

Causal chain analysis

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details on the methodology, please refer to the GIWA methodology chapter.

Overexploitation of living resources in the East China Sea

The last four decades of fisheries exploitation in the East China Sea clearly show the impact of human activities. Rapid development occurred in the 1950s after the recovery from the civil war, followed in the 1960s by overexploitation and fluctuations in fish stocks. In the 1970s overexploitation was a serious problem, and development of the fisheries slowed in spite of an increase in fishing effort. Although production still increased by 4% each year, there were serious collapses of prime stocks such as Large and Small yellow croaker. Since the 1980s, the major economic species have shifted to pelagic species,

particularly the small pelagic fish such as scad, young chub, mackerel and anchovies. The development of capacity to harvest fish has grown the most during the last decade.

Nearshore species are migratory fishes that travel south and north along short distances of the coast, consisting mainly of warm-temperate species. Offshore species mainly consist of warm water species due to the influence of Kuroshio warm current. The traditional major fishery species include: Largehead hairtail, Large yellow croaker, Small yellow croaker, Chinese herring, pomfret, Filefish (*Navodon septentrionalis*), Scad (*Ecapterus maruadsi*), Spanish mackerel, Chub mackerel, Daggertooth pike-conger (*Muraenesox cinereus*), White croaker (*Argyrosomus argentatus*), Cuttlefish (*Sepiella maindroni*), and Blue crab. At present, the most important fishery for largehead hairtail is highly dependent on recruitment and is fully or overexploited. Most of the species that have been mainstays of the traditional fishery are much like the Largehead hairtail, fully or overexploited. Large yellow croaker and Filefish have been fully depleted.

An analysis of the causal chain from immediate causes of overexploitation of fish to root causes are illustrated in Figure 31.

Immediate causes

Increased fishing effort

Although landings for marine fisheries have increased in the last five decades, the catch per unit effort (CPUE) has decreased almost linearly after the mid-1950s, from 37.9 tonnes/horsepower in 1953 to 3.3 tonnes/horsepower in 1962, to 2.1 tonnes/horsepower in 1972, 0.8 tonnes/horsepower in 1982, and below 1 tonnes/horsepower thereafter (Figure 32). Overfishing in the East China Sea is also the result of the growth of the region's fishing fleets. China has 12 633 steel fishing vessels, of which 890 have more than 600 HP; there are another 80 000 smaller wooden fishing vessels in China, with more than half of

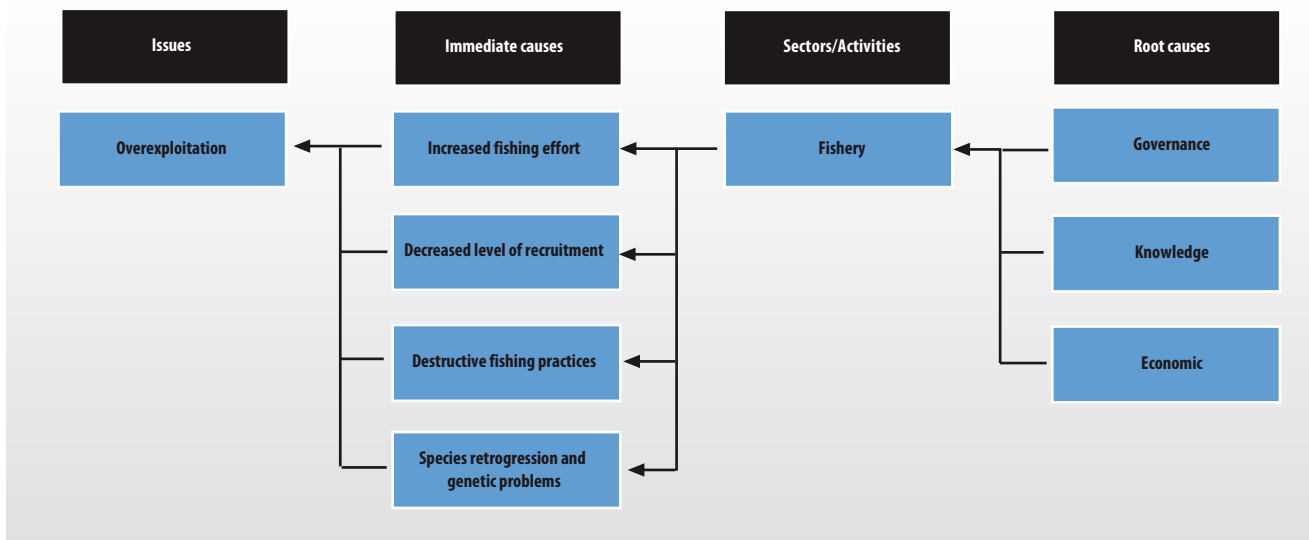


Figure 31 Causal chain diagram illustrating the causal links resulting in overexploitation of resources in the East China Sea.

them with motors less than 15 HP. There are also 13 854 non-motorised fishing vessels fishing the coast of the East China Sea. The size of the fishing fleet has greatly increased over the last few years. The number of steel vessels with more than 600 HP engines has shown a 77% increase since 1997, the greatest increase to date.

