the foundation of the revolution by combining power and instituting populist economic policies. The pragmatists prefer more Persian focused technocratic leadership and support market oriented economic reform, including foreign investment. On the other hand, the reformists seek to moderate clerical rule by strengthening civil institutions with more liberal social policies. Reformers are more tolerant of the ethnic and religious minorities and favor economic efforts designed to redistribute wealth. For the first decade of the Islamic Republic's existence *Ayatollah Khomeini* (the first supreme leader of Iran) struggled to consolidate his power as the Supreme Leader by forming a tenuous alliance between these competing political camps. Within two years of the revolution the conservatives emerged as the dominant political school of thought and actively sought to eliminate those that opposed their views.[39]

3.3.Sanctions 1979-2009

The first major period of US sanctions began in 1979, as US and Iranian relations deteriorated sharply following the Islamic Revolution and the hostage crisis at the US embassy in Tehran. In response, President Carter laid out a series of economic sanctions that were intended to both punish Tehran and change its behavior. The Reagan administration continued this trend and declared Iran "a sponsor of international terrorism", making Iran ineligible for various forms of US foreign assistance. Reagan also imposed a ban on US imports of Iranian crude oil and all other Iranian imports in

[38] In the 2009 presidential election Ahmadinejad (active president) used his presidential powers to cheat his way to be re-elected as president. The majority of the middle class who had voted for the other candidates (Karoubi and Mousavi) flooded the streets of the major cities throughout the country (Tehran, Mashhad, Shiraz, Tabriz and Isfahan) to try and force the government to reverse the outcome of the election.

[39] Amuzegar, Jahangir Iran's Economy under the Islamic Republic (New York, NY: St.Martin's Press, 1997)

1987. The sanctions were continued by The George H.W. Bush, Clinton and George W Bush administrations.

During the 1990s and within the Iran-Iraq war, long before the current attack of sanctions, the government found itself unable to service its debt. In 1993, a particularly severe balance of payments crisis was accompanied by rapid depreciation of the currency and large increases in money printing. Before the 1979 revolution, the *Rial* had been pegged to the Dollar at a rate of 68.73 Rials to the Dollar. The current account of Iran's balance of payments was generally in surplus, with Iran earning more foreign exchange than it spent. By 1978, with the Ayatollahs in control, the rate was 71.46. Over the next twenty-one years, the Rial lost 99.2% of its exchange value against the dollar reaching 9,430 Rials to the dollar in July 1999.[40]

3.4.Sanctions since 2010

After the revolution centrists (president Hashemi Rafsanjani 1989-1997) and especially reformers, such as President Khatami (1997-2005), attempted to establish more liberal reforms and better relations with the west, the conservatives eventually regained control of Iran's parliament in 2004. The election of President Mahmoud Ahmadinejad – an ultra-conservative and a radical Islamic idealist – in 2004 marked the return to revolutionary values and more authoritarian governance. While excessive state ownership in petroleum and industrial sectors, state welfare programs, government subsidies, religious and ideological tensions, restrictions on foreign investment, heavy reliance on oil revenues, and international sanctions since 1979 had already resulted in the relatively poor performance of Iran's economy, Ahmadinejad's re-election in 2009, in the highly argued presidential election that sparked what is referred to as the "green movement" today, resulted in even more darker relations with the west. Ahmadinejad's re-election and his radical policies marked a new stage in the country's political history

[40] Katzman, Kenneth , Iran Sanction, Congressional research resvice, Specialist in Middle Eastern Affairs. October 23, 2013 (Accessed February 2014), http://fas.org/sgp/crs/mideast/RS20871.pdf

followed by more strict international sanctions and the downfall of the country's economy and currency in merely a couple of years.

Figure 19 – The Green Movement, Tehran, Iran, 2009

2011 may be viewed as one of the most important years in the 21st Century for shaping the future of the Middle East. The opening of Iran's Bushehr Nuclear Power Plant in September and evidence of a Uranium enrichment program within Iran have sparked concerns in the international community.

U.S. policy towards Iran has centered on sanctions that are planned to strain Iran's economy by restricting revenues from exports and limiting the import of military equipment, and advanced technology. Recent U.S. and EU sanctions against the Islamic Republic's Central Bank have the potential to cripple the state if critical oil customers support the measures. For instance, if China, Japan, India, and South Korea found alternate oil suppliers it would reduce Iran's oil revenues by up to 60%, which will

manifest as the economic pressure applied on the government, institutions, and mostly people of Iran.[41]

The Obama administration and the US Congress have drastically increased the size of US sanctions as Iran‘s nuclear program has grown increasingly closer to nuclear weapons production capability. Alternative exporters like Saudi Arabia, Iraq, and Libya have increased production to help make up for the loss of Iranian exports, and key nations like China, India, and Japan have already reached out to Saudi Arabia and other Arab exporters to help reduce their dependence on Iranian oil.

Oil exports provide about 70% of Iran’s government revenues, and Iran’s oil exports have declined to about 1.25 million barrels— decreasing for the 2.5 million barrels per day Iran exported during 2011. Also evidence shows that Iran’s oil export dramatically dropped to about 700 thousand barrels per day in April 2013. The causes of the drop have been a European Union embargo on purchases of Iranian crude oil that took full effect on July 1, 2012, and decisions by several other Iranian oil customers to substantially reduce purchases of Iranian oil. To date, 20 of Iran’s oil customers have reduced Iranian oil imports.

As early as July 2012, the US Energy Information Agency (EIA) estimated that the growing impact of sanctions was impacting Iran‘s ability to produce oil. The EIA announced that it expects Iran's crude oil production to fall by about 1 million bpd (barrels per day) by the end of 2012 relative to an estimated output level of 3.6 million bpd at the end of 2011, and furthermore by an additional 200,000 bpd in 2013. Iran has no chance for the foreseeable future of meeting its stated goal of some 5.3 million bpd of production capacity. According to the International Energy Agency (IEA), those estimates appear to be correct as Iranian oil production hit 2.68 million bpd in March 2013, and 700 thousand bpd in April 2013 (domestic news). Recent data from sources such as the EIA, the IEA, and various news organizations point to a substantial reduction in both Iranian crude production and crude exports. Iran exported roughly 1.1 million bpd in March 2013, down from an average of 1.53 million bpd in 2012 and 2.5 million bpd in

[41] Maloney, Suzanne and Takeyh, Ray The Self-Limiting Success of Iran Sanctions, (2011), (Accessed February 2014), http://www.brookings.edu/research/articles/2011/11/iran-sanctions-maloney-takeyh

2011 and 2010. This is costing Iran roughly $100 million a day and roughly $5 billion a month.[42]

Figure 20 – Bushehr Nuclear power plant

3.5.Resistive Economy, a solution for the future

While it is not possible to obtain reliable information on the effects of sanctions, most sources report a steadily tougher economic climate within Iran, with high inflation, high unemployment, and rising consumer goods prices hitting the country. The new sanctions that went into effect over the summer of 2012 have created serious banking and trade problems by cutting off Iranian banks from international finance networks. All signs point to production is down, industry is stopping, and there is a massive brain drain, estimated at least 250,000 high-educated Iranians that try to leave the country annually.[43]

[42] "Country Analysis Brief: Iran" U.S. Energy information administration, Last Updated July 2013, (Accessed Febraury 2014), http://www.eia.gov/countries/analysisbriefs/Iran/iran.pdf
[43] Amuzegar, Jahangir. The Islamic Republic of Iran: Reflections on an Emerging Economy (Routledge, 2014)

Knowledge is now recognized as the driver of productivity and economic growth, leading to a new focus on the role of information, technology and learning in economic performance. The term "knowledge-based economy" stems from this fuller recognition of the place of knowledge and technology in modern economies.[44] Comparing knowledge-based economy in Iran and China during the sanctions period (1979-2009) in a research done by Abolfazl Shahabadi and Zohreh Bahari indicates that China increased the share of TFP (Total Factor Productivity) in economic growth and competitive strength through development of new agents markets and made the sanctions practically ineffective. Thus, sanctions not only didn't weaken economic and productive variables in China, but also provided an opportunity to further strengthen economic foundations. The research proves the positive effect of Knowledge-Based Economy on total factor productivity (TFP) and economic growth.

Iran on the other hand has not yet overcome the sanctions due to high dependence on oil wealth. A great part of Iran's economy is based on oil export. According to the Economist Intelligence Unit oil exports make up 80 percent of Iran's total earnings and 50-60 percent of government revenue. Iranian oil exports saw dramatic declines in 2012 compared to the previous year. Iran's net oil export revenues amounted to approximately $69 billion, significantly lower than the $95 billion total generated in 2011.

The solution lies within a resistive, knowledge-based economy. Iran must expand components of knowledge-based economy and markets of new production factors in order to neutralize the effects of the sanctions, turn non-renewable wealth into reproducible wealth and furthermore increase share of TFP in economic growth.[45] In other words, the government needs to promote technology by developing innovative knowledge-based companies and producing new job opportunities for the youth population to increase TFP and furthermore overcome the economic sanctions.

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[44] ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD), THE KNOWLEDGE-BASED ECONOMY (OECD publications, Paris 1996)

[45] Shahabadi, Abolfazl and Bahari, Zohreh. Comparison of Iran and China from the perspective of Knowledge-Based Economy in order to deal with economic sanctions (The Open Journal of Resistive Economic, Vol 1, December 2013)

4. Post-oil phase of the sea

Coal and oil, which are the buried products of several hundred million years of solar energy, photosynthesis, and geological pressure, have fuelled our industries and transport systems since the Industrial Revolution (a period of only 200 years). The inevitable conclusion is that oil is being consumed about one million times faster than it was made. Thus, the twenty-first century will be the century when societies have to learn to live without gas and oil.

Yet, there is an entirely separate motivation for living without fossil fuel: obtaining energy from oil, coal, and gas will continue to put carbon dioxide (CO2) into the atmosphere at levels which it is widely acknowledged are elevating the average temperature on the planet.[46] In the Caspian, excessive oil production is polluting the unique ecosystem of the Caspian, decreasing primary production, reduction of fish feeding and spawning areas, and disturbance of fish migration routes. There have been cases of mass waterfowl mortality due to oil spills in the sea. Furthermore, since the quality of the marine environment also determines the conditions for recreation in the sea coastal zone, tourism has not had much development in the region either.[47]

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[46] Armstrong, F. A., and Katherine M. Blundell. Energy... Beyond Oil.(New York; Oxford: Oxford University Press, 2007.)

[47] Zonn IS, Kostianoĭ AG and Kosarev AN. The caspian sea encyclopedia. (Berlin; London: Springer; 2010.)

Rapid settlement of the legal status of the Caspian is necessary for a transition to sustainable development capable of ensuring a balanced solution of the socioeconomic and nature-conservation issues in the interests of the Caspian countries and the whole world community. The first step in ecological diplomacy of the Caspian has been made. In November 2003 the five Caspian countries met in Tehran where they signed the Framework Convention on Protection of the Marine Environment of the Caspian Sea. This convention states that its member-countries undertake "to take jointly all necessary actions to prevent pollution of the Caspian Sea, lowering of its present-day level and further control of its condition".[48] Nevertheless, due to the excessive development of the fuel-power industries, drawbacks of legal foundations of the nature conservation activities, restricted application of the nature-saving technologies and low ecological culture there hasn't been significant development regarding this issue since then.

In the end everything related to this topic will be decided by politics, or better said the economic environment of the country, the region and other interested international parties. Nevertheless, regardless of what path Iran would take, the outcome will always be the same: abandoned platforms and the polluted Caspian Sea.

4.1.Offshore platforms; cities of the sea

Offshore structures have special economic and technical characteristics. Economically, offshore structures are dependent on oil and gas production, which is directly related to global investment, which is in turn affected by the price of oil. Most offshore structure platforms were constructed world-wide in the period of growing oil investment between 1970 and 1980. Consequently, a lot of mature offshore structures are going through rehabilitation designed to increase and maintain their structural reliability.[49]

[48] Hutzinger, O. The Handbook of Environmental Chemistry, volume 5, Water Pollution, Part P (Berlin; London: Springer, 2005.)
[49] El-Reedy, Mohamed A. Offshore Structures: Design, Construction and Maintenance. (Waltham, Mass: Gulf Professional Pub, 2012.)

The life of an offshore platform extends until it is no longer serviceable and must be replaced, or until the function that it performs is no longer needed. A well-designed steel structure has no defined life as long as it has not been overloaded and has been properly maintained to prevent corrosion. The useful life of an offshore platform depends on the duration of oil and gas production from that location, not necessarily on the strength of the structure. Offshore petroleum structures have an oil life span of 20 to over 35 years (considering their size). Beyond this point there are three basic options concerning the disposition of offshore platforms. They can be removed, relocated or left in place (presumably for some other use). In simplest terms, the procedures for removing fixed steel platforms are the reverse of the installation procedure. The primary procedure has been to cut the platform into sections and remove by lifting. Before a platform is to be removed, individual items of deck equipment, such as living quarters, cranes, buildings, heliports and generators, are returned to shore for reuse.[50] However, the structural portions of the jacket and deck are not as reusable as the deck equipment. In case of relocating the platform, the new location should have the same depth as the last one. Moreover, different soil conditions will require different foundation design. Thus, it is necessary to return the jacket to shore and modify the lower portion of the jacket to accommodate different water depth and return it offshore for installation. The cost of such procedures (removal or relocation of a platform) varies due to the size and the water depth of the platform's location. In this study, for instance, the removal cost of a steel jacket located at approximately 500-700 meters of water in the "sardar-e-jangal" gas field in the Caspian Sea (off the coast of Iran) would be between 5 million dollars up to 90 million dollars considering its size and complexity.[51]

[50] Leffler, William L., Richard Pattarozzi, and Gordon Sterling. Deepwater Petroleum Exploration & Production: A Nontechnical Guide. (Tulsa, Okla: PennWell Corp, 2011.)
[51] El-Reedy, Mohamed A. Offshore Structures: Design, Construction and Maintenance. (Waltham, Mass: Gulf Professional Pub, 2012.)

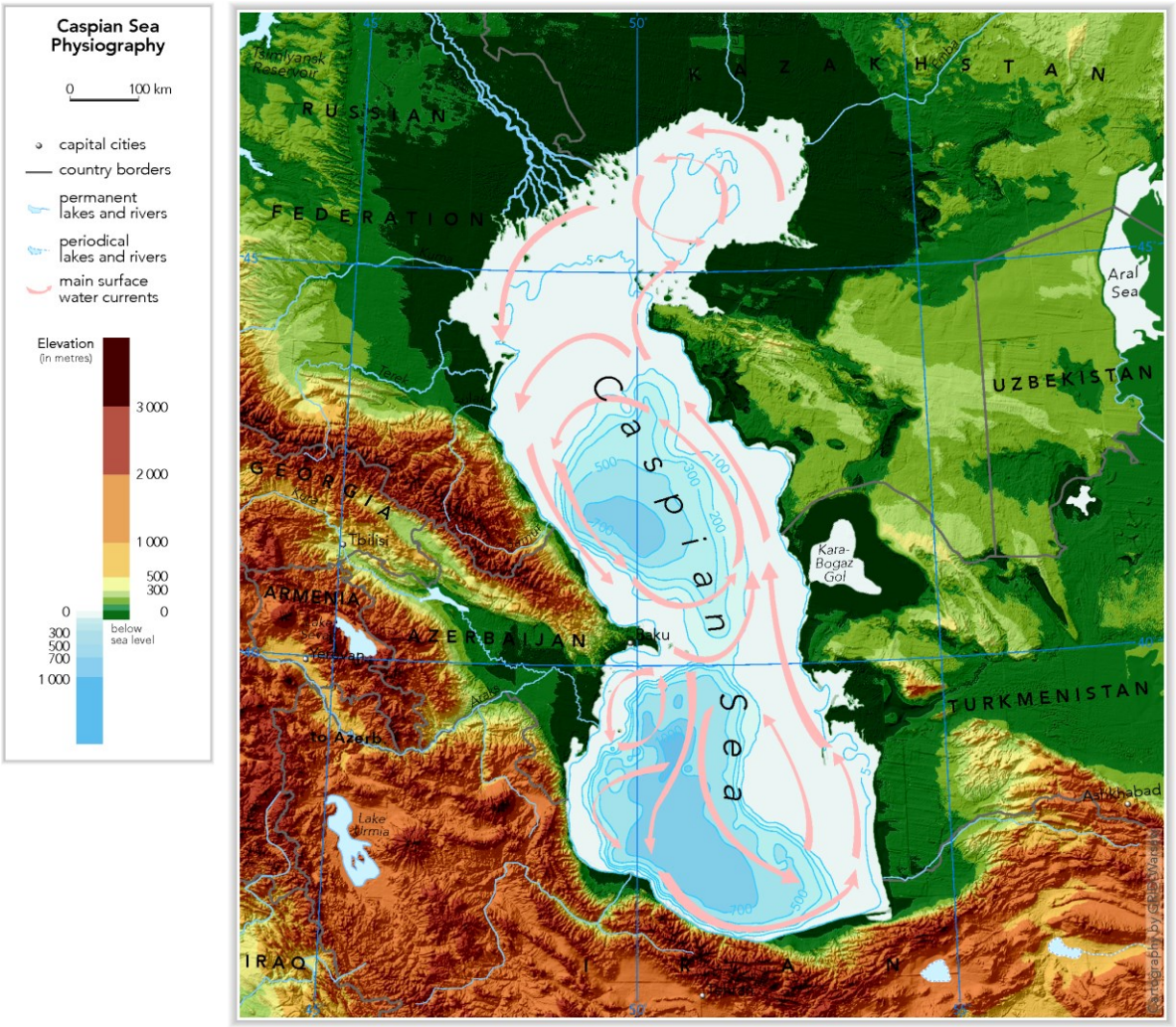

Figure 21 – Caspian Sea Physiography

The general practice has always been to remove all structural elements after petroleum production has ceased and return them to shore for salvage or scrap. Nevertheless, the offshore industry has reached a state of maturity such that the number of platforms to be removed has increased dramatically worldwide. Moreover, these large structures are expensive and very difficult to remove and some argue that complete removal of all platforms may not be beneficial to local biological communities. Thus, it is necessary to evaluate alternative solutions to use offshore oil and gas platforms during their post-oil phase life-span.[52]

[52] Committee on Disposition of Offshore Platforms, Marine Board,National Research Council. Disposal of Offshore Platforms. (National Academies Press, 1985.)

