Federal Ministry of Education and Research
FONA Forschung für Nachhaltigkeit

Options for Delivering
Ecosystem-based Marine Management

ODEMM

HUMBOLDT TIPPING

FRAMEWORK

Universität Hamburg DER FORSCHUNG | DER LEHRE | DER BILDUNG
CAU Kiel University Christian-Albrechts-Universität zu Kiel
University of Bremen
ZMT LEIBNIZ CENTRE for Tropical Marine Research
GEOMAR
IMARPE INSTITUTO DEL MAR DEL PERÚ
PUCP

CONTENT

The Humboldt Tipping Project

The Humboldt Tipping project, with an interdisciplinary consortium of scientists from Germany and Peru, is focussed on understanding the risks posed by global change to the Humboldt Upwelling System and exploring potential adaptation options. In our second phase, we aim to integrate the insights gained from the first phase into a comprehensive analysis of future scenarios under the Shared Socioeconomic Pathways (SSPs). This will help us to offer useful information for global climate change research and policy considerations.

To achieve this, we will engage closely with stakeholders: with those who know the Humboldt Upwelling System best.

Our central questions are:

1. What are the direct impacts on artisanal fishery communities?
2. What are the impacts on the industrial fleet?
3. How will the projected changes impact the local and global markets?
4. What kind of policy measures can ensure a sustainable use of the natural resources?

For more information visit:

https://humboldt-tipping.org

INTRODUCTION

Even for populations living far from the coast, the marine ecosystems play a critical role in every aspect of human life, by delivering multiple ecosystem services such as food production, climate regulation, participation in the nutrient cycle, and serving as a means of transport. In consequence, several marine ecosystems are among the most highly impacted on Earth by human activities. Additionally, the repercussions of climate change accelerate the degradation of marine ecosystems around the world.

This situation urged the creation of global legislation to attain sustainable management of the marine system and the preservation of ecosystem services.

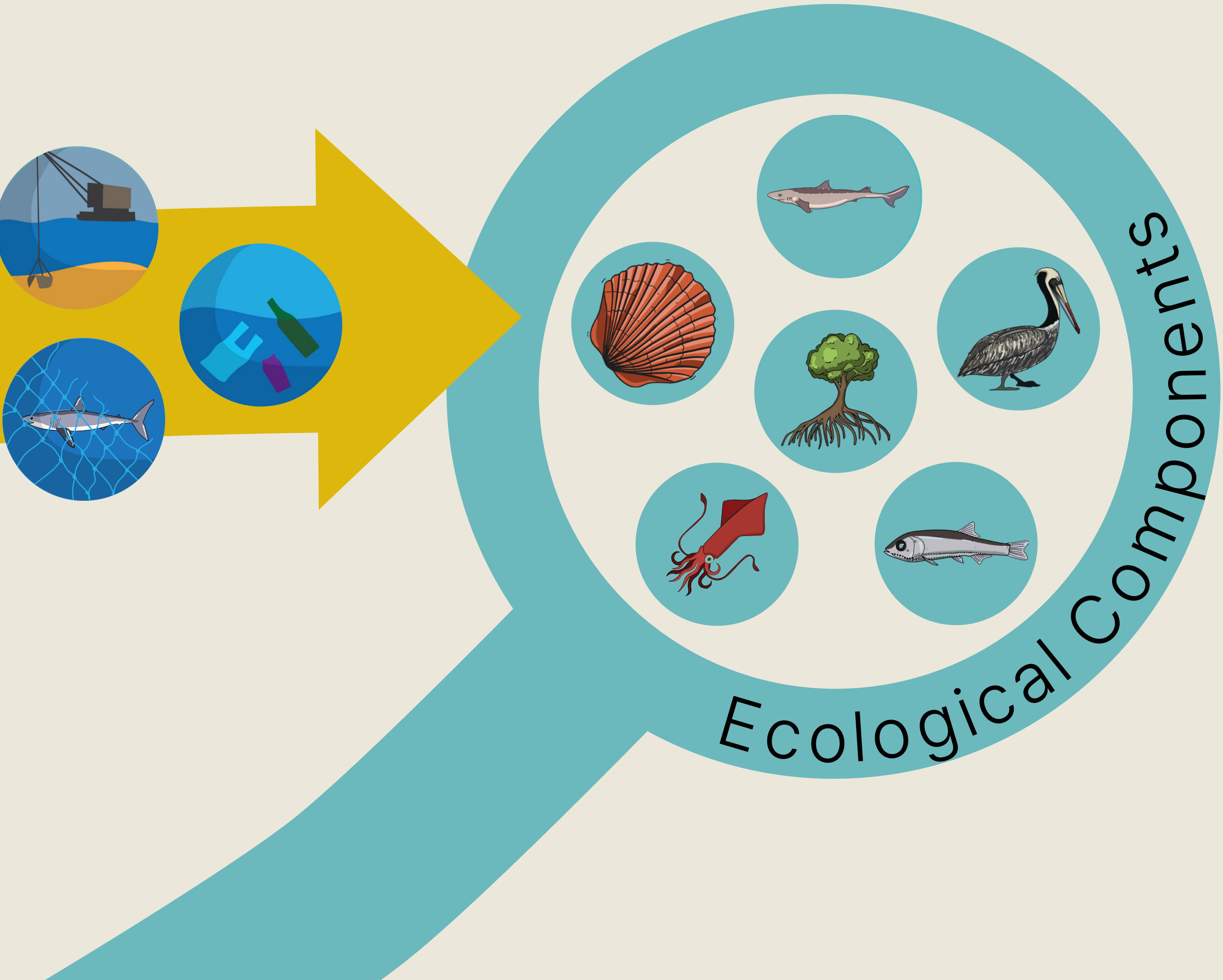
Hence, the 2030 Agenda for Sustainable Development includes, among its 17 goals, a goal to "**Conserve and sustainably use the oceans, seas, and marine resources for sustainable development**". Achieving this goal requires considering the whole suite of anthropogenic pressures affecting marine ecosystems. Yet the common perception is that fisheries are one of the biggest pressures on marine ecosystems in terms of magnitude and extension, although there are multiple other pressures that are less considered and should be tested to reduce the risk of pressures in marine ecosystems.