With the expansion of the fishing effort in the East China Sea, overfishing has threatened more and more marine biological resources. Overexploitation can reduce species biomass to the brink of extinction. Individual species are often targeted because of their value as a commodity, which results in a shift from big to small individuals (Jin 2000). In 2000, 40% of the total marine catch of China came from the East China Sea. Even though it is less important now than previously, the East China Sea is still the most important fishing area for the countries in the region, especially the coastal waters of Zhejiang, Fujian Provinces and Shanghai. Most fishing grounds are at depths between 100 and 200 m.

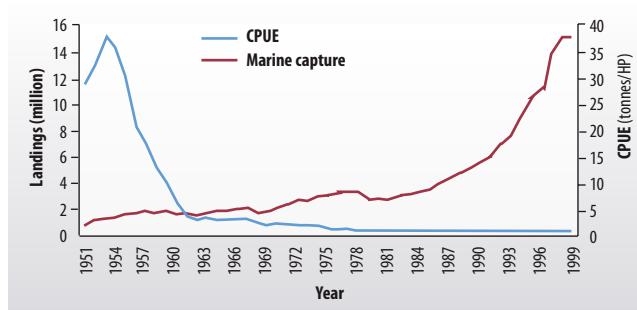


Figure 32 Marine capture and CPUE in China.
The Yellow Sea and East China Sea represent 60-80 % of the total.
(Source: Jin 2000)

Decreased level of recruitment

There has been a continually decreasing level of recruitment in the fisheries resource in the East China Sea, especially in squid and crabs which have a short lifespan and rapid growth, and with reproduction highly dependent on the level of supplemental recruitment. The increased effort in marine fishing has become a problem in recent years as this has led to reduced marine resources recruitment. The spawning ground of the common Chinese cuttlefish (*Sepiella maindroni*), one of the most well-know marine species of economic importance, is situated near Zhoushan Island and Ningbo. Under increasing fishing pressure, typified by an increasing number of fishing boats using improved and new techniques, the overfishing of Chinese cuttlefish has reached a level that gives stocks no time to recover and reproduce. Now fishing of Chinese cuttlefish at its spawning and hatchery grounds has dropped to a very low level. Similar serious problems have happened with recruitment of Yellow croaker (*Larimichthys polyactis*), Large yellow croaker (*Pseudosciaena crocea*), Large shrimp (*Penaeus orientalis*) and the crab *Portunus trituberculatus*.

Destructive fishing practices

These practices include fishing with explosives, trawling with nets and chains, and using cyanide to stun fish so that they can be caught alive, and other practices that damage or degrade important fish habitats such as reefs and mangroves. Illegal fishing methods have accelerated resource declines. Before the 1970s, the popular fishing technique called boat-knocking destroyed populations of the large yellow croaker and the Small yellow croaker, finally leading to the extinction of the Small yellow croaker in the middle 1970s and the Large yellow croaker in the middle 1980s. Trawl fisheries, mainly bottom trawl, have had the

highest yield of all fishing fleets, between 40-61% of the total catch. This fleet accounts for 47% of the total catch which slightly decreased. The other major fishing methods are purse seining, driftnetting, and fixed netting.

Species retrogression and genetic problems

Because of species retrogression and genetic problems due to successive inbreeding aquaculture stocks have shown some genetic problems such as declines in growth and age at maturity, smaller adult fish, and an increase in the incidence of diseases (Ye et al. 2004). In natural populations of silver carp, the female age of maturity is 3-4 years with an average body weight of 4.85 kg, and the male age of maturity is 3 years with an average body weight of 3.81 kg. After inbreeding for five generations, the female age of maturity declined to 2 years with a body weight of only 1.25 kg and the male age of maturity declined to one year with a body weight of only 0.69 kg. Severance of the links between lakes and rivers by hydroelectric and irrigation projects has changed or disrupted dispersal and migration of species. These environmental changes accelerate the extinction of remnant species, and consequently decrease biodiversity abundance.

Root causes

Knowledge

Insufficient knowledge about the maximum sustainable yield (MSY) of the fisheries resource and a lack of both systematic monitoring and surveys of fish stocks are the main problems in fishery management. The dynamics of fish resources and the maximum sustainable catch are not well understood, thus marine fisheries have been managed without any concern for sustainable yields. Many fishers and marine fishing businesses continue to believe that the marine fishery is unlimited, and that the more fishing vessels that are deployed, the more fish will be caught.