4.2.Reviving the platform

Due to high pollution in industrial bays and city shores purification of the bay waters is a priority project for all neighbouring countries in the Caspian region. Although Iran's coastal waters are relatively cleaner than that of the west (Baku, capital of Azerbaijan) and the northern Caspian, yet the Caspian environment is a closed basin, so the matter is just as crucial to Iran as it is to other countries.[53]

One of the basic mechanisms for settlement of the socioeconomic and ecological problems of the Caspian Sea may be, and this was already proposed more than once, establishment of an "international Caspian center" for environmental monitoring.[54] Thus, the abandoned offshore platforms can be revived as monitoring stations during the post-oil phase of the sea to preserve and restore the marine environment of the Caspian Sea. These monitoring stations will research hydrometeorology, oceanography, and Caspian Sea pollution; providing uniformity for carrying out online marine observations and participating in integrated online monitoring of Caspian Sea environment pollution. Furthermore, these stations can prepare information and forecasts on the state of the Caspian Sea.

As sound as the idea of a monitoring station is, these platforms are costly structures (both construction and maintenance) and they need to be economically self-sustaining. In a few cases, offshore structures have been towed to deep water and dumped, or placed in specified locations to serve as artificial reefs to enhance living resources.

Historically, fishermen have identified natural snags, reefs and other bottom features as likely locations for fishing, providing valuable habitat for the smallest of marine organisms (e.g. phytoplankton) as well as for numerous species of fish. In order to provide increased marine habitat, man has often enhanced natural processes by placing various natural and man-made materials on the ocean floor. Early artificial reefs were made of submerged logs, rocks or other natural materials as well as man-made materials

[53] Zonn IS, Kosti̇anoi̇ AG and Kosarev AN. The caspian sea encyclopedia. (Berlin; London: Springer; 2010.)
[54] Hutzinger, O. The Handbook of Environmental Chemistry, volume 5, Water Pollution, Part P (Berlin; London: Springer, 2005.)

such as construction rubble, automobile tires, junked cars, ships and most recently from abandoned offshore petroleum structures.[55] For example, waters offshore from the Louisiana coast hold one of the largest assemblages of the abandoned reef structures in the world. As of 1983, there were some 4,094 petroleum structures located in the Gulf of Mexico. Approximately 3100 oil and gas structures lie in state and federal waters of Louisiana.[56] A research was done based on the gathered data from a previous study (done by Ditton and Auyong in 1984) that addressed the recreational fishing use of offshore oil and gas structures to gain further insight into predicting fishing use of petroleum platforms in the central Gulf of Mexico. Based upon the data it was concluded that offshore platforms serve as principal fishing destinations in the area, persuading fishermen to travel up to a hundred miles in pursuit of their recreation. Moreover, it was reported that fishing by platform personnel was widespread as it was the main recreation on the platform.

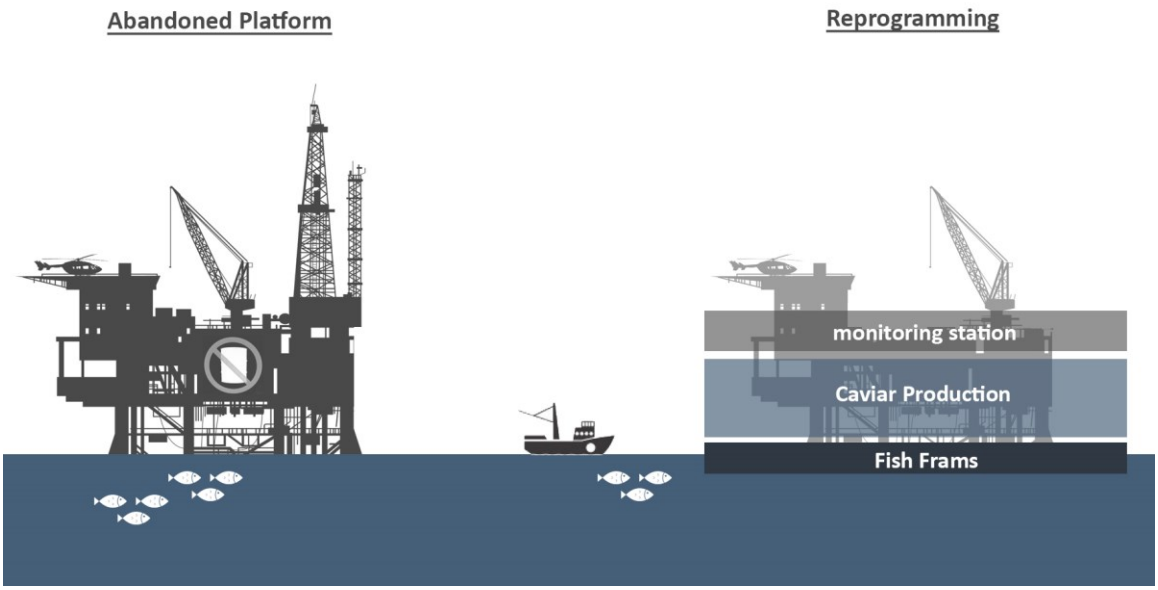

Figure 22 - creating new occupations on the platform

[55] GORDON, WILLIAM REGINALD, JR. "PREDICTING RECREATIONAL FISHING USE OF OFFSHORE PETROLEUM PLATFORMS IN THE CENTRAL GULF OF MEXICO." (UMI Dissertations Publishing, 1987.)
[56] Ditton, Robert B. Fishing Offshore Platforms, Central Gulf of Mexico : An Analysis of Recreational and Commercial Fishing use at 164 Major Offshore Petroleum Structures / by Robert B. Ditton, Janice Auyong ; Project Officer, Villere Reggio ; (in Cooperation with Gulf of Mexico Offshore Operators Committee., 1984)

Figure 23 – Fishing near offshore platforms

With ever-increasing recreational fishing demands on natural habitats on the coasts of the Caspian Sea, artificial reefs provide an effective means for delivering additional opportunities for marine and freshwater fishermen. Although intended to facilitate the exploration and recovery of hydrocarbons, Biological assessments demonstrate that offshore oil and gas structures directly provide shelter and indirectly contribute food for fish species. As discussed earlier the logical solution for Iran struggling with sanctions is to leave its long-lasted oil-dependant economy and take a new path based on a knowledge-based resistive economy to create new opportunities. Furthermore, as noted it is necessary to elaborate efficient measures for protection of the marine environment of the Caspian Sea from negative anthropogenic impacts, most importantly, the rehabilitation of the unique sturgeon community. Since offshore petroleum structures have already been proved to work as an artificial reef sheltering various fish species, they can be revived as sturgeon fish farms and caviar production facility. Caviar, the salted roe

of sturgeon, is considered a delicacy worldwide, and taking into account its high value in the word market, the revived platform will itself be economically self-sustaining while addressing the economic issue the country is facing by creating a new occupation at sea.

4.3.Sustainable caviar production

However, as mentioned earlier the Caspian's marine life is generally endangered due to the vast developments of oil industry in the area and sturgeon is no exception to this matter. Moreover caviar is typically produced from unripe, unovulated sturgeon eggs, which can only be harvested by sacrificing fish. Sturgeon are slow growing creatures that may take 20 years to reach sexual maturity (depending on species) and, even then, do not spawn every year. In the absence of adequate management systems, particularly since the decline of the USSR, they have been harvested faster than they can ever reproduce. Thus, some of the sturgeon species are predicted to become extinct within a few years. Apart from the ecological problem the production process of the caviar presents, it is not economically efficient if the sturgeon can be harvested for caviar only once during its life.[57]

Today, German scientists have discovered a new sustainable technique for caviar production from ovulated stripped sturgeon eggs. Roe can be harvested from live sturgeon through a caesarean-style incision or, if ultrasound is used to locate them within the fish, through the urogenital opening by massage. The latter requires only a 2 mm cut to be made to relax the muscles and the fish can subsequently be returned to its tank and stripped again when it has produced more eggs. Using this technique, it is claimed that sturgeon may well fulfil their natural lifespan, which could be up to 200 years.[58] This new technique preserves the endangered sturgeon from extinction while there is also no denaturation and quality loss of a high value luxury delicacy as eggs remain in their native state. Moreover, harvesting of eggs is harmless for the fish and, thus can be

[57] Armson, Myra. SUSTAINABLE CAVIAR PRODUCTION: SAVE OUR STURGEON! (accessed November 2014) http://www.ifis.org/resources/features/sustainable-caviar-production-save-our-sturgeon!/

[58] New sustainable caviar production – without the necessity to kill sturgeon, Alfred Wegener Institute (Accessed November 2014) http://www.awi.de/index.php?id=5946&type=123

repeated over many production cycles and is only limited by the maximum handling size of the animals which addresses the economic issue of the previous method.

Figure 24 – conventional method kills the fish (left) while the new sustainable method only makes a small incision on the sturgeon's stomach to remove the eggs

Using this new technique, along-side the monitoring station, the platform can be transformed to a fish farm and a caviar production facility. These two will work together in preserving and monitoring the endangered sturgeon while proposing a solution for the socioeconomic problems of Iran. Moreover, "the creation of an artificial reef, or a system of reefs, may be incorporated into the general or comprehensive plan of adjacent coastal community. A local government, in defining its community goals may see its potential growth integrally linked to the tourism appeal of its recreational resources."[59] Thus, revived platforms provide an optional source of recreational fishing for the community of saltwater fishermen in Iran attracting more tourists to the area and ultimately providing a target population for the newly born ship industry in the country.

[59] Ditton, Robert B. Fishing Offshore Platforms, Central Gulf of Mexico : An Analysis of Recreational and Commercial Fishing use at 164 Major Offshore Petroleum Structures / by Robert B. Ditton, Janice Auyong ; Project Officer, Villere Reggio ; (in Cooperation with Gulf of Mexico Offshore Operators Committee., 1984)

5. Redesigning the platform

Over the past 40 years, two major types of fixed platforms have been developed: the steel template, which was pioneered in the Gulf of Mexico, and the concrete gravity type, first developed in the North Sea. Recently, a third type, the tension-leg platform, has been used to drill wells and develop gas projects in deep water. Different structural methods are applied in different locations mainly considering the depth of the water.[60]

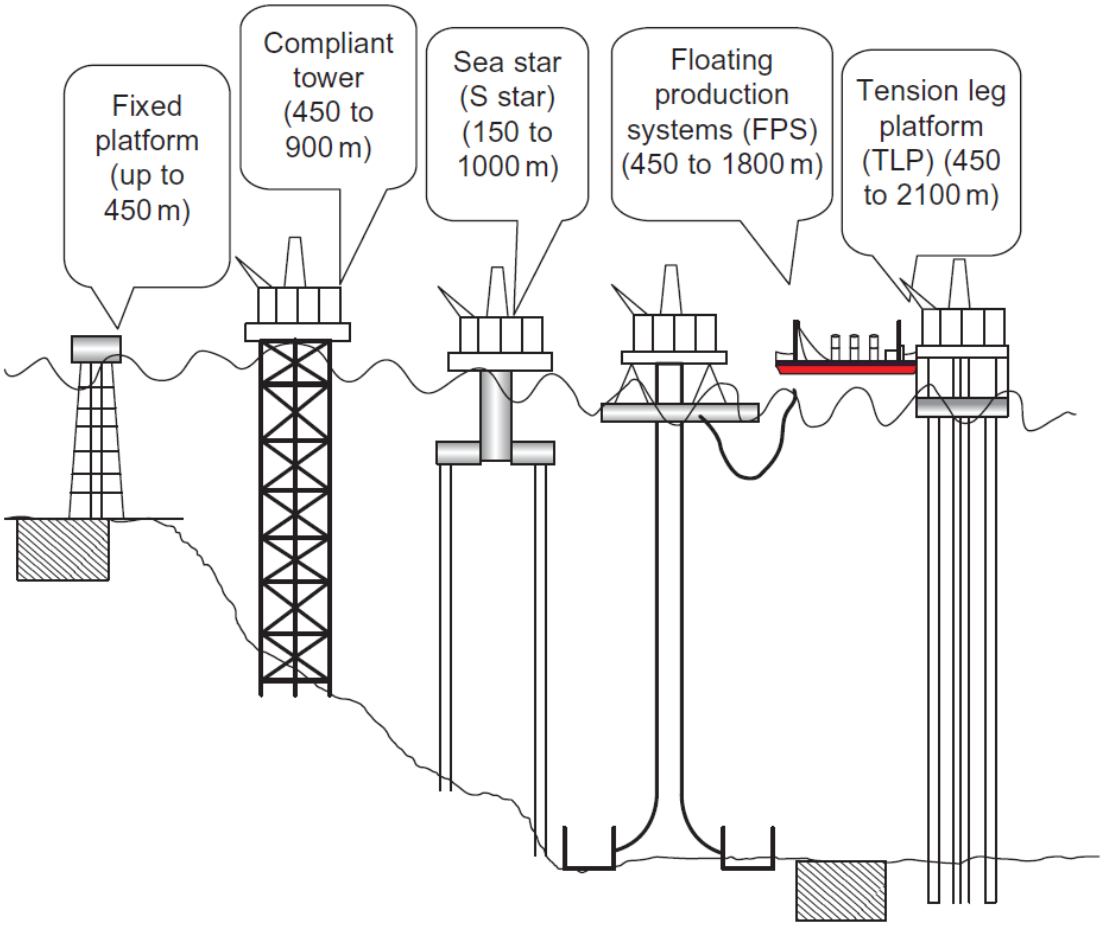

Figure 25 - different types of platforms and their depth compatibility

[60] El-Reedy, Mohamed A.. Offshore Structures: Design, Construction and Maintenance. (Waltham, Mass: Gulf Professional Pub, 2012.)

The proposed site for revival of a platform is as mentioned before “sardar-e jangal” gas field in Iran’s jurisdiction of the Caspian Sea. However, due to the government’s secrecy on this matter the exact location of the site and the extent of development is unknown. Nevertheless, global news agencies have put the site approximately 20 kilometers offshore of “Bandar Anzali” and Anzali Harbor (the largest harbor on southern Caspian coastline). The offshore structure in these depths (500-700 meters) is a compliant tower which is an extension of the fixed steel platform. For the purpose of thesis and lack of information on any existing offshore platforms Iran might have erected in the Caspian Sea, two platforms (a compliant tower and a drilling jack fixed platform connected by a bridge) has been selected as an example to be redesigned.

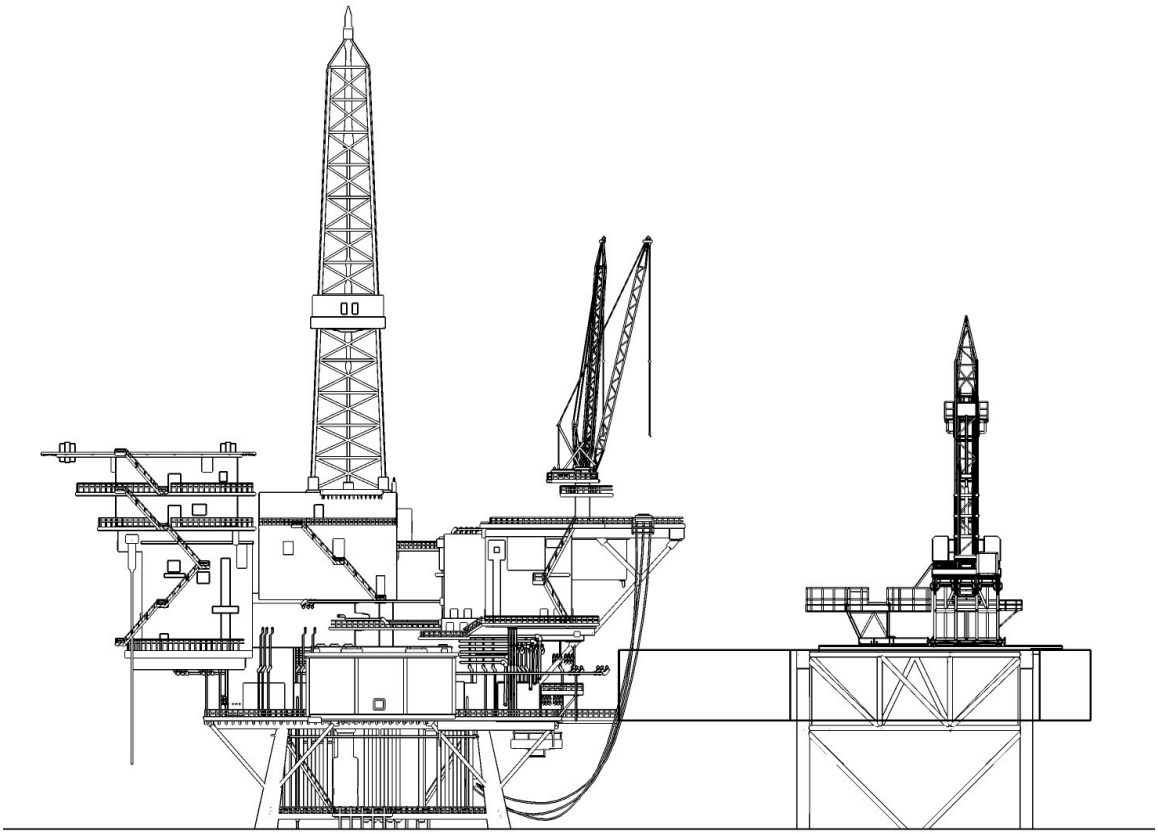

Figure 26 - generic elevation of the two sampled platforms

These structures (fixed steel platforms) consist of three main components: the superstructure or deck, which provides work space, the jacket, and the piling. The jacket rests on the ocean floor and has open pipe columns, or legs, which extend above the

water surface. Tubular bracing members interconnect the legs to make the jacket a single rigid structural unit or space frame. Pilings are driven through the legs of the jacket into the ocean floor. The jacket serves as a guide during pile installation and as a structural unit to support the deck and resist horizontal loads from wind, waves, earthquakes, and currents.[61]