One way to test the anthropogenic pressures exerted by different sectors is to conduct **Integrated Ecosystem Assessments (IEA)**. IEAs propose ecosystem-based management based on a general view of coexisting pressures from identified sectors over ecosystem components. Hence, a key element of IEAs is the risk assessment of pressures on ecosystem components' susceptibility and resilience post-pressures. Among IEAs, there is a wide range of methodologies that can be classified as qualitative (based on expert references), quantitative assessments (based on monitoring and assessment of ecosystem indicators), and a mix of both. Qualitative and quantitative types of IEAs are complementary and after a qualitative IEA could be a quantitative being implemented for a selected number of indicators.

In the framework of the Humboldt Tipping project, we propose to use a qualitative approach to identify and assess the risk of multiple marine ecosystems that allows providing **Options for Delivering Ecosystem-based Marine Management (ODEMM).**

The ODEMM framework

HUMBOLDT
TIPPING



The ODEMM framework is a flexible tool that can be tailored to the characteristics of particular ecosystems and has integrated several requirements of legislative policy such as the Marine Strategy Framework Directive (MSFD; European Union, 2008), Common Fisheries Policy (CFP; European Union, 2013), and the Maritime Spatial Planning Directive (MSPD; European Union, 2014).

The main concept of ODEMM is the tracking of the **pressures** between multiple **activities** and the marine environment composed of **ecological components**, to provide a structure within which management options can be explored (Robinson et al., 2014). The ecological components are also linked with ecosystem services that are previously fixed using the reference of ODEMM typology (Böhnke-Henrichs et al., 2013).

Content Overview

Methodology

The methodology of ODEMM consists, as a first step, in the mapping of sectors-pressures-ecological components. This mapping will be carried out in 2 stages:

1. First, a pilot mapping of sectors-pressures-ecological components should be conducted among experts by means of an electronic survey.
2. During a second stage, the experts may gather in a panel assembled by scientists, advisors, policymakers, and members of the main sectors from national state agencies, scientific institutions, and companies with activities in marine ecosystems.

During the workshop, the pilot mapping of sectors-pressures-ecological components will be judged, and scores would be assigned for the spatial extent/overlap, frequency of occurrence, degree of impact, persistence, and resilience for each pressure-ecological component, based on predetermined categorical thresholds (Table 1).

The scores should be based in expertise and data and later supported by cross-checking using expert judgment and literature where gaps exist. Experts should judge and assign scores based on data. The experts will be classified into groups based on their knowledge of ecological components. The scores should be applied according to the current status (present facts) rather than potential risk in the future. A consensus for the mapping and scores is sought from each group of experts based on the best evidence or majority where consensus was not immediate. In the case of ecological components with multiple species, scoring should be based on assemblage and ecosystem functioning rather than focused on single species.

The qualitative scores should be later converted into numerical scores to calculate 'Proportional Connectance', and 'Impact Risk' (based on the 'overlap', 'frequency', and 'degree of impact' scores); and 'Recovery Lag' (based on 'resilience' and 'persistence' scores).

Proportional Connectance, Impact Risk, and Recovery Lag should serve to inform ecosystem management and evaluate the ecosystem components and ecological services paths at risk at present. Finally, the results should be related to the scenarios of climate change developed during the Humboldt tipping project and presented to the stakeholders in order to discuss options for marine ecosystem management in the future.

This booklet will give you an overview of the activities, sectors and ecological components that are important for this framework. If you are viewing it as a PDF, you can click on the text in the contents (page 02), overview (page 10) to get to the corresponding sections.

Table 1: Scores applied to each link between sectors- pressures- ecological components.

