

Appendix II Case Studies used to develop the illustrative typology.

Yellow Clam Fishery, La Coronilla-Barra Del Chuy, Rocha, Uruguay – Omar Defeo

Sandy beach clams of the genus *Mesodesma* are a valuable resource along the Atlantic and Pacific coasts of South America. In the Atlantic, the yellow clam *Mesodesma mactroides* inhabits sandy beaches of Brazil, Uruguay and Argentina. Mass mortalities decimated populations of *M. mactroides* along its entire geographic range during the last 20 years. These mass mortalities have been attributed to a number of factors, namely positive sea temperature anomalies, harmful algal blooms, environmental stress, parasitism and storms. The effect of these mortalities may swamp management measures.

The study area, comprised between La Coronilla and Barra del Chuy resorts in the NE of Uruguay, is also affected by an artificial freshwater canal discharge (Andreoni Canal) used for agriculture and cattle rearing (Figure 1). This freshwater effluent causes a broad deterioration in habitat quality and affects resident sandy beach populations, which experienced reduced survival, growth and fecundity rates. These impacts spread to the community level, affecting macrofauna diversity, abundance and structure. In addition, the artisanal communities that harvest the yellow clam are affected because of the reduction of the stock towards the proximity of the effluent discharge.

Mass mortalities and freshwater discharges are the two Main Issues considered in this case study, even though special emphasis will be given to the effect of mass mortalities in the ecological, social and governance systems.

Mantis Shrimp Fishery, Tokyo Bay, Japan - Mitsutaku MAKINO

Tokyo Bay, located on the Pacific side of the central part of Japan the most urbanized and developed bay in Japan, with the two largest cities in Japan, Tokyo and Yokohama on its shores, with a total of 26 million people living within the watershed of the Bay (8,000 km²). It is highly populated. The coastline of Tokyo Bay has been reclaimed for residential use, aquaculture, agriculture, salt production, port, etc since the 1860s. In the 1950s, the national government legislated an act to promote the heavy industry development along the coastline of the Tokyo Bay, which was one of the major drivers of the Japanese economic development after the Second World War. In 2014 95% of the coastline has been reclaimed.

These changes have resulted in marine pollution, and the loss of wetlands and sea grass bed has impacted the reproduction of marine species. Both the catch amount and catch diversity decreased. Mantis shrimp, *Oratosquilla oratoria*, which has been one of the most famous and branded species of Tokyo Bay fisheries since the feudal era in the 19th century has been drastically damaged. In attempt to reverse this damage, local fishers' cooperatives autonomously implemented entry control (vessel size, gear size, number of boats, total days at sea, etc), catch limits (size, volume), and finally, ban on mantis

shrimp operation for 5 years (2007-2011), but no recovery observed. During the 5 years of autonomous ban, local mantis shrimp fishers and researchers found some amount of juvenile mantis shrimps by the experimental operations. But they cannot find mature shrimps. So, fishers think shrimps move deeper area when they grow, and die because of the anoxic environment there.

Local fishers think there is one more important cause of the catch decrease. The rainwater dispose system around Tokyo Bay has been very highly developed in the last several decades. When a very heavy rain comes (the frequency of very heavy rain is recently increasing, they think), a lot of fresh water runs out at once. Mantis shrimp (and octopus) are intolerant of freshwater, and they die after the heavy rain. Therefore, fishers are now monitoring the salinity of the fishing ground after heavy rains.

Small Pelagic Fishery, Southern Benguela, South Africa – Moenieba Issacs

The small pelagic fish industry started in South Africa in the Western Cape after the Second World War. The purse-seine fishery for small pelagics, based primarily on anchovy (*Engraulis encrasicolus*) and sardine (*Sardinops sagax*) is the largest fishery in South Africa in terms of total landings and the second most valuable. This fishery directly employs 7 700 people, of which 4 500 work full time. The majority of the factories are located in Saldanha and St Helena Bay, on South Africa's West Coast. Employment security in the pelagic sector is affected by the sector's vulnerability to large fluctuations in its TAC. This is because the sector functions on a high volume/low profit basis. The most valuable of South Africa's fisheries is also experiencing the TAC reductions for large companies.

Since the early 2000s there has been a shift in the relative distribution of the small pelagic fish stock (sardine and anchovy) from west to south coast of South Africa. This has led to the unemployment of processing workers in the West Coast, and also on predators of small pelagics such as endangered African Penguins. Both of Saldanha's major fishing sectors, based on pelagic and hake fisheries, are experiencing notable declines. Such a drop in productivity inevitably means that the fishing sector will not be providing employment for the growing population in Saldanha as it used to, or that some employers will be forced to close down. Ultimately, this means that fishery employees will lose their jobs.