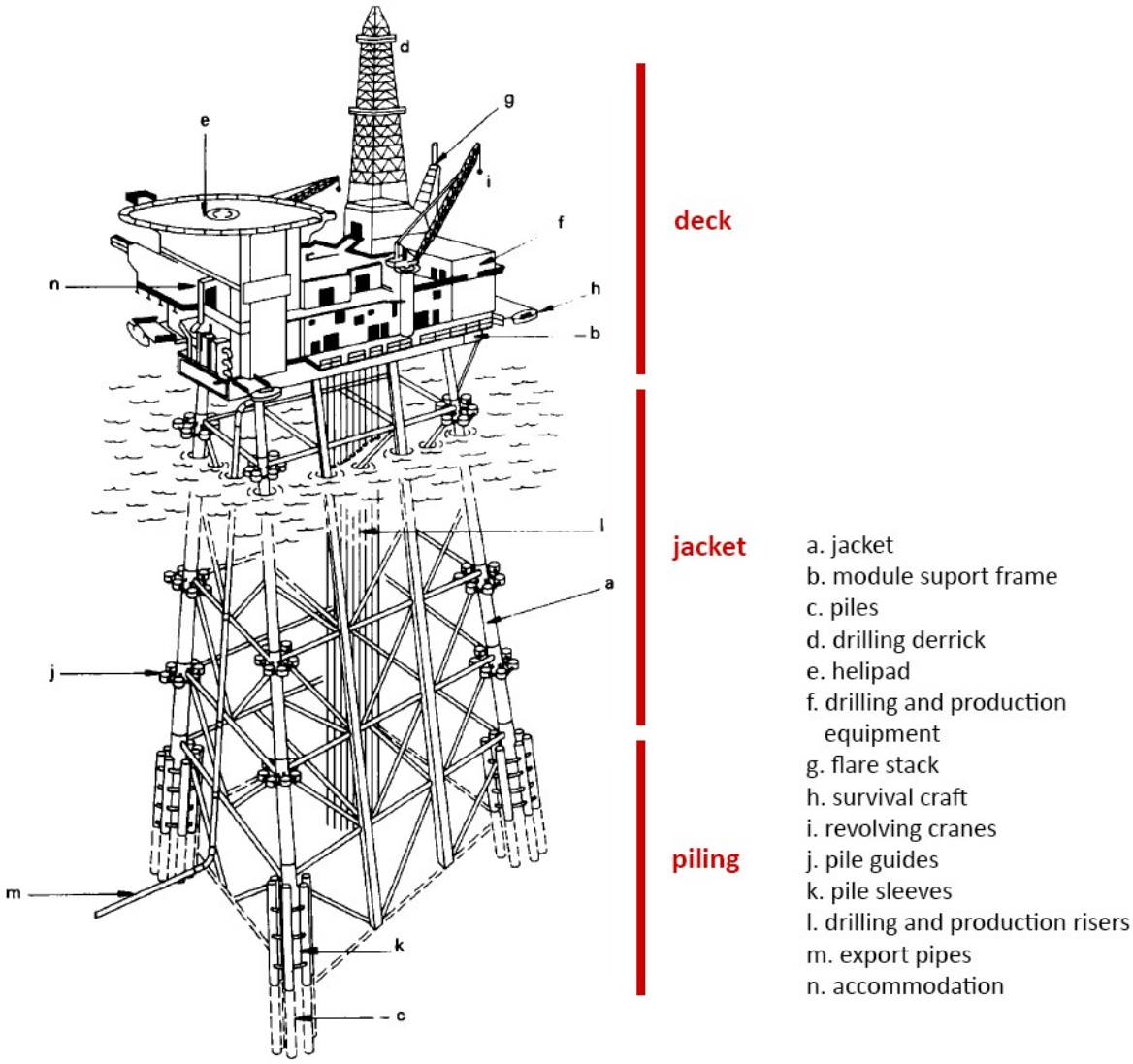

Figure 27 - different sections of fixed steel platform

[61] Committee on Disposition of Offshore Platforms, Marine Board,National Research Council. Disposal of Offshore Platforms. (National Academies Press, 1985.)

Fixed offshore platforms are unique structures since they extend to the ocean floor and their main function is to hold industrial equipment that services oil and gas production and drilling. These structures are designed to withhold several loads comparing to the structures built on shore. In general the loads that act on a platform are wind loads, wave loads, earthquake loads and gravity loads. Gravity loads consist of the dead and the live load. The dead load is the platform's own overall weight and, in addition, the weight of the equipment, such as piping, pumps, compressors, separators, and other mechanical equipment, used during operation of the platform. Live load is the load imposed on the platform during its use including the weight of drilling and production equipment, living quarters and the weight of liquid in storage tanks.[62] Reusing a platform as anything different than what it was designed for in the first place requires the smaller and lighter individual equipment items on deck to be removed. More importantly, all tanks, piping, and other vessels that have contained oil or gas have to be removed or completely decontaminated.[63] Thus, reviving the platform requires removal of all its previous live loads and part of its dead load which would ultimately make place for the weight of the newly designed sections to be added to the platform. In most offshore platforms everything above the jacket structure is constructed of pre-fabricated modules. This flexible but reliable technique makes it easier and faster to add or remove parts of the platform in the future. Moreover each of these components and modules will be outfitted with specific hardware to allow them to be connected to each other. On-site cranes are used to place these topside modules over the supporting jacket and furthermore, to rearrange or remove them in the future.[64]

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[62] El-Reedy, Mohamed A.. Offshore Structures: Design, Construction and Maintenance. (Waltham, Mass: Gulf Professional Pub, 2012.)

[63] Committee on Disposition of Offshore Platforms, Marine Board,National Research Council. Disposal of Offshore Platforms. (National Academies Press, 1985.)

[64] Patel, Minoo H., and Joel A. Witz. Compliant Offshore Structures. (Burlington: Butterworth-Heinemann, 1991.)

Figure 28 – topside modules come in different sizes. Some are as big as a multi-storey building

However, in redesigning these two platforms some of the topside parts will be left in place to be used differently in the new redefined platform. Furthermore, these sections will act as an architectural archeology of what once was an offshore "oil platform". Accordingly, one of the crane towers will be left in place to be used during installation of the newly designed sections while the drilling tower will remain in place to serve as a structure to install wind turbines inside. However, only the slabs and columns of the lower portion of the tower will remain in place to be redesigned later. The living quarter

section will be removed to be replaced while the smaller platforms will remain mostly untouched. (Except for the oil related pipes and equipments)

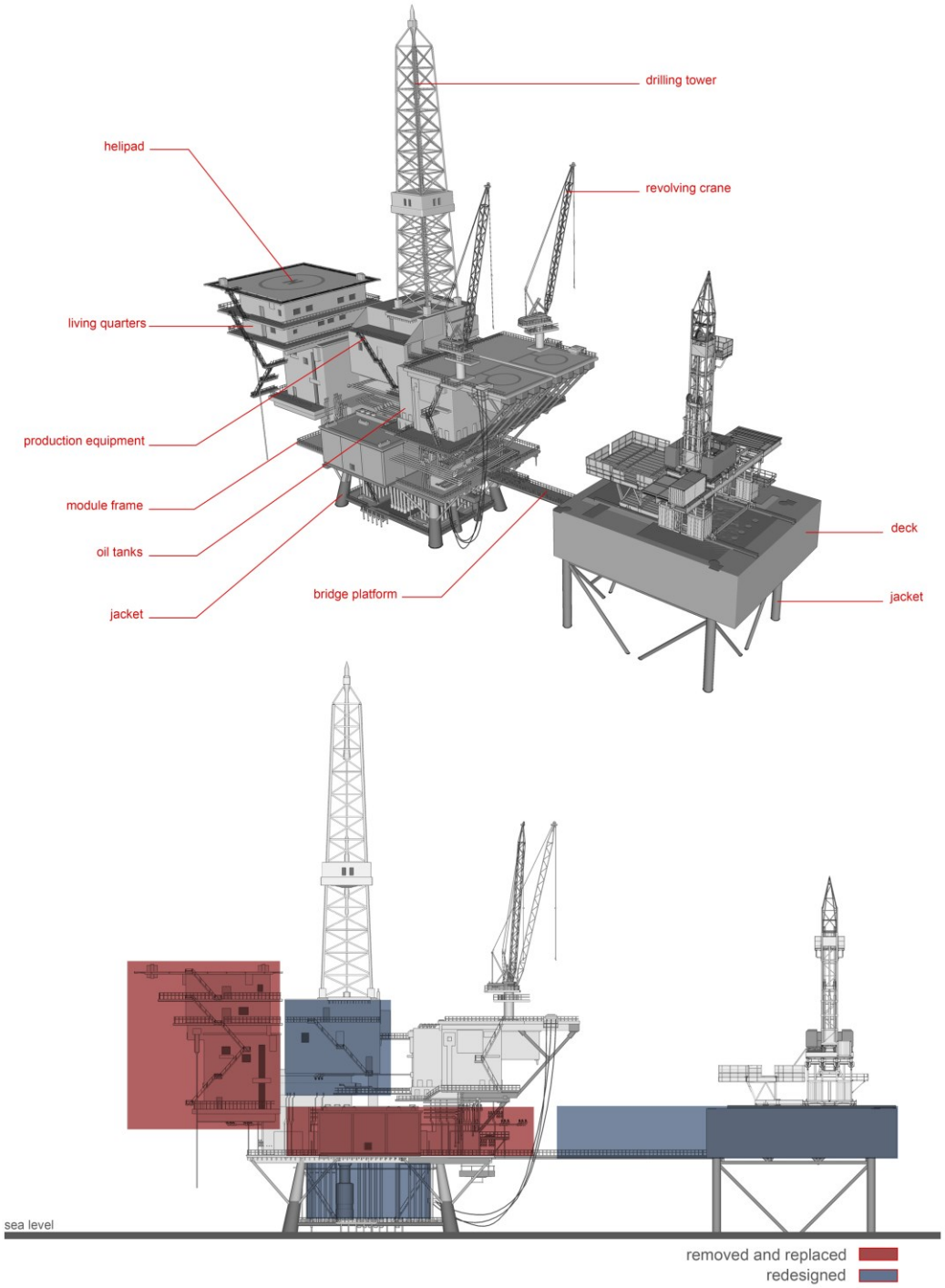


Figure 29 - unwanted sections of the existing platform are removed. The deck and the jacket (structure of the platform) will remain untouched to make basis for the newly designed section to be installed.

Figure 30 - The Aquatic City

As discussed earlier the main goal of redesigning the platform is to address both the environmental issues of the Caspian Sea and Iran's economic situation. Hence, the main programming of the redesigned platform will be sturgeon fish farms, caviar production and the International Caspian Center. (A research and monitoring station to observe and report any changes to the Caspian eco-system) The rest of the revived platform includes housing followed by other amenities to provide a more comfortable stay for the on-site personnel. Accordingly, in redesigning the platform the newly revived platform has been divided into three main sections to address these different functions; the industrial zone, the residential zone and the communal zone.

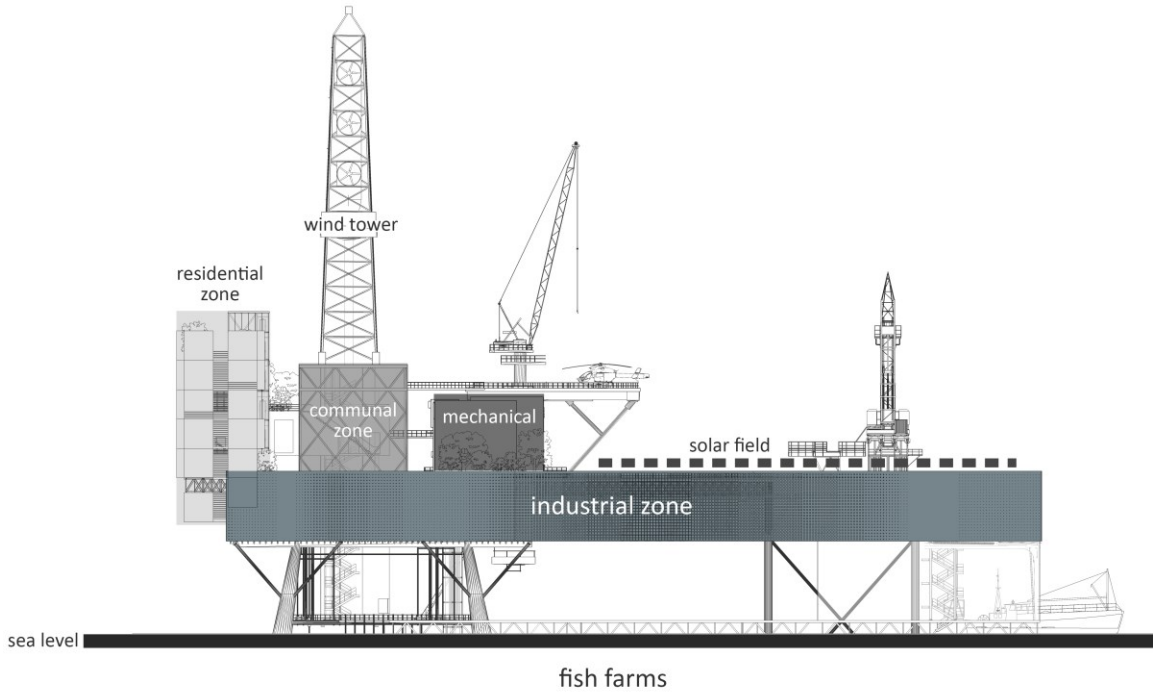


Figure 31 – Revived Platform

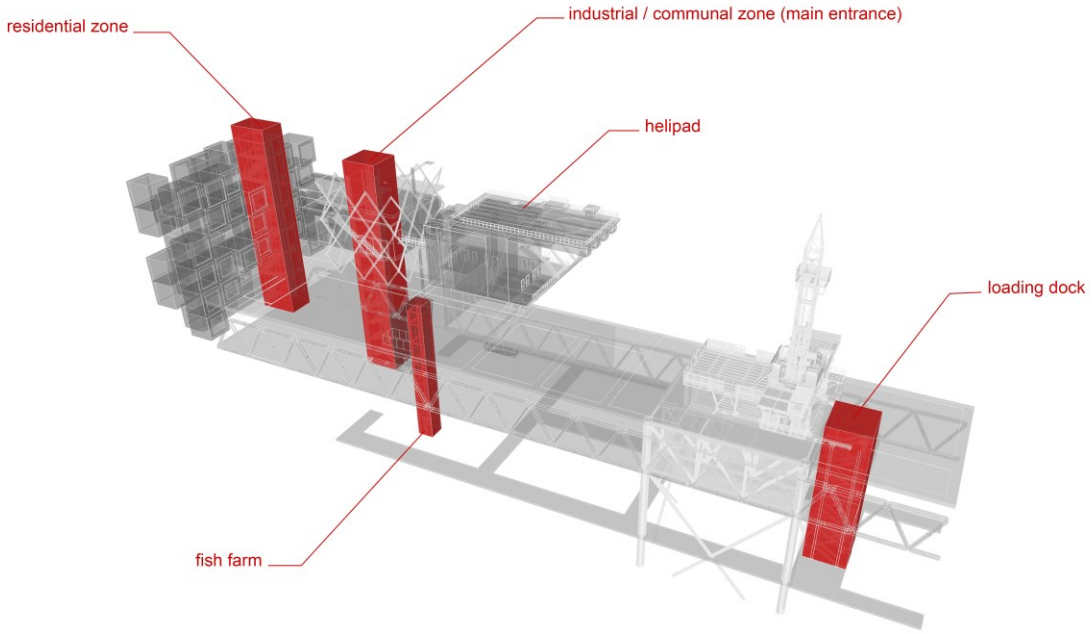


Figure 32 - vertical circulation

5.1.The Industrial Zone

In the new design the two platforms are connected by a bridge structure as wide as the smaller platform to create a 100 meters long industrial space for the caviar production line. This whole section will be dedicated to caviar production followed by research labs on the other end. The industrial zone is connected to the upper levels (residential and communal zones) through the main staircase underneath the former drilling tower.

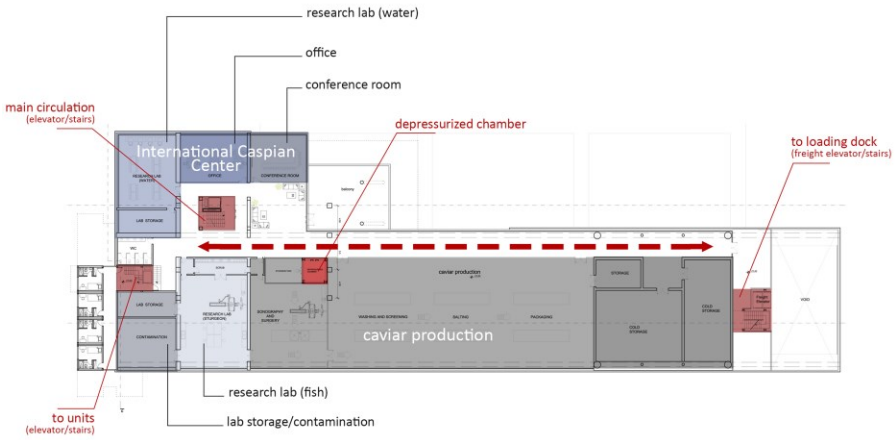


Figure 33 -industrial zone plan

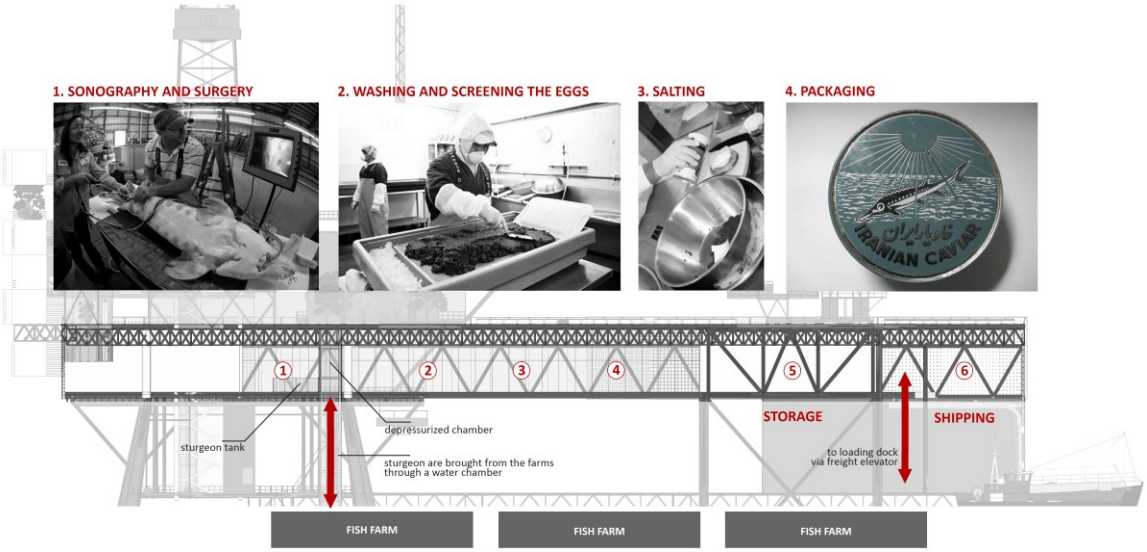


Figure 34 – caviar production line

The sturgeon will be brought up from the farm (sea level) using a depressurised chamber into a fish tank in on the first level. They will then be brought into sonography to be checked first and if ready will be moved to surgery for the hard-roe removal. The eggs

will then go through the screening (separation) process. The caviar is then salted for preservation and better taste. Finally they are canned and stored in a refrigerated storage.[65]

This whole industrial section is covered by an exterior ETFE (very light weighted material which won't add much load to the structure) skin. The square module on the skin is inspired by the skin texture of the fish which will provide openings for the translucent walls. Furthermore, this feature will add a sense of movement addressing the production of caviar and the waves of the sea.