Spatial overlap	Frequency (annual)	Degree of impact	Resilience	Persistence
No overlap	Rare	Low	High	Low
Site	Occasional	Chronic	Moderate	Moderate
Local	Common	Acute	Low	High
Widespread patchy	Persistent		None	Continuous
Widespread even				

Overview

I. Sectors

Aquaculture
Artisanal fisheries
Industrial fisheries
Shipping
Navigational dredging
Non-renewables
Coastal infrastructure
Land-based industry
Agriculture
Tourism & recreation
Domestic sewage
Aggregates

II. Pressures

Physical loss
Sealing

Physical disturbance
Noise
Litter

Physical damage
Abrasion
Siltation/Smothering
Non-living resources

Chemical composition interference
Salinity regime
Oxygen changes
pH changes
Contaminants
Organic matter

Hydrological process interference
Thermal regime
Wave exposure
Current changes

Biological disturbance
Invasive species
Barriers
Species extraction
Bycatch
Incidental loss/Collision

III. Ecological Components

Littoral
Littoral sediment
Seabirds
Marine mammals
Reptiles
Littoral rock & reef
Mangroves/Saltmarshes

Shelf
Peruvian anchovy
Pelagic fish
Hake
Bonito
Shelf pelagic
Coastal pelagic
Demersal fish
Shelf/Shallow sediment
Shelf/Shallow rock & reef
Scallops
Demersal elasmobranchia

Oceanic
Giant squid
Dolphin fish
Pelagic elasmobranchia
Oceanic pelagic

Disclaimer

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Thanks for your participation in the ODEMM survey. This survey is part of the research activities of the Humboldt Tipping project.

Here we detailed the conditions of data usage:

1. The data collected will be used to better understand the impacts on marine ecosystems and to formulate management fisheries recommendations.
2. The data provided will be treated anonymously and will not be used for any other purpose outside of the project.
3. Upon completion of the study, a summary of the results will be communicated to you.
4. No monetary compensation is offered for your participation in this survey.
5. If at any time you decide not to continue, you can close the app.
6. This booklet was created by Lena Hindenberg and Giannina Passuni in the frame of Humboldt Tipping, and is protected by copyright.
7. For any question and detailed information about this study, please contact us at: giannina.passuni.saldana@uni-hamburg.de

Giannina Passuni,
University of Hamburg

I. Sectors

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Aquaculture

The main cultivation resource is the calico scallop, which is mainly found in the bays of Sechura, Samanco, and Pisco. Scallops are raised in floating cages that are constantly monitored by boats and diving. Other important crops include macroalgae and shrimp farming in mangroves. The aquaculture sector is still in development and has potential to expand production and diversify the species cultivated. Obstacles to develop the aquaculture are infrastructure, regulation, and staff training.

Artisanal fisheries

Artisanal fishing in Peru involves small-scale operations using vessels up to 15 m long and 32 m^3 hold capacity. It operates within 5 miles from the coast, focusing on meeting local fresh and frozen fish demand.

The sector grew 300% from 1996 to 2015, but now faces challenges like oversized fleets, overfishing, and regulatory issues, leading to conflicts with industrial fisheries. Effective management policies are crucial for the long-term viability of the sector.

Industrial fisheries

Industrial fishing is the second largest sector contributing to the Peruvian GDP. The only species targeted by this sector is Peruvian anchovy for the production of fish oil and meal. Around 6 million tons of fish are caught anually, yielding 1.5 million tons of fishmeal and 150,000 tons of oil, mainly exported to China (78%), Ecuador (6.2%), and Germany (5.4%). The anchovy fishing is carried out by around 800 metal and wood vessels operating with purse seine nets. It's dependency on a single species poses challenges for sustainability.

Shipping

Maritime transport is vital for Peru's economic growth, serving as a key link for imports & exports, mainly from the ports Paita, Salaverry, Chimbote, Callao, Pisco, Matarani and Ilo. With strategic positioning between the Pacific with connections to the Atlantic, Peru handles approximately 97 million tons of cargo annually, with 91% of exports shipped by sea. While trade volumes are rising, there is a need for better port management, fleet modernization, and infrastructure upgrades. Balancing development with sustainability requires addressing environmental impacts. Passenger transport, notably large cruise ships is still in development.

Content Overview

Navigational dredging

This sector includes activities related to the removal of sediments from the seabed and littoral zones for the maintenance, expansion, or adaptation of aquatic infrastructure. This includes structures like ports, landing sites, navigational channels, industrial terminals, and maritime access areas.

Non-renewables

Oil and gas industries are widely developed along the coast and the continental shelf, contributing to 24% of the national fuel production (20 million barrels annually; World Bank). Activities in the maritime scope of the northern and central coast include seismic exploration, exploitation, and refining. The main refineries are Talara, La Pamilla, and Conchan. Activities of this sector can pose environmental risks, as seen in the recent oil spill off La Pampilla.

Coastal infrastructure

This sector includes all forms of infrastructure on the coastal edge, such as ports, resorts, breakwaters, and beach nourishment. It also includes coastal modification like land reclamation. Peru has 45 maritime ports, the most important being Paita, Salaverry, Chimbote, Callao, Pisco, Matarani, and Ilo. Several of the biggest cities are close to the coast and includes resorts like Punta Sal (Tumbes) and Huanchaco (La Libertad), which have undergone refurbishment or expansion due to erosion and growing tourism.