Degradation of natural resources in a coral island archipelago in Indonesia - Bernhard Glaeser

The Spermonde Archipelago covers an area of roughly 2,500 km², consisting of some 67 low-lying coral atoll islands 54 of which are inhabited, with a total population of roughly 45,000 people, almost exclusively dependent on marine resources for their livelihoods. The islands are usually very densely inhabited, with densities of up to 750 people/ha. The shelf area extends up to 60 km from mainland Sulawesi, and stretches around 80 km along the west coast of South Sulawesi. It is situated in front of the city of Makassar, home to about 1.8 million people (almost 3 million in the wider metropolitan area).

The predominant activity in the area is fishing, which occurs in wide variety of different types, gears and target species. The vast majority of fishers are organized in a patron-client system, with fishing patrons providing access to markets, fishing gear, licenses and loans. They also use their contacts to law enforcement agencies to provide insurance against prosecution in case illegal fishing gears are used or protected species caught.

As a result of the links to external markets, variety of fishing gears, low effectiveness of law enforcement, and the widespread perception that marine resources are either inexhaustible or diverse enough to always provide additional target species, there is little concern as to overfishing, and a wide range of species are harvested in an unsustainable manner, leading to widespread over- and destructive fishing. The large and growing number of inhabitants, and low environmental awareness, furthermore result in an overuse of freshwater resources, scarcity of available land for construction and farming, and pollution.

A number of different species (economically important as well as endangered) have been severely overharvested, with little signs of recovery. These include groupers, sea cucumbers, turtles, dugongs (sea cows, scientific name *Dugong dugon*), sharks, and a number of stony corals sold to the international marine aquarium trade. A race for efficient fishing technologies is inevitable reality and will be reinforced by the ever decreasing fish abundance. Fishermen are motivated to forage in the waters surrounding other than their home islands and to use distant fishing grounds outside Spermonde Archipelago. Island fishing grounds are not only exploited by the adjacent islanders, but also by outside fishermen. Most of the coral reefs surrounding the islands show (sometimes) severe signs of degradation, with low live coral cover and fish biomass.

Oyster Farming, Bay of Bourgneuf, France – Patrice Guillotreau

The major issue is the recent (summer 2008 onwards) higher vulnerability of oyster larvae and juveniles of farmed oysters (*Crassostrea gigas*) to bad quality of shell and to epizooties (Vézina et Hoegh-Guldberg 2008), suffering very high mortality rates (up to 80-100%) because of the presence of Herpes-Virus species (OsHV-1 - μ Var - Maurer and Combs 1986, EFSA 2010). This sudden mortality might be caused by recent changes in environmental conditions like higher temperatures (ongoing debate).

Oyster farming represents the major activity of the Bay, with an average production (prior to the issue) of approximately 10,000 tonnes within 283 farms. Total area of the Bay is 340 km², including a 100 km² of tidal flat foreshore where oysters are mostly settled (discovering at ebb-tides). The Bay of Bourgneuf is surrounded by several small towns with a few thousand people in each of them and distant of a few kilometers the one from the others. In overall, some 90,000 inhabitants (up to 320,000 in summer) live around the bay, including the island of Noirmoutier bordering the western side.

Mass mortality of bivalves, Pacific Northwest Coast, USA – Sarah Cooley

Major production failures of Pacific oyster (*Crassostrea gigas*) spat at Pacific Northwest shellfish hatcheries from 2005-2009 were traced to pH declines associated with upwelling water that carried the signatures of ocean circulation, normal biological activity, and anthropogenically released fossil fuel carbon dioxide (which drives ocean acidification). Many species of bivalve shellfish and urchins have been observed to grow more slowly and survive poorly under ocean acidification. The effects of ocean acidification spurred action first in Washington State, even though the issue also impacts marine ecosystems in Oregon, California, and British Columbia.

In Washington State, the country's top provider of farmed oysters, clams, and mussels, annual sales of farmed shellfish account for almost 85 percent of U.S. West Coast sales (including Alaska). The estimated total annual economic impact of shellfish aquaculture is \$270 million, with shellfish growers directly and indirectly employing more than 3,200 people. In addition to commercial aquaculture activities, recreational shellfish harvesting licenses generate \$3 million annually in state revenue. Recreational oyster and clam harvesters contribute more than \$27 million annually to coastal economies. Overall, Washington's seafood industry generates over 42,000 jobs in Washington and contributes at least \$1.7 billion to gross state product through profits and employment at neighborhood seafood restaurants, distributors, and retailers. Shellfish generate more than two-thirds of the harvest value of the state's wild commercial fisheries. Other shellfish of ecological and economic importance include oysters, mussels (native and Mediterranean), clams (e.g., geoduck, razor, littleneck, Manila), scallops, Dungeness crab, shrimp (e.g., spot prawns, pink shrimp), pinto abalone, and urchins.