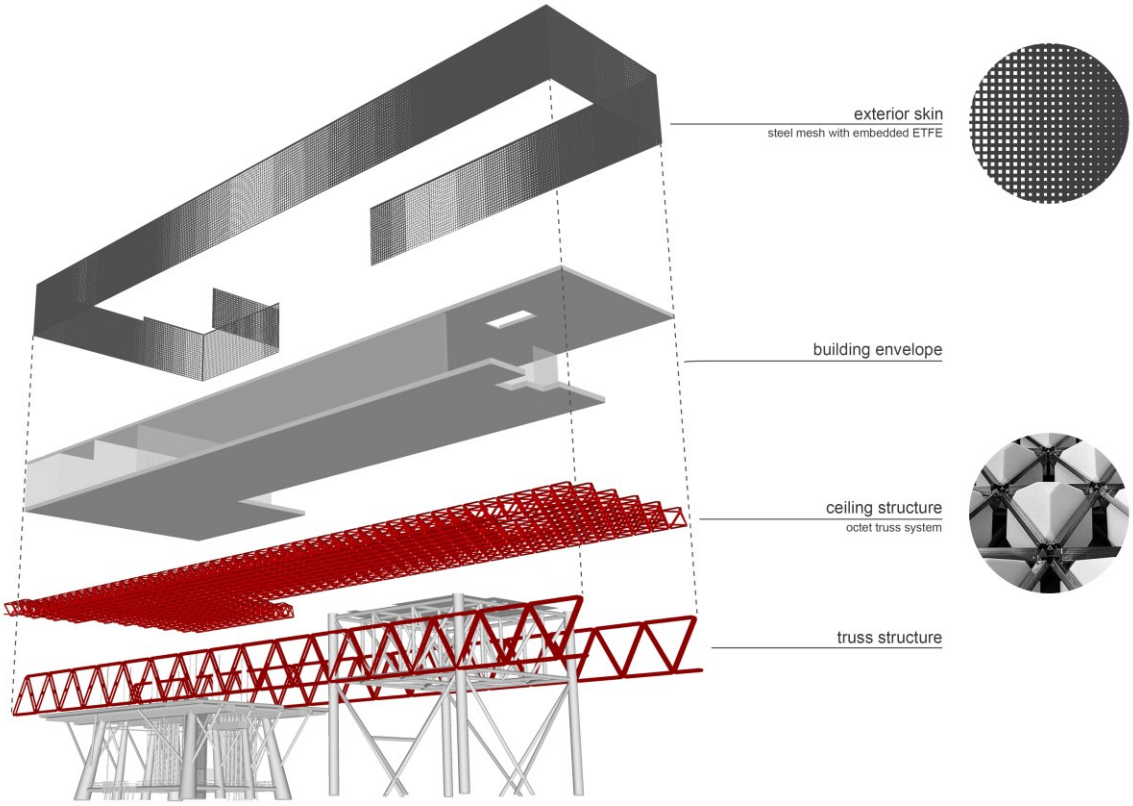
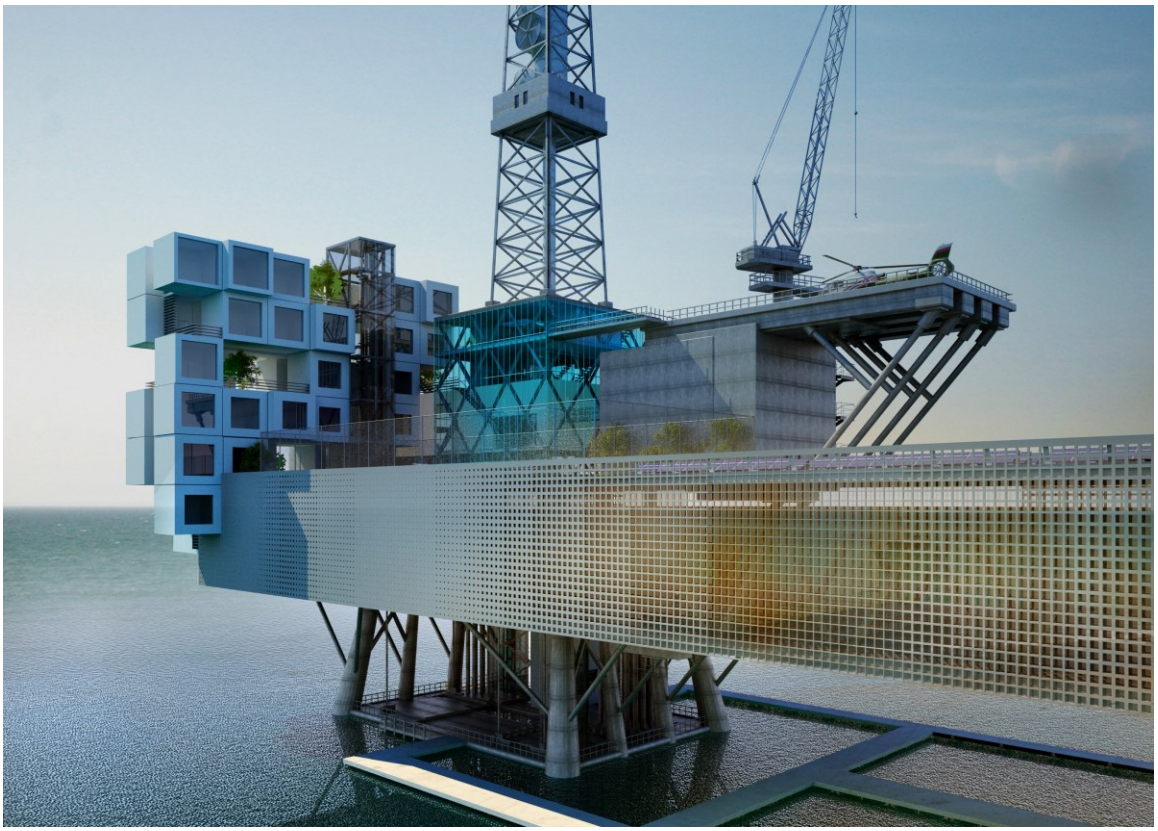


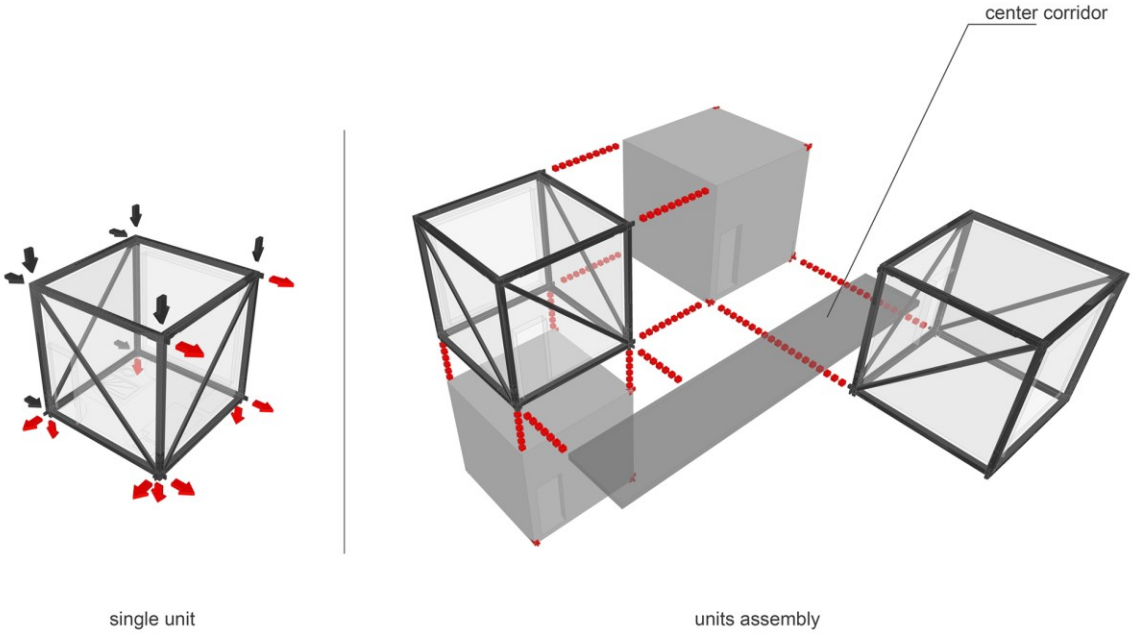
Figure 35 - industrial zone explode axo

[65] Zonn IS, Kosti̇anoï AG and Kosarev AN. The caspian sea encyclopedia. (Berlin; London: Springer; 2010.)



5.2.The Residential Zone

The living quarters is redefined as residential units to accommodate comfort for the on-site personnel. The residential units follow the same design as the modular technique used to construct and install the topside components of the platform. Each unit is pre-fabricated as a 4x4x4 meters module offshore and shipped to the site to be assembled. The preserved crane will place each unit into place where they are installed together to form a separate structure which will then connect to the truss system of the main industrial section.



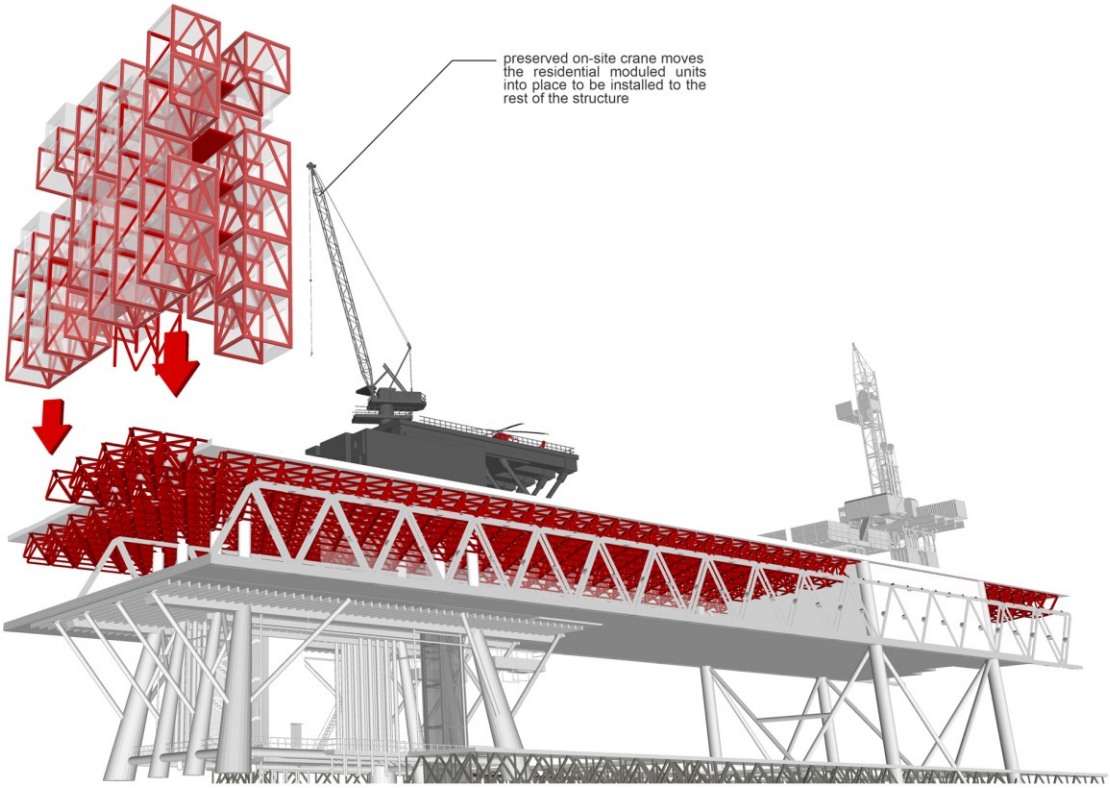


Figure 36 - modular units are stacked and assembled together and finally connect to the structure of the platform

Furthermore the openings on these modular units (operable windows) are designed to follow the same motive of the exterior skin which covers the industrial section. The area designated for windows on the units gradually shrink down and expand to create the same wave-like motion on the skin.

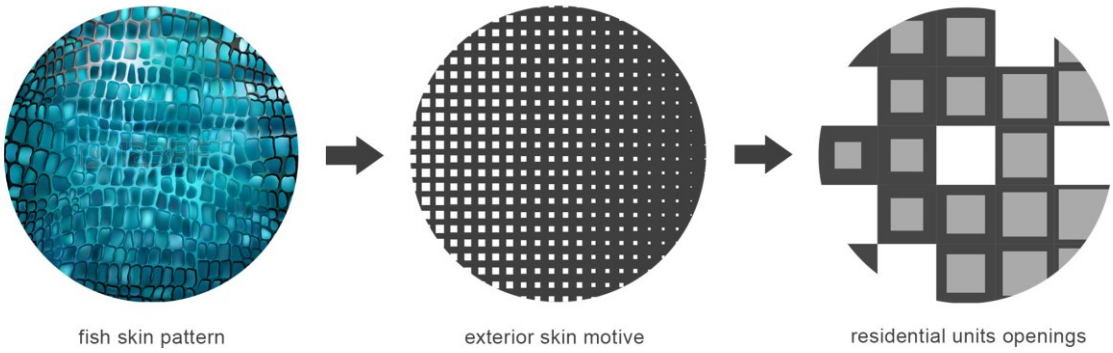


Figure 37 - exterior skin and residential units' façade design concept

5.3.The Communal Zone

The whole flat surface above the industrial zone is separated into two sections. The eastern side will provide the area needed for the solar panels while the western side - with proximity to the residential zone - is dedicated to landscaping to provide open-door activities for the on-site personnel (i.e. walking paths, seating areas, green spaces and a tennis court). The section underneath the existing drilling tower works as a central hub connecting all the different spaces (i.e. caviar production, research labs, residential units and mechanical rooms below the existing crane tower) of the project with each other and furthermore to the landscaping.

This central hub is in 4 levels. The first level is directly connected to the landscaping and the open area on top of the industrial section. The second floor is the cafeteria and lounge which is directly connected to the residential units and provides a communal area for the personnel to gather. This floor extends through a side stair to the roof garden located on the rooftop. The third floor is the monitoring station for the International Caspian Center

with a clear view of the sea. The upper floor is designated for the on-site medical unit which is closest to the helipad for emergencies.

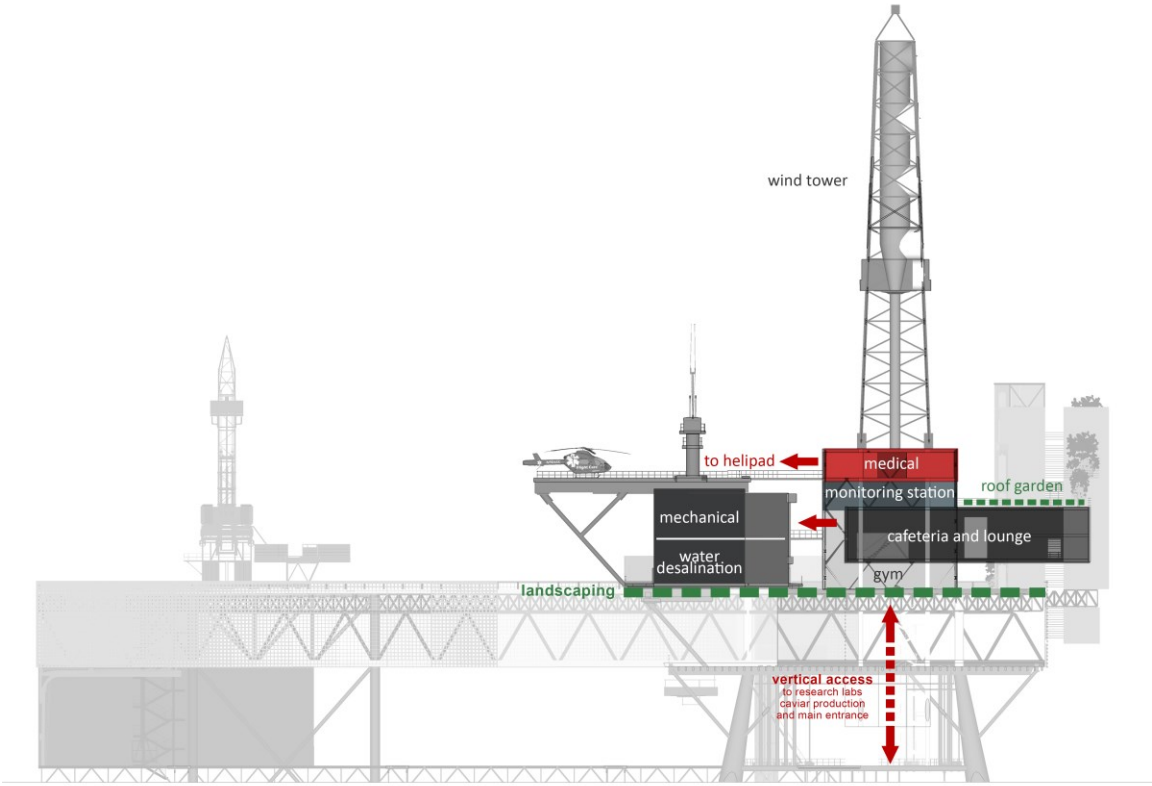


Figure 38 - the communal zone schematic section

5.4.Natural Ventilation, An adaptation of a vernacular architecture

As mentioned earlier the primary concept in redesigning the platform is to preserve the architectural archeology of the platform by keeping certain elements like the drilling tower and the crane. Moreover, it can be argued that the design approach follows the modernist "form follows function"[66] principle. Nevertheless, certain aspects of the platform's design have been inspired by the vernacular architecture of Iran's Northern Lowlands.