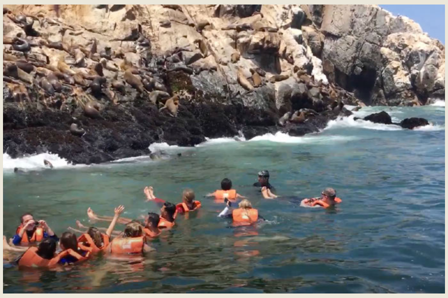
Land-based industry

Activities included here are within a 5km radius of the coastal edge and should interact with the marine environment, either through material extraction or the discharge of products into the sea. Examples of important industries on the Peruvian coast include fish processing companies, canneries (Tumbes and Piura), fish meal producers (Chimbote & Pisco), desalination plants (PROVISUR), and poultry farms (90% of national poultry production occurs on the coast).

Agriculture

Traditional crops on the Peruvian coast include cotton, sugarcane, and rice. However, since 2000, agriculture had a large development through the diversification of crops, including export fruits like blueberries, avocados, and asparagus. Agriculture can interact with the marine environment through runoff and drainage. Although the water deficit in mostly sandy terrain decrease the interaction with marine areas, except during torrential rains due to El Nino events. Rains produces landslides known as “huaycos”, which increase runoff of sediments and organic matter, including chemical compounds from fertilizers and pesticides to the sea.

Tourism & recreation



Constituting the third largest sector contributing the most to the Peruvian GDP. In the marine environment, tourism focuses on beaches and resorts in the summer. Marine reserves, such as the Paracas National Reserve attract visitors through their rich marine and terrestrial biodiversity. Tourism activities include the use of recreational boats, surfing, recreational and sports fishing, water parks, horseback riding or walking along beaches, and food vending. Tourism exerts significant pressures on the marine environment, including water pollution, disturbances of habitats, vessel collisions with marine species, and overexploitation of resources.

Domestic sewage

In Peru, there is a deficit in wastewater treatment. According to the entity overseeing the operation and maintenance of sewage systems (Sunass), 77% of wastewater is treated in plants located in major cities. From them, 11% of sewage after treatment in plants is discharged into the sea. Although the level of treatment in most of the plants only includes the removal of macro-residues.

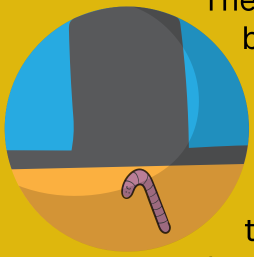
Aggregates

This sector includes the mining of aggregates located within 10 km of the coastline and in the insular system. Along the Peruvian coast, this includes materials such as phosphate, sand, salt, and bedrock, as well as biologically derived resources like shells and guano.

II. Pressures

Physical loss

Sealing



The physical loss of soil due to sealing by construction or permanent substrate change. It becomes permanent when structures are built for longer than 50 years. Soil includes substrate from the beach, intertidal & subtidal bottom, and seabed.

Sources: port construction, beach urbanization, installation of offshore wind parks

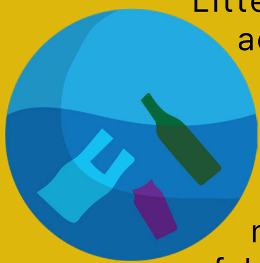
Physical disturbance

Noise

The introduction of sounds into the aquatic environment can interfere with the communication and navigation of marine species. Birds, marine mammals, and fish depend on sound for feeding, orientation, and communication. Noise pollution can disrupt their behavioral patterns.

Sources: boat engines, acoustic surveys, underwater construction, and military activities

Litter



Litter generated by domestic activities, fishing, agriculture, and coastal industry that enter the marine environment. The litter considered includes microplastics, macroplastics, metals, glass, rubber, wood, and fabric. Only the direct effects on marine organisms are considered, excluding the effects on the food chain.

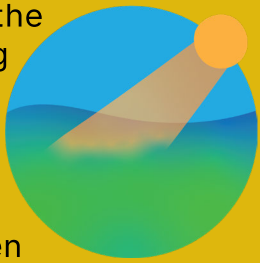
Physical damage

Abrasion

The wear or removal of the seabed due to human activities such as, anchoring, trawling, and removal using air compressors. The substrate includes the beach, the intertidal and subtidal zones, and the seabed.

Sources: dredging for the construction of ports, navigation channels and anchoring of vessels

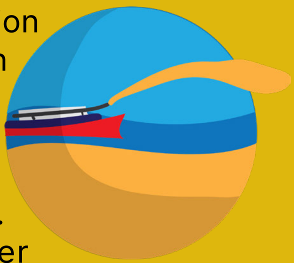
Siltation/Smothering



The increase in sediments in the water column can hinder, among other factors, the penetration of sunlight, negatively affecting photosynthesis. Additionally, turbidity and sedimentation on the seafloor can impede oxygen circulation and clog gills and filtering apparatuses, causing suffocation and death of organisms like mollusks, crustaceans, and fish.

Sources: construction of coastal infrastructure, and runoff from agriculture and coastal industry

Non-living resources

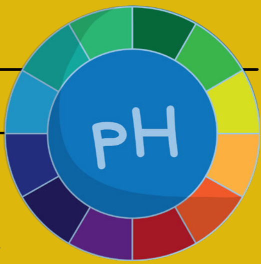


Involves the removal or collection of materials from water column and seafloor for industrial use. This includes mining, guano extraction, and the extraction of sand, gravel, and seawater. Resource extraction can alter sedimentation patterns, water quality, and have adverse effects on coastal stability, biodiversity, and habitat conservation.

Sources: seawater extraction for industrial plant cooling, desalination, sand and gravel extraction for construction, and concrete production

Chemical composition interference

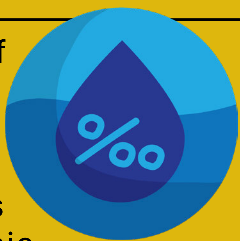
Contaminants



The incorporation of human-made substances, like pesticides, pharmaceuticals, heavy metals, and hydrocarbon compounds in the water column or marine sediment. For example, pesticides in agricultural activities can be carried by runoff water, pharmaceuticals by urban wastewater, and hydrocarbons by marine transport accidents. Heavy metals, like mercury, lead, and cadmium from mining can also accumulate in marine organisms.

Sources: agriculture, industry, fishing, oil and gas industry, and domestic use

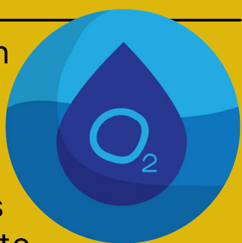
Salinity regime



Variations in the concentration of dissolved salts in seawater, both in average and range, due to human activities. This pressure does not include variations due to natural oceanographic phenomena or climate change. Stenohaline organisms can be affected, leading to stress and changes in distribution.

Sources: domestic and industrial wastewater, and alteration in the mixing of fresh and saltwater due to coastal infrastructure

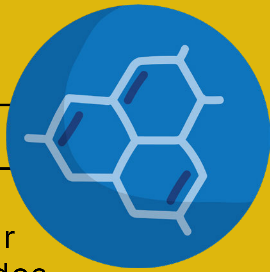
Oxygen changes



Variations in the concentration of dissolved oxygen in seawater, both in average and range, due to human activities. The pressure does not include variations due to natural oceanographic phenomena or climate change. The peruvian coastal area is highly sensitive as the water mass predominating in the coast are bottom upwelled water naturally poor in oxygen.

Sources: domestic and industrial wastewater, increase of organic matter

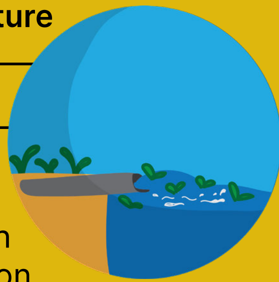
pH changes



Alterations in the acidity or alkalinity level of seawater and/or substrate. This excludes oceanographic changes, natural river flow, and changes caused by climate change.

Sources: industrial and domestic wastewater, and changes in substrate structure

Organic matter

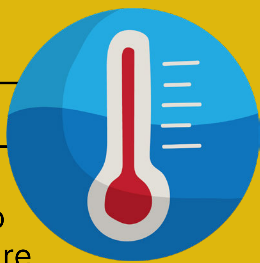


The enrichment of the water column and marine sediment with organic materials, which can lead to water deoxygenation. For example, the discharge of organic waste, such as fish remains, and unconsumed food can decompose and consume oxygen. This can negatively affect marine life.

Sources: agricultural runoff, urban and industrial drainage, aquaculture effluents

Hydrological process interference

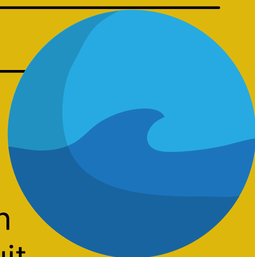
Thermal regime



Variations in water temperature, both in average and range, due to drainage discharge. This pressure does not include variations due to natural oceanographic phenomena or climate change. Increased water temperature can cause thermal stress in ectothermic organisms, resulting in reduced growth and survival.

Sources: industrial, urban, and agricultural wastewater, cooling water from power plants

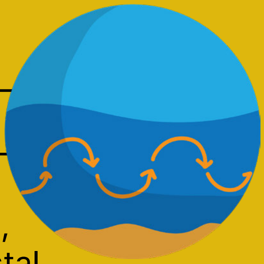
Wave exposure



Modifications in littoral dynamics due to the presence of infrastructure that affects wave frequency and height. These changes can alter sedimentation and the recruitment of sessile organisms in a specific area.

Sources: piers, dams, dikes, and other artifical structures

Current changes



Modifications in water dynamics, such as currents and tides, caused by the presence of coastal infrastructure. These changes can alter water flow, nutrient distribution, and sedimentation for a given area. They may especially affect low-mobility organisms, like plankton, macroalgae, and fish larvae that rely on currents for dispersal.