The boldest feature that addresses the vernacular architecture of Iran's Northern Lowlands region is the design of the residential units which is inspired by the unique architecture of Masouleh.[67] The historical context of Masouleh is comprised of more than

[66] Form follows function is a principle associated with modernist architecture and industrial design in the 20th century. The principle is that the shape of a building or object should be primarily based upon its intended function or purpose.

[67] Masouleh is a village located in a mountainous region, 55 km from the city of Rasht (coast of Caspian Sea) in Gilan province in Iran, with an altitude of 1050 meters from sea level. The whole village is an architectural masterpiece. Masooleh is definitely the most characteristic place in the Caspian Coast region. One of the most unique features of the village is that since the design of the urban texture is

350 residential units with an architecture that has adapted to the climatic and topographic conditions, creating a similar socio interior space in almost every unit.

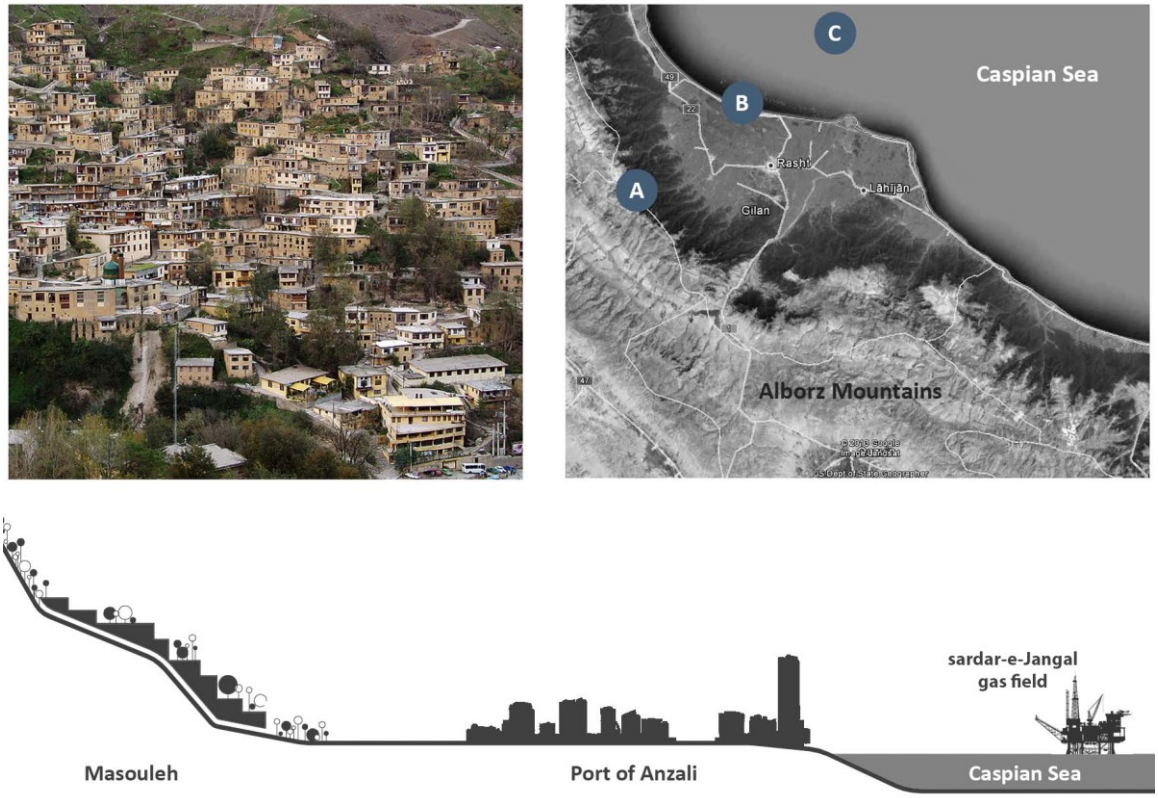


Figure 39 – A. Mashouleh B. Port of Anzali C. Srdar-e-Jangal gas field (location of the platform)

The most characteristic feature of the village is the adjacency of these units. This adjacency is considered in a way that will interlink the units together while arranging them along the topographic lines. Units vary from 1 story to 4 stories while more than 70 percent of them are built in 2 levels. The position of the units toward the sun, rain water drainage over the roofs and the adjacency of the buildings are the most important aspects in the design of each house in Maouleh which has been used in the design of the residential units in this project. The layout of the units places the access corridor in the center which ultimately provides an opportunity to use large windows and balconies on

completely consistent with the climatic and environmental conditions, there is no motor vehicle access in the whole village. Masooleh is not just a historical section of a modern city, but as a whole, is part of the history and culture of the region (Ashkevary 1993)

the exterior walls on each side. The use of these large openings in the residential zone addresses the extroverted architecture of the village.

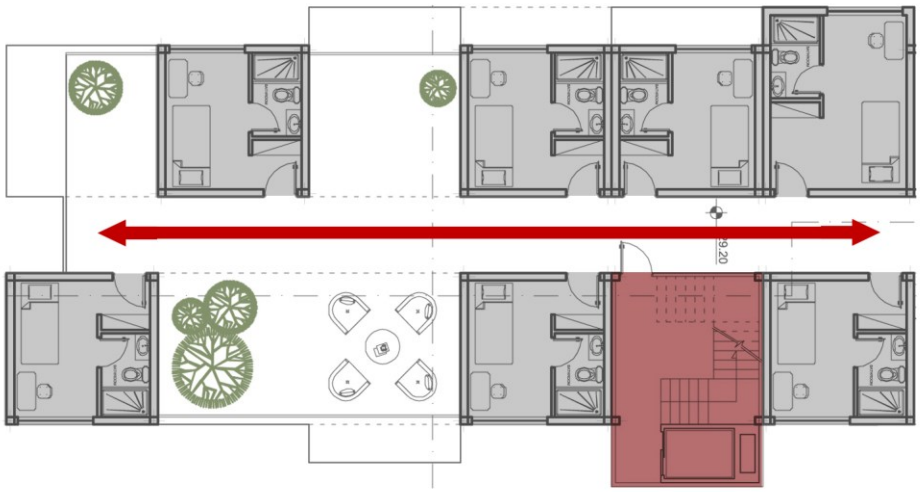


Figure 40 - residential units layout

Furthermore, Taking advantage of the humidity in the summer season the units are designed in a stepped manner in Masouleh. The roof of each unit is the courtyard for the upper one. This kind of extroverted architecture is the best morphology for such humid subtropical climates which uses wind flow and natural ventilation to balance the environmental conditions. [68]

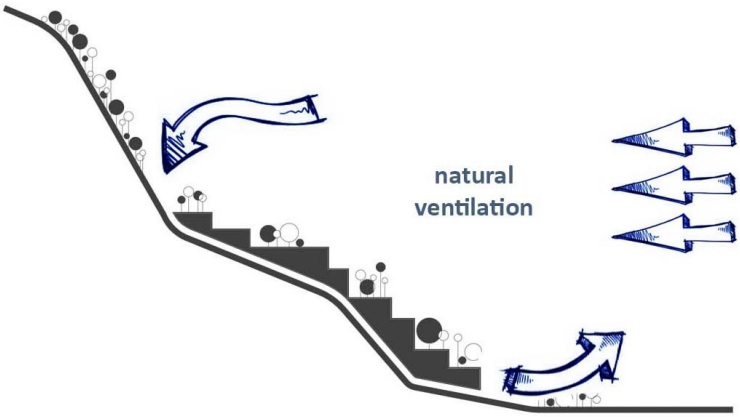


Figure 41 - Masouleh's natural ventilation

[68] Hamidi, Saeed Architecture of Masouleh (Journal of Architecture and Urban Planning, Volume 105, April 2012)

The modular design of the residential units on the revived platform provides the opportunity for architecture to respond to the climate conditions of the region. The same notion is used in the arrangement of the units. Removing a handful of units creates negative spaces which will allow air flow in between the residential quarters creating a natural ventilation sequence.

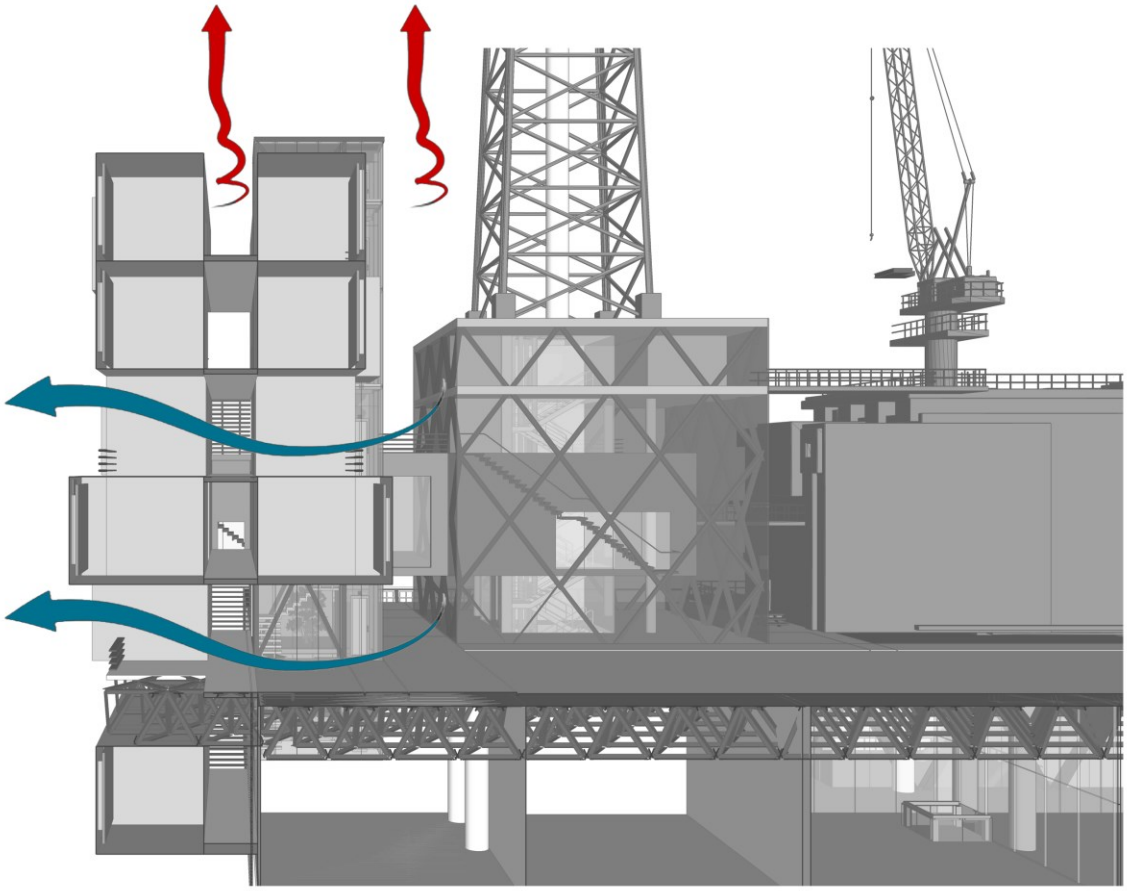


Figure 42 - residential units extroverted design enables air circulation and natural ventilation

Moreover, a combination of operable windows and shading screens adjust the amount of sunlight penetrating the units through the large openings during cold and warm seasons. The shading screens are made of “Hasir” (حصیر), a local mat-weaved material (from wheat and rice plant) used in various hand-made souvenirs in Iran’s northern region. (Hasir has a high tolerance for humidity and can be transformed into various shapes.)

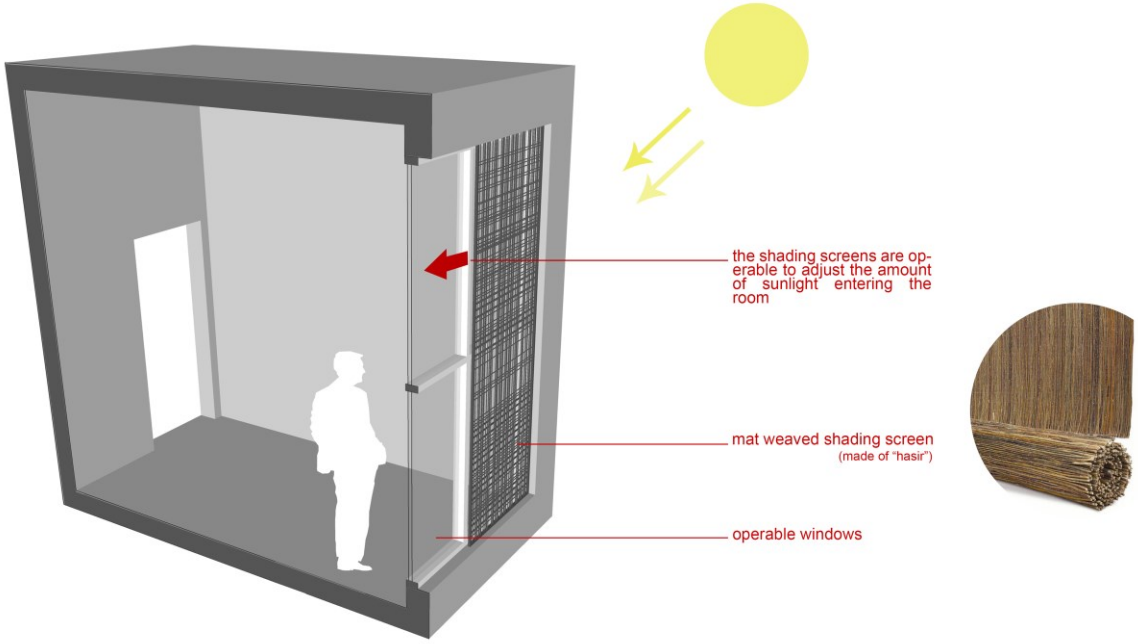


Figure 43 - residential unit section cut

The rest of the project is designed with a double-skin profile. The communal zone has an exterior ETFE[69] skin which can reduce heating up to 50 percent blocking sun's radiation during the day. The drilling tower is converted to a wind tower which provides fresh air for the interior spaces. Moreover, the operable windows and revolving ETFE panels are opened during the night to provide night flush ventilation for the whole building.

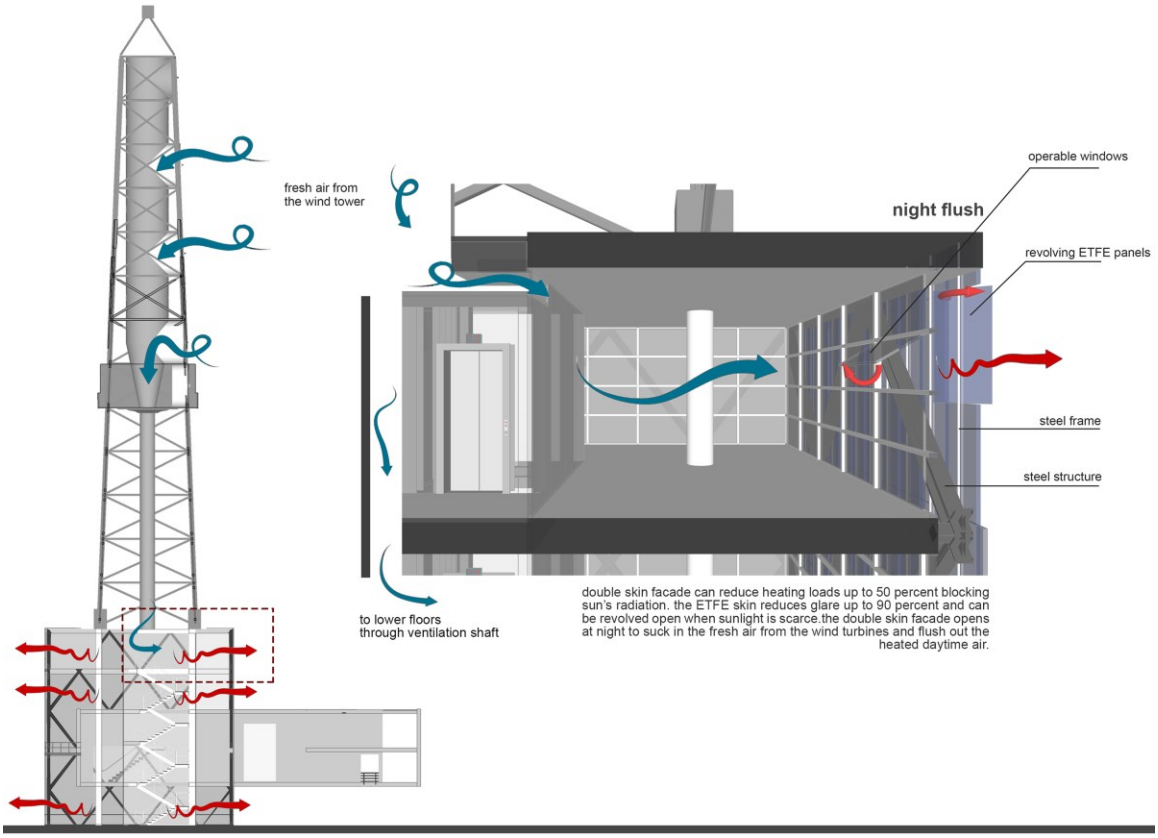


Figure 44 - the communal zone natural ventilation

[69] ETFE, a fluorine based plastic, was designed to have high corrosion resistance and strength over a wide temperature range. ETFE is a polymer and its source-based name is poly(ethene-co-tetrafluoroethene). ETFE has a relatively high melting temperature, excellent chemical, electrical and high energy radiation resistance properties.