Sources: piers, dams, dikes, wind turbines, and other artificial structures

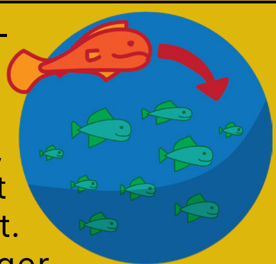
Biological disturbance

Species extraction

The collection or capture of biological resources from the beach, water column, or seabed. These activities may involve extracting parts of an individual, capturing the entire individual, or even entire populations. The extraction of biological resources has secondary effects on the population dynamics of species. When it reaches the point of overexploitation, it can alter the population viability of one or multiple species.

Sources: extraction of biological marine resources like fish, mollusks, and crustaceans

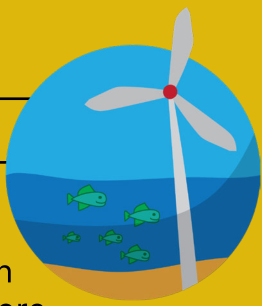
Invasive species



The introduction of non-native organisms like, the dinoflagellates *Alexandrium ostenfeldii*, introduced through ballast water in the Peruvian coast. Dinoflagellates can trigger harmful algal blooms, which have adverse effects on the health of ecosystems, marine life, and human activities.

Sources: ballast water exchange of ships, aquaculture, and wastewater

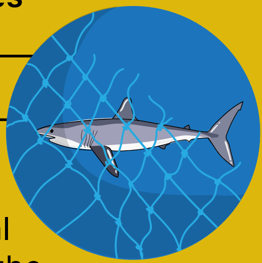
Barriers



Limitation in the movement of marine fauna along a key migration route or inside its distribution habitat. The formation of barriers due to human activities can impact life history processes such as reproduction, feeding, or seasonal migration. This considers species that actively move, such as fish, birds, and marine mammals.

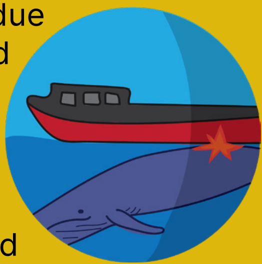
Sources: presence of coastal infrastructure, such as piers, dikes, and turbines

Bycatch



Unintentional capture of species during fishing activities, usually of fish and invertebrates. Incidental capture can be associated with the low specificity of fishing nets. The pressure from incidental capture often leads to the discarding of these species or their subsequent use for consumption or commercialization. Bycatch can include the capture of endangered or protected species such as sharks and dolphins which are later commercialized.

Incidental loss/Collision

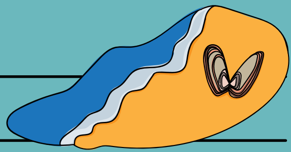


Death or injury of marine fauna due to human activities. This would primarily affect top predators and charismatic species such as birds, whales, dolphins, and sea turtles. For example, entanglement in fishing nets and fishing gears can cause serious injury and/or subsequent mortality. Additionally, collisions with vessels pose a significant threat to the conservation of these species, as they can result in severe injury or even death following an accident.

III. Ecological Components

Littoral

Littoral sediment

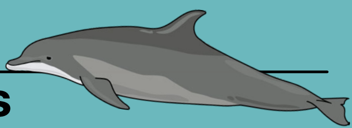


It is a coastal ecosystem composed by sandy substrate, covering the supratidal and intratidal zones. Some examples of organisms found here are polychaetes, crustaceans, and molluscs. Some characteristic crustaceans are

Emerita analoga and *Neotrypaea californiensis* are often used as bait in artisanal & recreational fishing. The mollusc Peruvian bean clam (*Donax peruvianus*) and concha macha (*Mesodesma donacium*) are also commercially important.

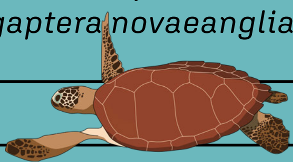
Seabirds

Includes birds inhabiting beaches, estuaries, and islands, and feeding on marine resources. Peru has around 60 species of seabirds, including 3 which are known for their guano production: Guanay cormorant (*Leucocarbo bougainvillii*), the Peruvian booby (*Sula variegata*) and the Peruvian pelican (*Pelecanus thagus*).



Marine mammals

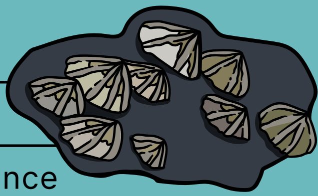
Includes marine mammals inhabiting coastal and oceanic realm. Some of the most conspicuous marine mammals near coastal areas are the South American sea lion (*Otaria flavescens*), the South American fur seal (*Arctocephalus australis*), and the Bottlenose dolphin (*Tursiops truncatus*). The Peruvian waters constitutes an important migration path and reproduction for Humpback whales (*Megaptera novaeangliae*).



Reptiles

The Peruvian coast is part of the distribution area of Green sea turtle (*Chelonia mydas*), Olive ridley (*Lepidochelys olivace*) and leatherback turtle. Green sea turtle also has areas of reproduction in the north coast. Among the principal risk, factors for the population of sea turtles had been reported the incidental loss and collision by fishing boats and nets.