The industrial zone is designed as a double skin façade as well which enables summer/winter ventilation throughout the year. The trapped air between the two skins provides isolation for the interior spaces during the cold months while the open hatches create natural ventilation during the warm months.

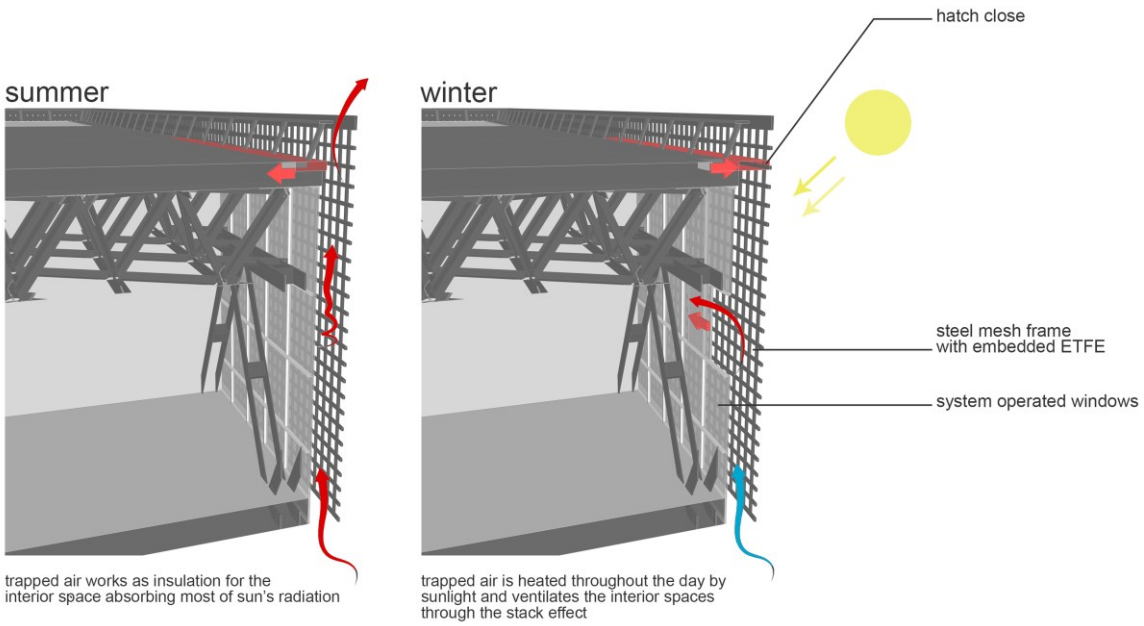


Figure 45 - the industrial zone natural ventilation

5.5.The Aquatic City, A self sustaining structure at sea

Since the offshore platform is remote form the nearest connection point to the national (or regional) power grid and oil is already out of the picture, the new design needs to be self-sustaining. The first and most important issue in making this facility self-sustaining is the matter of drinkable water for the personnel. Hence, the Caspian's salt water needs to be desalinated. As of today the most conventional salt-water desalination method is the Reverse Osmosis (RO) technology. Reverse osmosis is the most advanced filtration technology. The RO membrane acts as a barrier to all dissolved salts and inorganic molecules. Water molecules, on the other hand, pass freely through the membrane creating a purified water product.[70] The capacity of the RO unit is decided by the number of people it services. As in this case there are 50 personnel on site, the RO unit will be designed for the desalination of 10 cubic meters per day of sea water and continuous

[70] Cipollina, Andrea, Giorgio Micale, and Lucio Rizzuti. Seawater Desalination: Conventional and Renewable Energy Processes (Green Energy and Technology). (Springer-Verlag, 2009.)

power supply. This would be sufficient at most remote sites to supply about 200 people and has been selected for this facility due to the large area footage.[71]

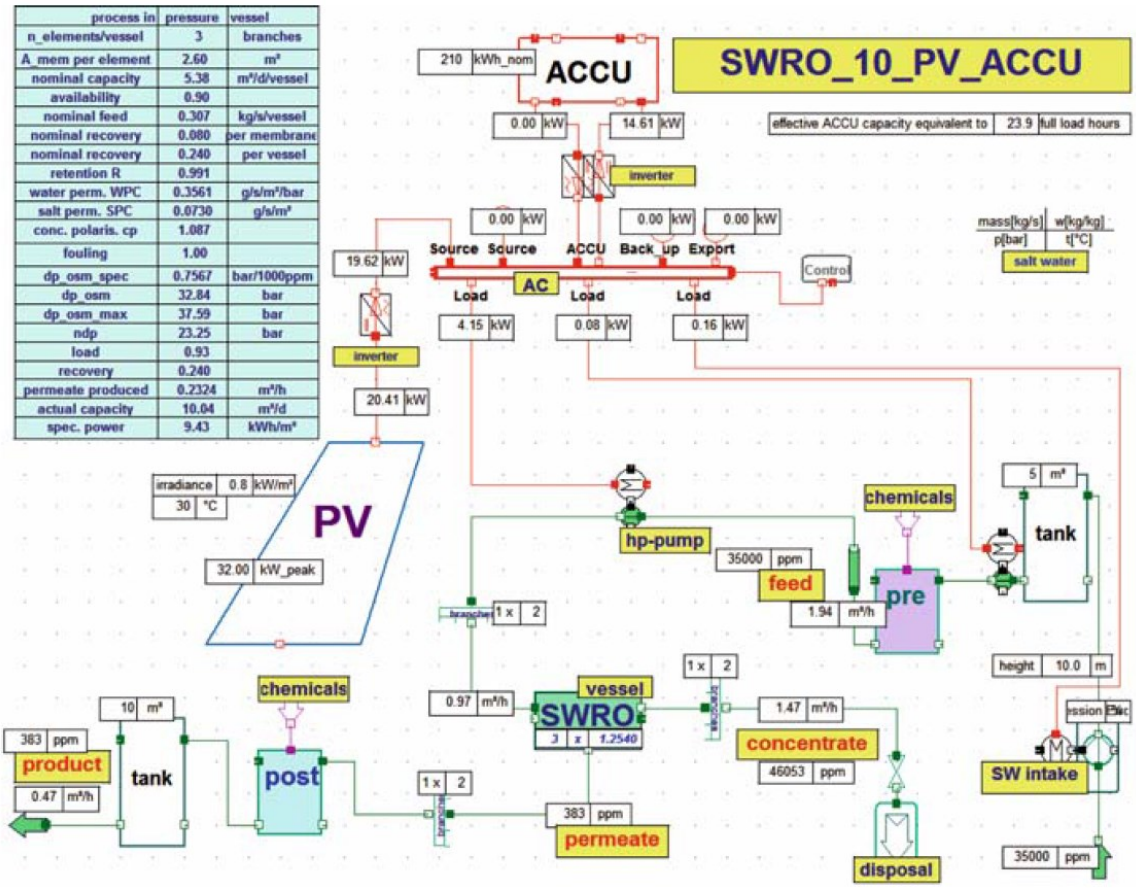


Figure 46 - Schematic of a 10 m3/day sea water reverse osmosis powered by PV

As this unit is the most energy consuming feature of the facility it needs 300 square meters of photovoltaic (PV) modules surface.[72] The plain surface above the industrial section (1000 square meters) along with the rooftop of the residential units and the central communal building (400 square meters) are designated for PV solar cells. The rest of the solar cells on these designated surfaces will be used to fuel electricity for the rest of the facilities. According to the data acquired from Iran's Ministry of Energy online information website each Iranian household consumes an average of 18.1kWh electrical

[71] Rizzuti L, Micale G, Cipollina A. Seawater desalination: Conventional and renewable energy processes. (New York; Heidelberg: Springer; 2009)
[72] Rizzuti L, Micale G, Cipollina A. Seawater desalination: Conventional and renewable energy processes. (New York; Heidelberg: Springer; 2009)

energy per year (as of 2013).[73] As the average household size in Iran is four (parents and two kids) and considering the daily working hours each person consumes an average of 6.01 kWh electrical energy per year. Hence, the average PV cells required for each person is 12.5 square meters. (PV cells produce an average of 120 Wh energy.)[74] Putting all the data together the estimated PV sells required for the revived platform will be 800 square meters.

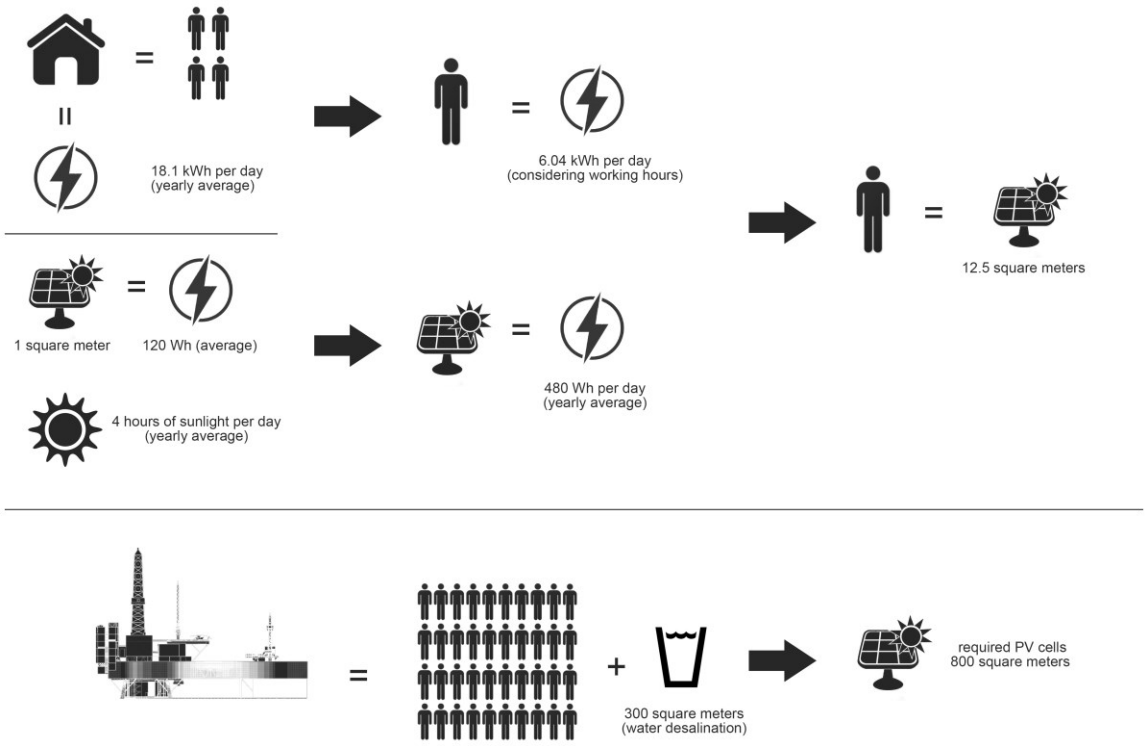


Figure 47 - energy consumption analysis / required PV cells estimate

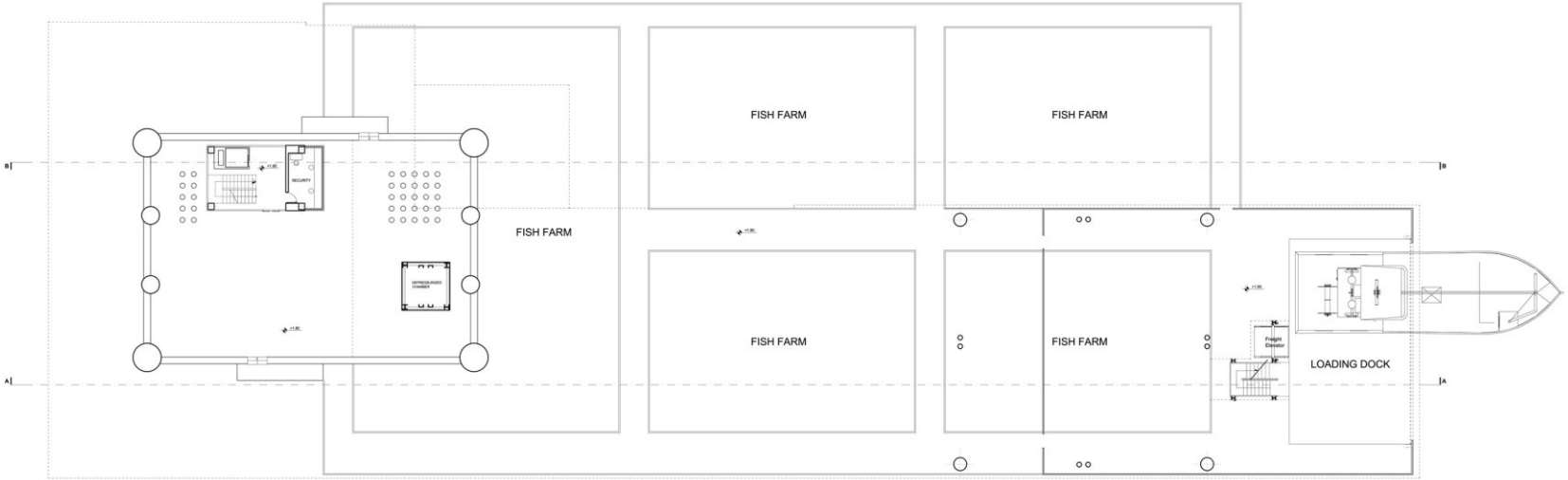
[73] New Sources of Energy, Iran's Ministry of Energy online informative website, (Accessed November 2014) http://news.moe.gov.ir/default.aspx?lang=fa-IR

[74] Jordan, Richard C. and Liu, Benjamin Y. H. A Rational Procedure for Predecting The Long-Term Average Performance of Flat-Plate Solar-Energy Collectors (Minnesota: University of Minnesota, 1963)

As discussed before, under present circumstances the only solution to revive Iran's economy is the resistive economy which essentially means to explore other possibilities and try to shift the economy in another direction by making new job opportunities. Hence, this thesis has tried to provide an alternative self-sustaining (both economically and energy-wise) solution to address both Iran's economic situation and the Caspian Sea's environmental problem. Ultimately, the same concept can be studied in the rest of the Caspian countries and applied with a different economic approach (due to each country's economic situation and resources) to other abandoned offshore petroleum platforms to create a chain of monitoring stations all over the Caspian Sea and help save the Caspian's unique eco-system.

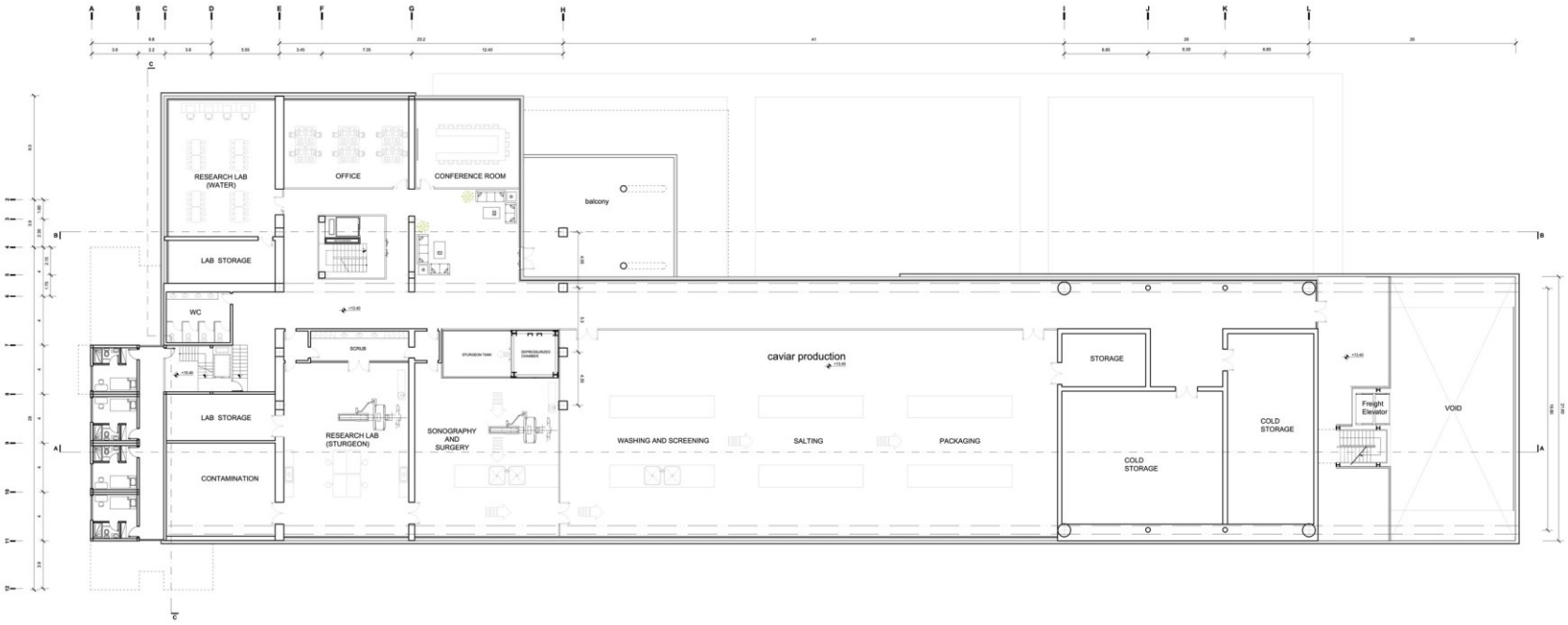
Figure 48 - The Aquatic City; A self-sustaining structure at the Caspian Sea