Littoral rock & reef



Characterized by the presence of rocky substrates emerging from the sea, either permanently or during low tide, ranging from pebbles to larger rocks, extending from the supratidal to the rocky intertidal zone. They provide a unique habitat to species of macroalgae (for example, *Ulva lactuca*), bivalves (for example, *Perumytilus purpuratus*), and comercially important molluscs like limpets (*Fissurella spp.*) and goose barnacles (*Pollicipes elegans*).

Example: Ancon Bay

Mangroves/Saltmarshes

Coastal ecosystems placed in the transition between brackish water and the sea. Mangroves consist of salt-tolerant vegetations. They are important for coastal erosion control, carbon storage, and particle filtration. They provide a habitat for species like the red mangrove crab (*Ucides cordatus*) and black clam (*Anadara chemnitzi*).

Estuaries are semi-closed coastal ecosystems where river water mixes with seawater, influences by tides & currents. They serve as fish nurseries, nesting sites for birds, and resting places of species like the green turtle (*Chelonia mydas agassizii*).

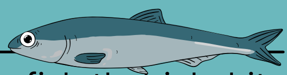
Wetlands include swamps and ecosystems permanently flooded by brackisch water from rain, rivers, or groundwater. They are carbon and organic matter sinks, filter particles, and regulate tides. They are fish breeding grounds and habitats to species like waterfowl.

Examples: regions fo Tumbes & Piura (mangroves), Virrila estuary & Cira River estuary (estruaries), and Pantanos de Villa & Albufera de Medio Mundo in Lima (wetlands)

Content Overview

Shelf

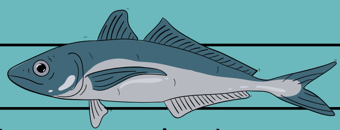
Peruvian anchovy



Peruvian anchovy is a pelagic fish that inhabits the cold waters of the Humboldt Current and is key in the food chain for multiple fish, birds, and mammals. It has great commercial importance, with around 6 million tons of annual landings, making it the largest single-species fishery. Despite having the highest biomass in the pelagic system, it is vulnerable to climatic variability and overfishing.

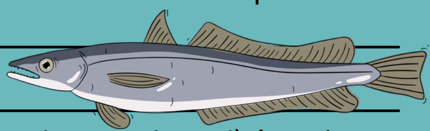
Locations: north-central stock off the Peruvian coast & southern stock, shared with Chile.

Pelagic fish



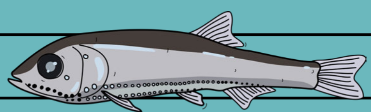
Includes other bony fish present in the water column within the epipelagic zone of the continental shelf (<200 nautical miles), with the exception of anchovy and bonito. Among the commercial species of pelagic fish are mackerel (*Scomber japonicus*), jack mackerel (*Trachurus murphyii*), Long-nose anchovy (*Anchoa nasus*) and Sardine (*Sardinops sagax*). The capture of these species is mainly carried out by artisanal fishing and destined for direct consumption.

Hake



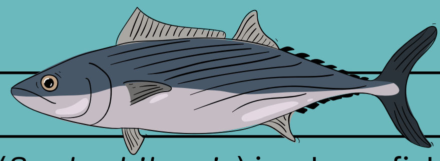
Peruvian hake (*Merluccius gayi gayi*) is a bony fish distributed along the continental shelf of the South-eastern Pacific. In Peru, it is found in the Piura and Tumbes region and targeted by artisanal and industrial fishing among the 4-8 nautical miles from the coast. The landings fluctuate among 1000 to 5000 tonnes per year.

Shelf pelagic



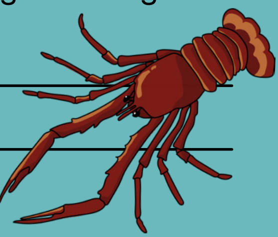
Includes various mesopelagic elements, both abiotic (seawater, currents, nutrients) and biotic components on the continental shelf (<200 nautical miles) and deeper than 200m. Biotic components include decaying phytoplankton and bacteria, zooplankton and mesopelagic fish as lantern fish (*Myctophydae*). This category includes pelagic and migratory bony fish that commonly inhabit oceanic mid-waters.

Bonito



Pacific bonito (*Sarda chilensis*) is a bony fish that distributes in the South-eastern Pacific coast (2-30 mn). It is an important fish resources for the artisanal fisheries with an average landing of 5 000 to 20 000 tonnes per year.

Coastal pelagic

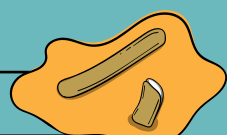


Includes pelagic elements, both abiotic (seawater, currents, nutrients) and biotic, distributed within the epipelagic zone (<200 m) of the continental shelf (<200 nautical miles). The biotic elements include coastal plankton, composed of phytoplankton (20 µm- 200 µm), zooplankton (200 µm - 2 µm), jellyfish (2 cm - >1 m) and macroinvertebrates as Euphausiids and Red squad lobster (*Pleuroncodes monodon*). Pelagic fish described in an individual category.