6. Architectural Drawings



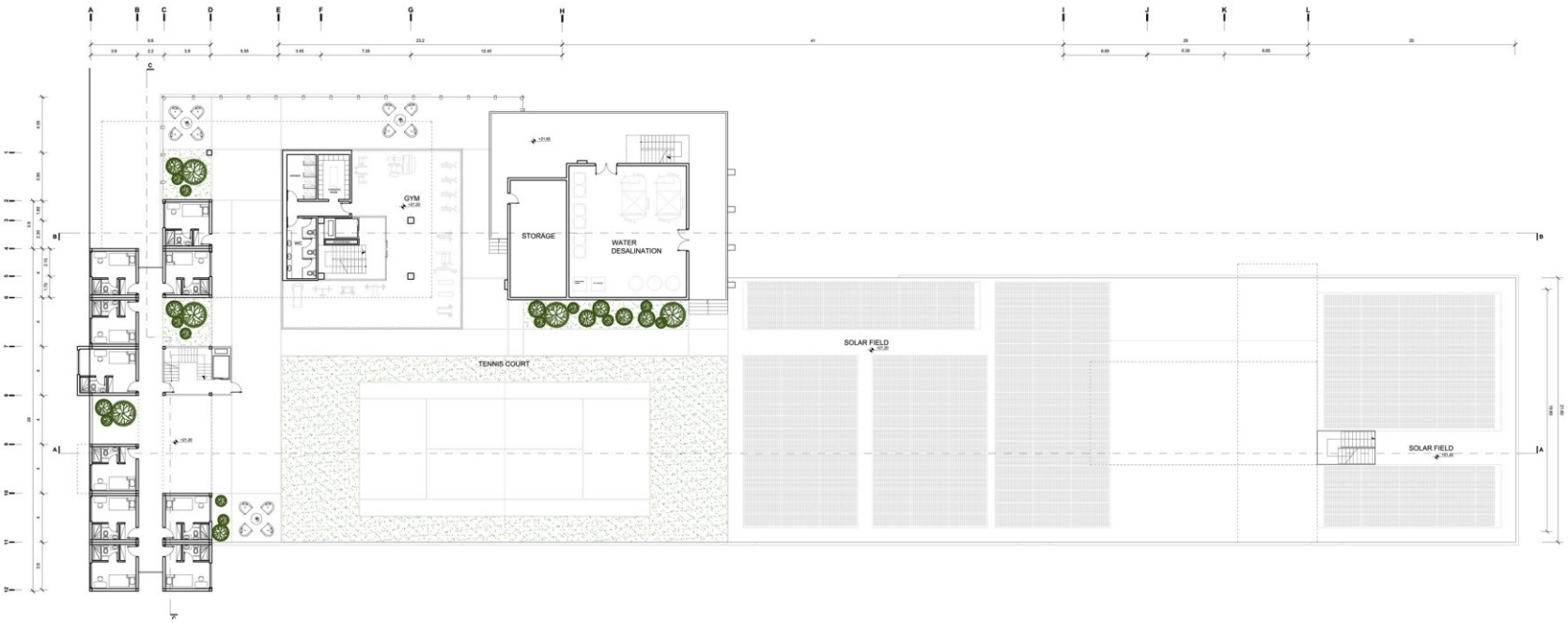
SEA LEVEL PLAN

SCALE 1:200 @+1.80



FIRST FLOOR PLAN

SCALE 1:200 @+13.40



SECOND FLOOR PLAN

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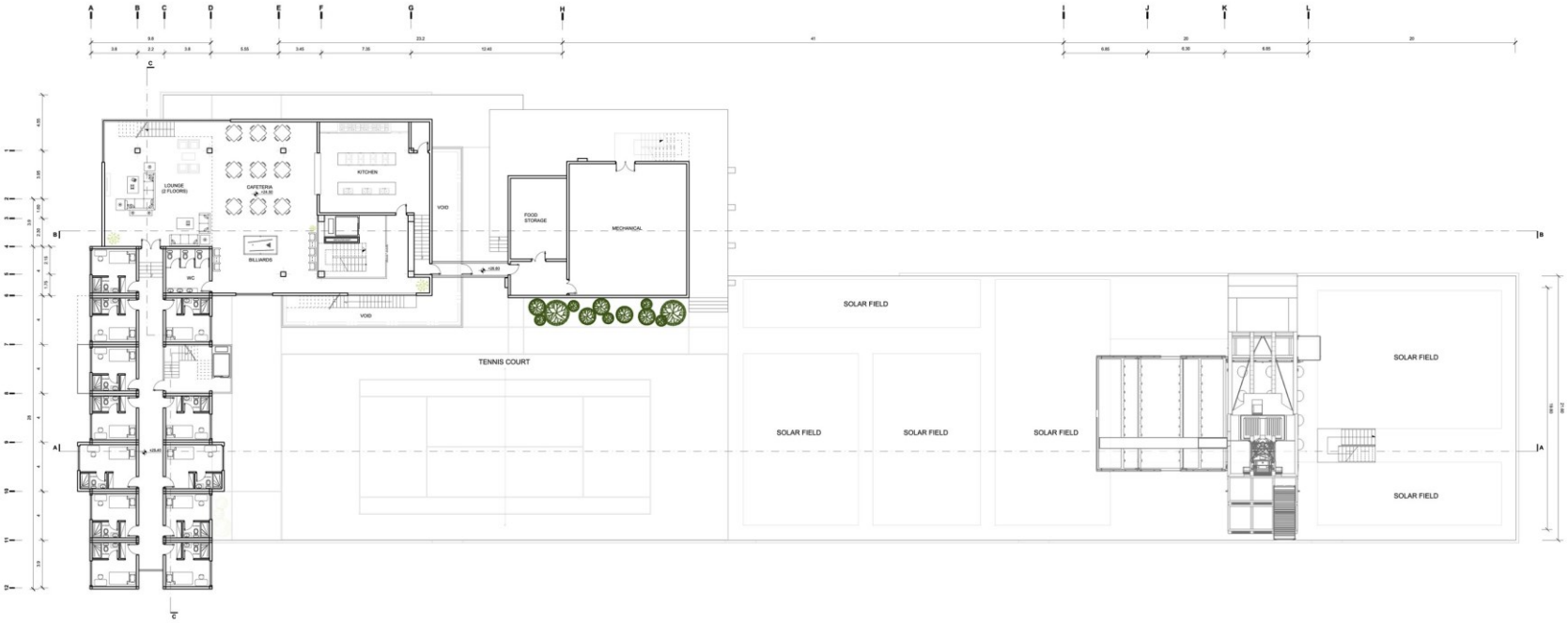
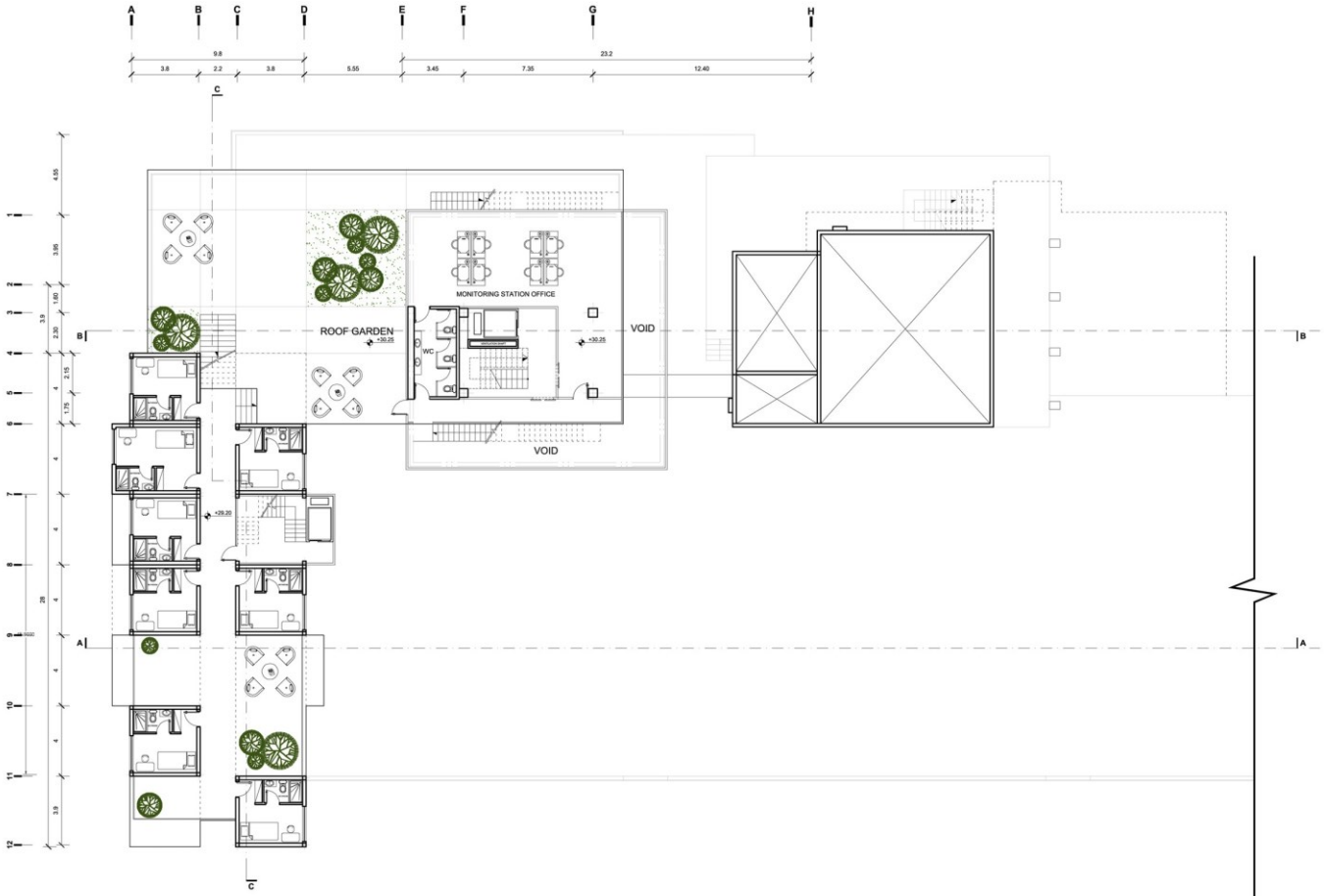


THIRD FLOOR PLAN

SCALE 1:200 @+24.50

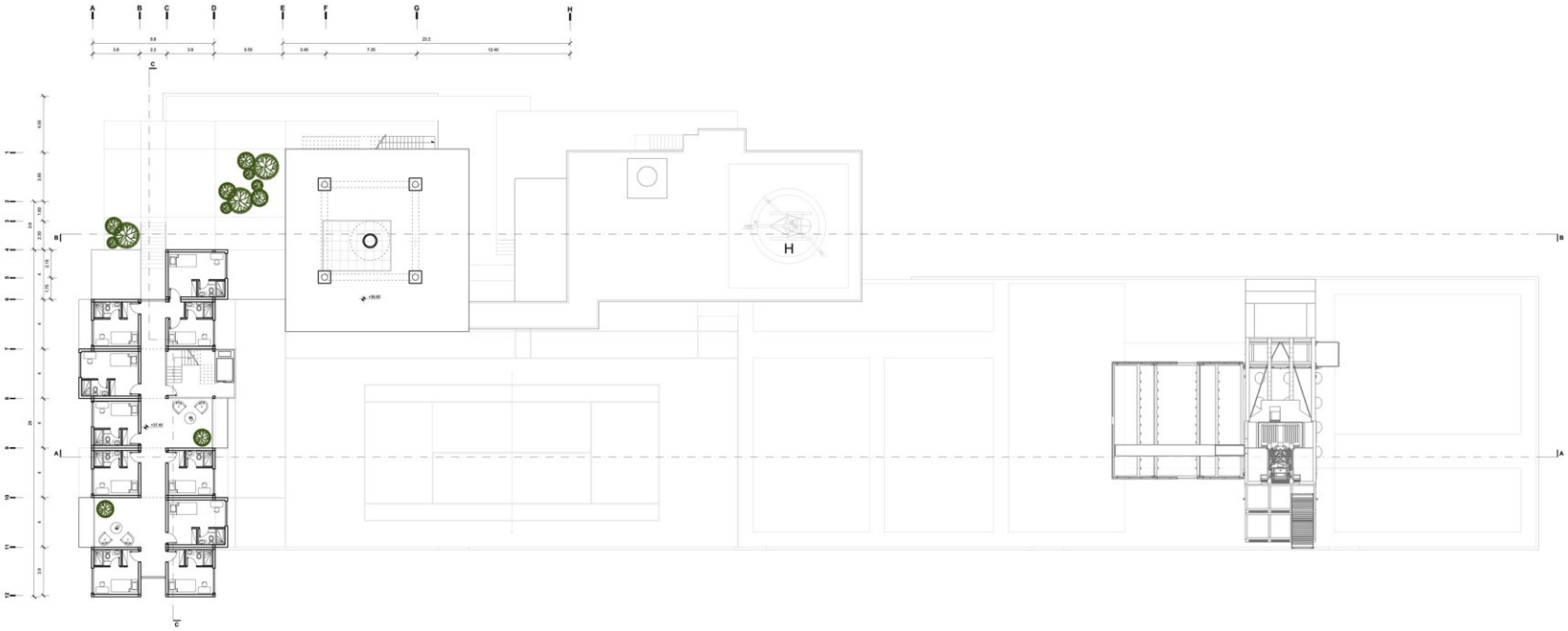


FOURTH FLOOR PLAN

SCALE 1:200 @+30.25

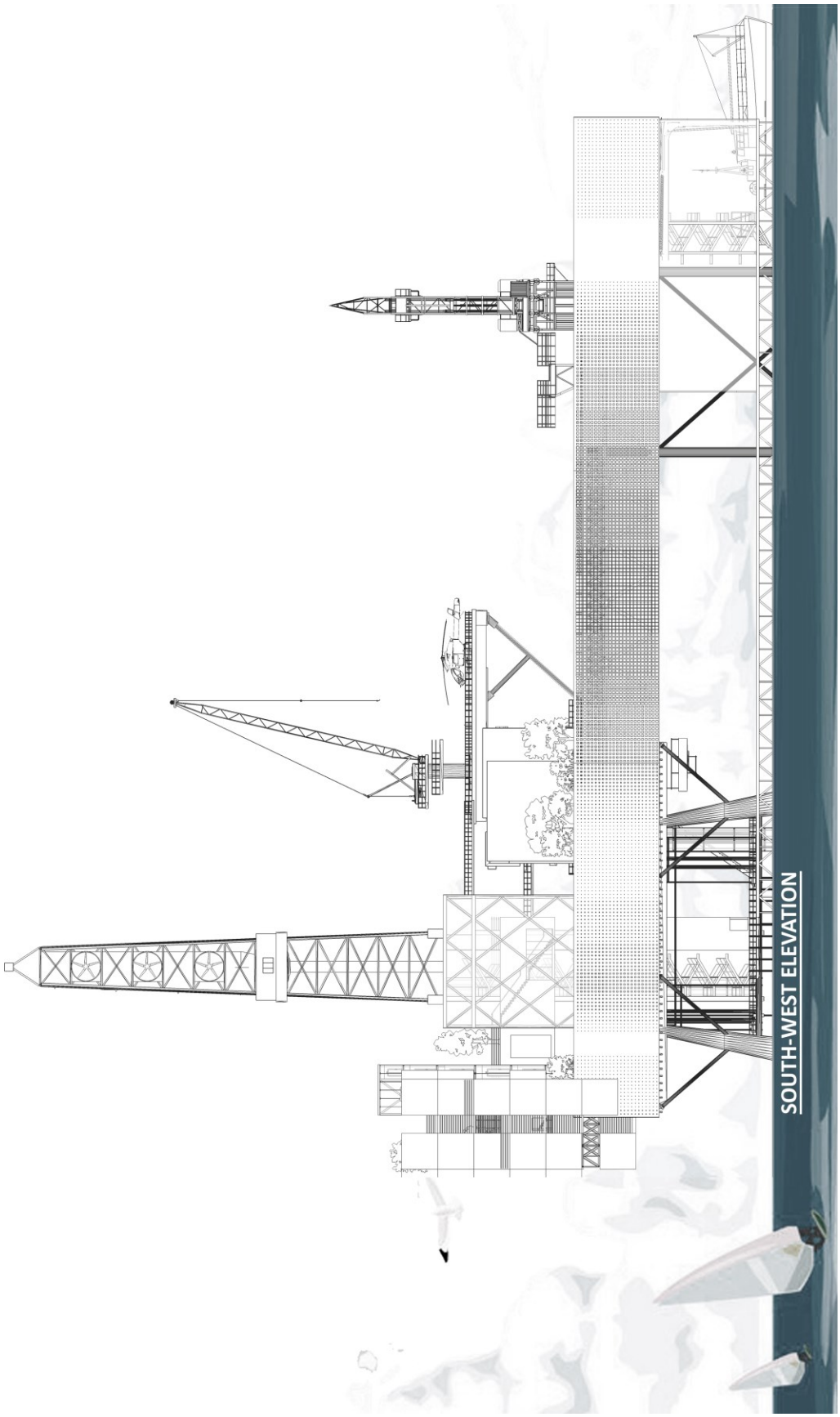
FIFTH FLOOR PLAN

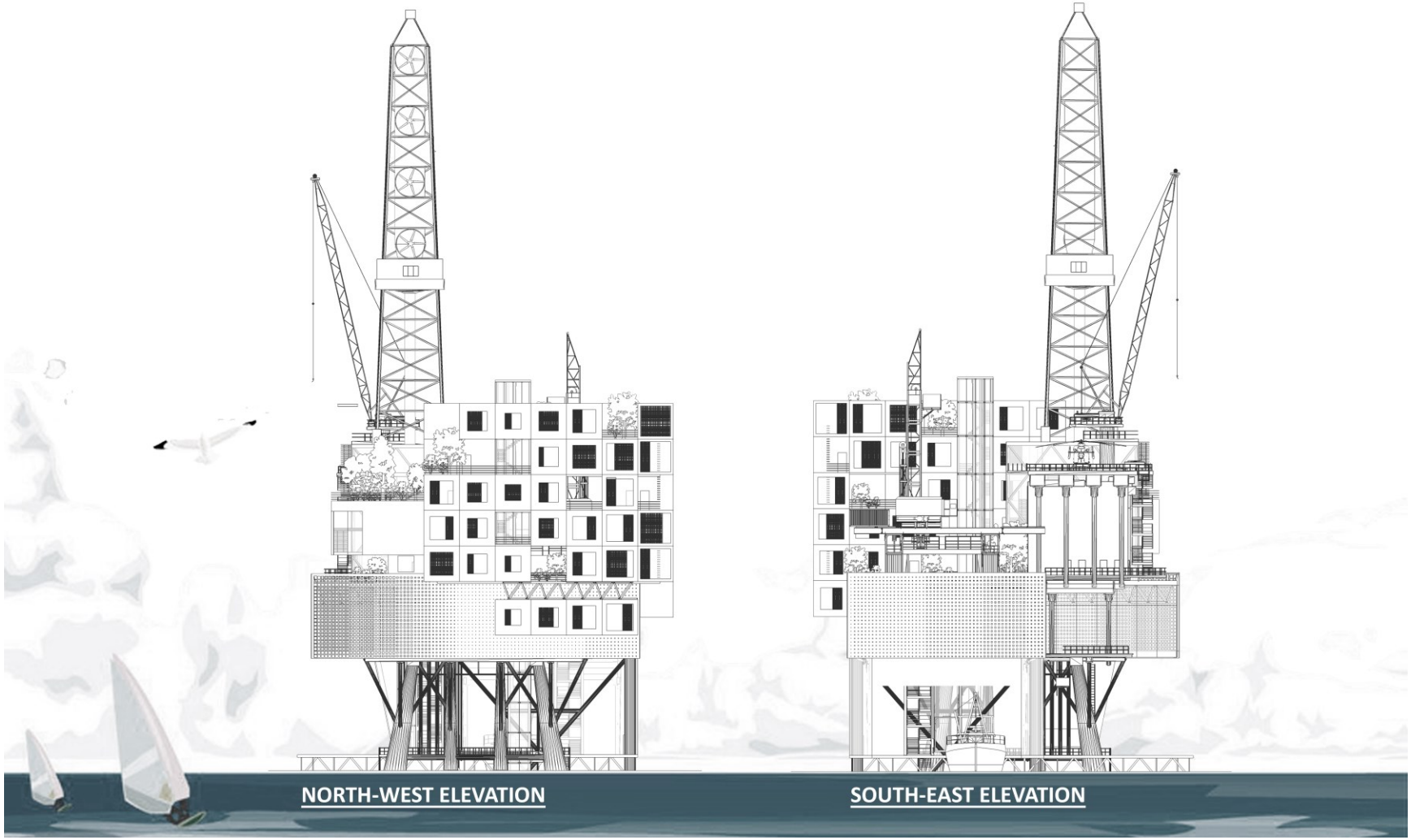
SCALE 1:200 @+33.40



SIXTH FLOOR PLAN

SCALE 1:200 @+37.40


SOUTH-WEST ELEVATION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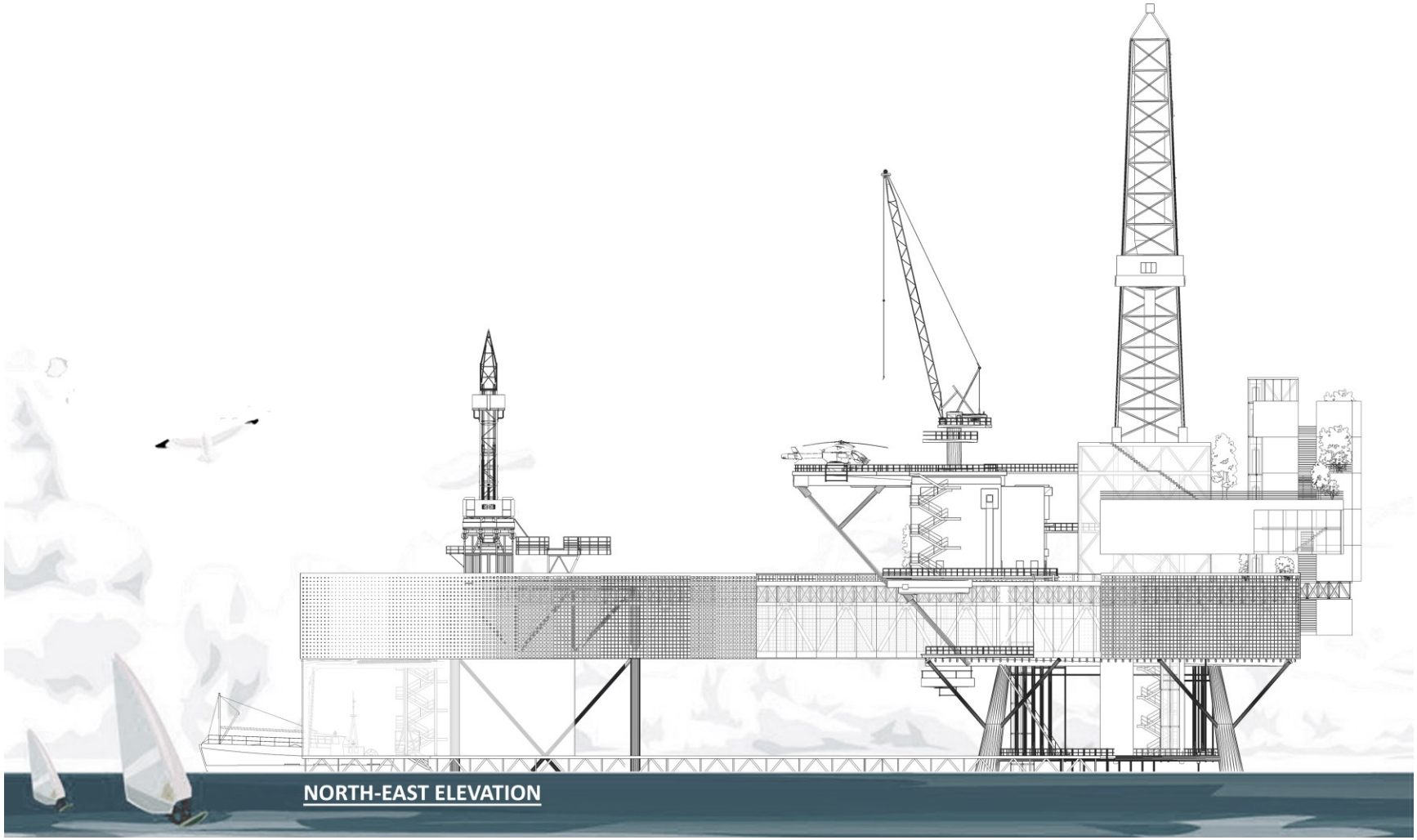
SOUTH-EAST ELEVATION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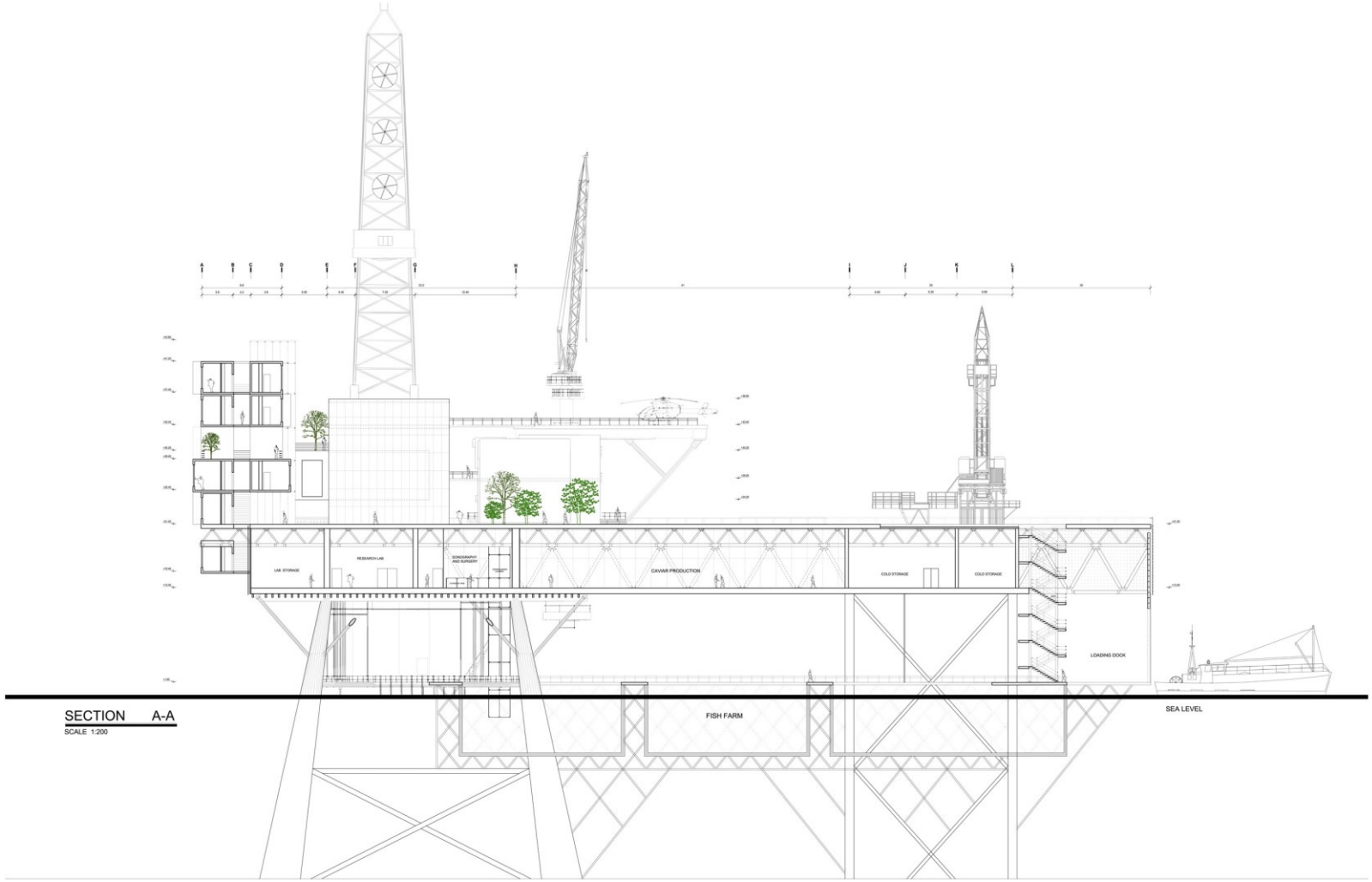

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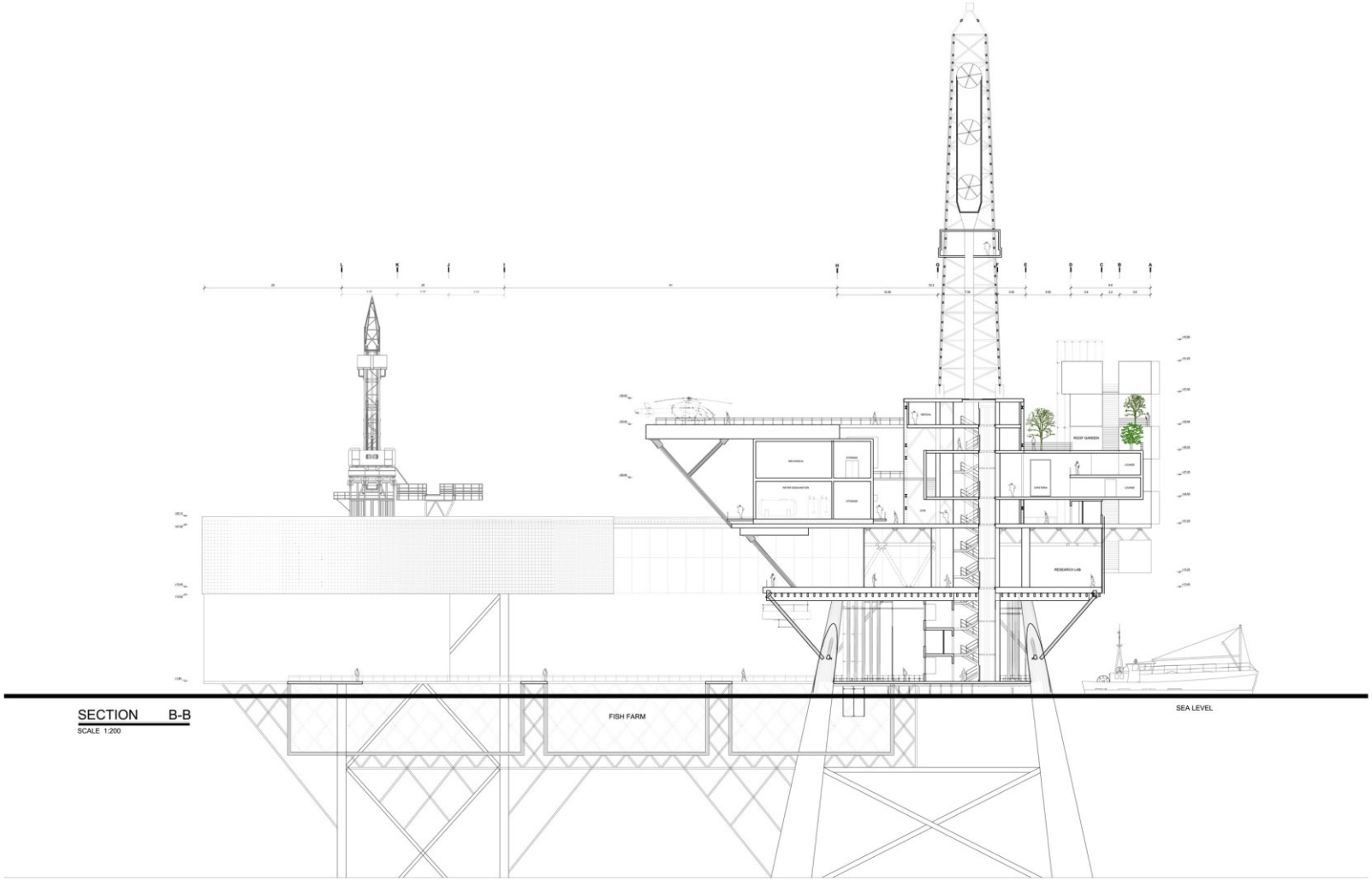
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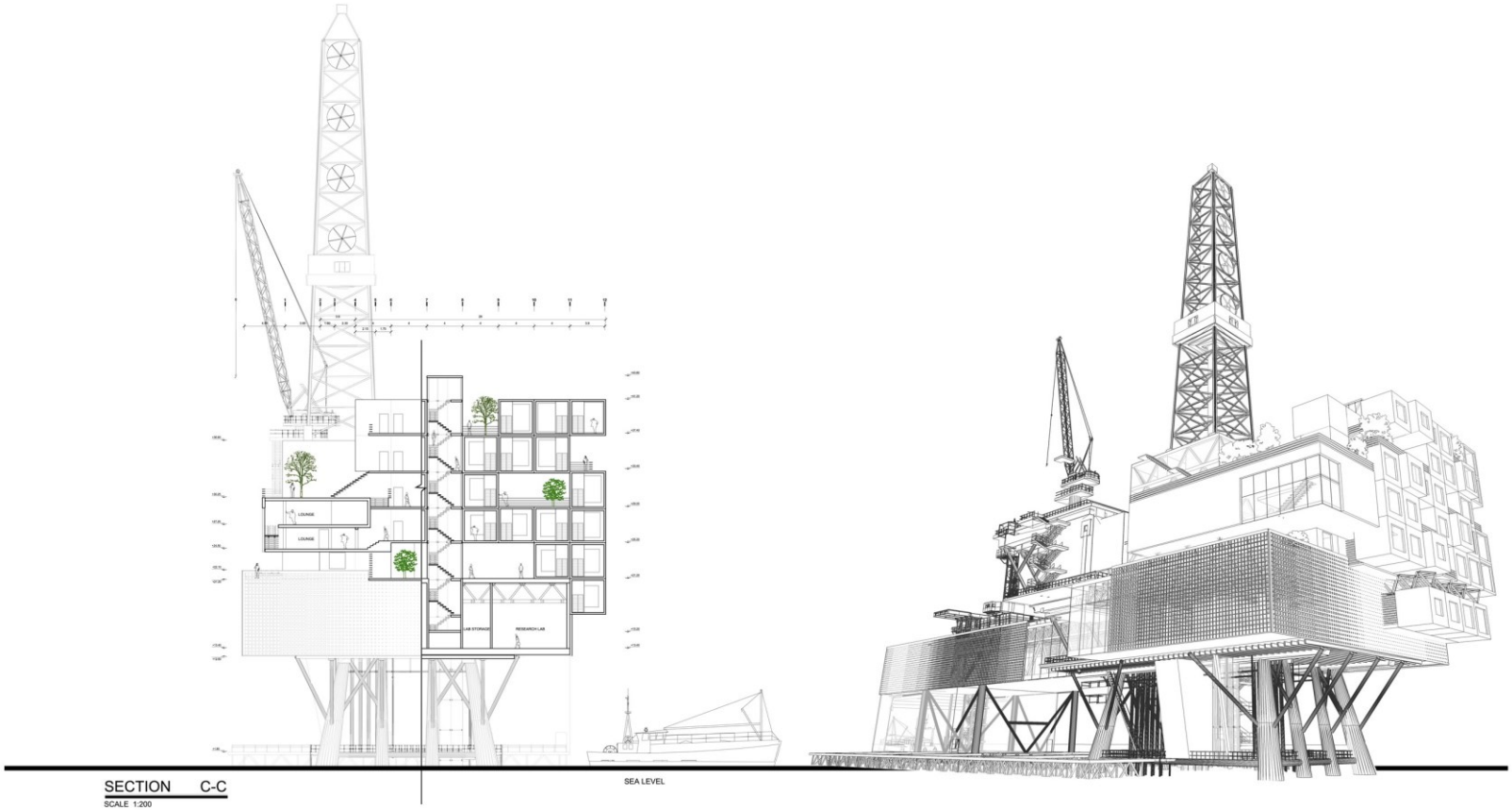
LOUNGE
CANTEEN
RESEARCH LAB



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