Demersal fish

Bony (demersal) fish that inhabit and are associated with the seafloor for food or shelter, distributed mainly in coastal waters (<200 m depth). They are found either on soft substrates (sand or mud) or rocky substrates and caught for direct consumption by artisanal fishing. Among commercially important species are: kelp bass (*Paralabrax humeralis*), and grouper (*Mycteriperca xenarcha*).

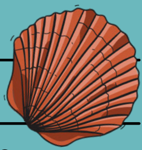
Shelf/Shallow sediment



Characterized by sandy muddy substrate extending from the subtidal zone to the edge of the continental shelf (<200 nautical miles). It is defined by oxygen levels that allow the distribution of organisms sensitive to hypoxia and where light penetration allows the growth of more plankton than at the bottom. It hosts, for example, polychaetes, mollusks, bivalves, and crustaceans, like the clam (*Leukoma thaca*), razor clam (*Ensis macha*), and the moon snail (*Sinum cymba*).

Shelf/Shallow rock & reef

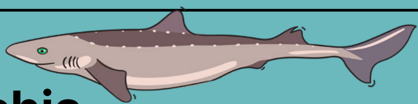
Characterized by the presence of benthic rocky substrates, including natural outcrops, artifical reefs, or artifical structures. It extends from the subtidal zone to the continental shelfs, covering a range from a few meters to 200 m. It hosts a variety of species like polychaetes, mollusks, bivalves, and crustaceans. Some commercially important species are: black mussels (*Aulacomya atra*), hairy crab (*Romaleon setosum*), and green sea urchin (*Loxechinus albus*).



Scallops

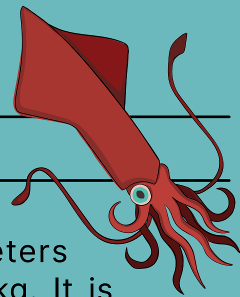
A commercially important bivalve mollusk. It is mainly found on the central and southern coast, especially in the bays of Paracas, Pisco, and Independencia. It's ideal habitat is cold, nutrient-rich waters with sandy or muddy bottoms between 10-30 m. The scallop fishery depends mainly on cultivation by catching seeds from natural beds and larvae. It has high international demand. In 2021, scallop export value reached 122 million dollars.

Demersal elasmobranchia



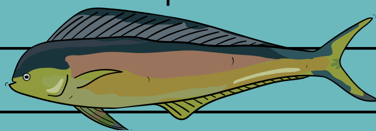
Cartilaginous fish associated with the bottom for food and shelter. They are mostly distributed in coastal waters (>200 m depth). They are trageted for local consumption, however, many species are threatened by overfishing. The most characteristic species are common dogfish (*Mustelus whitneyi*), angel shark (*Squatina californica*), and common guitarfish (*Pseudobatos planiceps*).

Oceanic



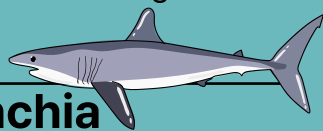
Giant squid

Dosidicus gigas is a cephalopod that can reach up to 1.8 meters in length and weigh up to 50 kg. It is distributed in the temperate and subtropical waters of the eastern Pacific Ocean, from the United States to Chile. In Peru, the giant squid is one of the fishing species with an annual catch of around 500,000 tons. Landings are used both for local consumption and for export.



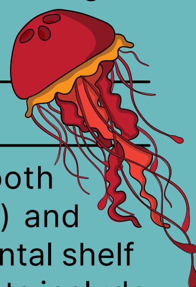
Dolphin fish

The Dolphin fish (*Coryphaena hippurus*) is the third most important fish target for artisanal fishery using surface longlines and curtain nets. Despite a Fisheries Management Regulation for sustainable fishing of dolphin fish only took effect in January 2024. Annual landings are in the order of 50 000 t.



Pelagic elasmobranchia

Includes cartilaginous fish that are distributed in the water column. While typically distributes in oceanic waters they can also enter coastal waters, Among the species most important are thresher shark, manta ray, shortfin mako shark, and blue shark. These top predators are crucial in the food chain and commercially important for consumption and fin extraction. Overfishing threatens many species, prompting a finning ban. CITES has advised Peru to strengthen shark and ray trade regulations, as Peru is the largest shark fin exporters in Latin-America.



Oceanic pelagic

Includes various pelagic elements, both abiotic (seawater, currents, nutrients) and biotic components outside the continental shelf (<200 nautical miles). Biotic components include phytoplankton (20 µm - 200 µm), zooplankton (200 µm - 2 µm), jellyfish (2 cm - >1 m). This category includes pelagic and migratory bony fish that commonly inhabit oceanic waters. Amongst the most important are tuna fish, swordfish, and flying fish. Tuna fishing is regulated by the Inter-American Tropical Tuna Commission (IATTC) resolution and in Peru is currently fished by industrial fishing.

Content Overview

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FONA
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