Trawlers have seriously damaged the juvenile fish populations of major economic species. Moreover, ground trawls damage not only the fisheries resource but also the habitat and environment of the inshore and offshore areas. The fishing grounds for static nets are all located in inshore waters or estuaries, and intercept the migration of fish, which causes severe damage to the fisheries resource, especially juvenile fish. Gill net operations have been greatly increased owing to the shift in target species to small-size species in recent years. Gill nets with small-size mesh catch a large amount of the juveniles of large-size fish species while also catching the small-sized, target fish species. In addition, all the gill net operations are conducted in inshore areas that are also the spawning and nursery grounds for fish, thus gill net fishing also damages the coastal fishery.

Governance

There are too many trawlers and static nets in operation, and gill net mesh sizes are smaller than are allowed by national regulations. At present, although China has taken measures such as imposing (1) closed fishing seasons and areas, (2) limits on fishing capacity, (3) controlling the licensing of access to fishing, and (4) restrictions on the construction of fishing vessels, these measures have not fundamentally reversed the overfishing situation, owing to a lack of awareness of fisheries resource status, along with no imposition of a total allowed catch (TAC) limit or fishing quotas, compounded by insufficient fisheries administration capability.

At present, the marine fisheries resource is a public resource over which none has complete ownership, so anybody can enter the fishery without payment and there is little accounting of the social costs of resource depletion. Failure to manage fishing and the fisheries resource in the East China Sea has led to a number of serious problems that stand in the way of sustainable development. Resource problems are inevitably linked to social and economic problems, including developing population, pollution, disease, income of fisherman, land shortages and lack of legislation.

Economic

Most of the fishermen along the East China Sea have not been well educated and lack the money to begin new businesses. People continue to become fishers because fishing still can generate relatively higher benefits than other occupations. For example, in Shenzhoushan Islands, the local fishery authorities are worrying about the future of about 1 200 fishermen who do not have boats. Zhejiang Province now has more than 200 000 fishermen who need new jobs. Without new training, fishing is their sole option.

Eutrophication in the Yangtze River estuary and adjacent inner shelf

The coastal region adjacent to the Yangtze River estuary is one example of an area suffering from the serious impacts of eutrophication, resulting in the proliferation of phytoplanktonic biomass and algal blooms. This type of environmental problem has caused great concern in the scientific community and has become a common topic of discussion in the media, and hence has been studied thoroughly within the framework of a Chinese national research project and through

international cooperative efforts such as the Intergovernmental Oceanic Commission/Scientific Committee on Ocean Research, Global Ecology and Oceanography of Harmful Algal Blooms (IOC/SCOR GEOHAB).

Eutrophication is an international problem but its form of expression has a strong regional character: in terms of the East China Sea region, the problem of eutrophication can be linked to either land-source inputs or human-related issues in coastal waters, or both.

The summer effluent plumes from the Yangtze River spread eastward over the East China Sea shelf and cover a surface area of 80 000-90 000 km². The front of Yangtze River effluent plumes may reach the break of the continental shelf in the summer. One of the special features of the Yangtze River inflow to the East China Sea is that high N/P and N/Si ratios can be tracked over a distance of 300-400 km from the river mouth in surface waters.

Although the record of harmful algal blooms in the East China Sea can be traced back to the 1930s, the number of HABs increased sharply in 1980s when China launched economic improvements. It was reported that the number of harmful algal blooms in the 1990s had increased to 50-100, which is an increase by a factor of 5 when compared to the 1980s (Zhou et al. 2001). Paralytic Shellfish Poisoning (PSP) and Diarrhetic Shellfish Poisoning (DSP) have been frequently reported. These illnesses cause human health problems and sometimes death in the area affected by HABs (Zhou et al. 2001). The number of HAB

species has increased dramatically after the 1990s, which parallels the development of eutrophication in coastal waters. For instance, the HAB events induced by *Prorocentrum* sp. in May 2000 covered an area of 5 000-10 000 km² in the region off the Yangtze River estuary.

Water quality assessments have been conducted in the East China Sea using the coastal monitoring programs of the SOA and the Ministry of Fisheries, and these assessments have been compared to predictions made by statistical models, using available information for discharges from point and non-point sources, increases in population and other relevant socio-economic data.

Figure 33 summarises the major characteristics of the causal chain analysis with regards to coastal eutrophication in the East China Sea, with links between the problems of eutrophication and immediate and root causes.

Immediate causes

The discharge of nutrients from land sources has increased considerably over the last two decades. For example, the dissolved inorganic nitrogen (DIN) level in the Yangtze River has increased by a factor of 2 on average from 1980-2000. Additional short-term impacts are due to deforestation and damming in the watersheds, followed by erosion and soil loss and trapping of sediments in reservoirs. These kinds of activities affect the riverine nutrient flux and are also responsible for high turbidity in the coastal environment.

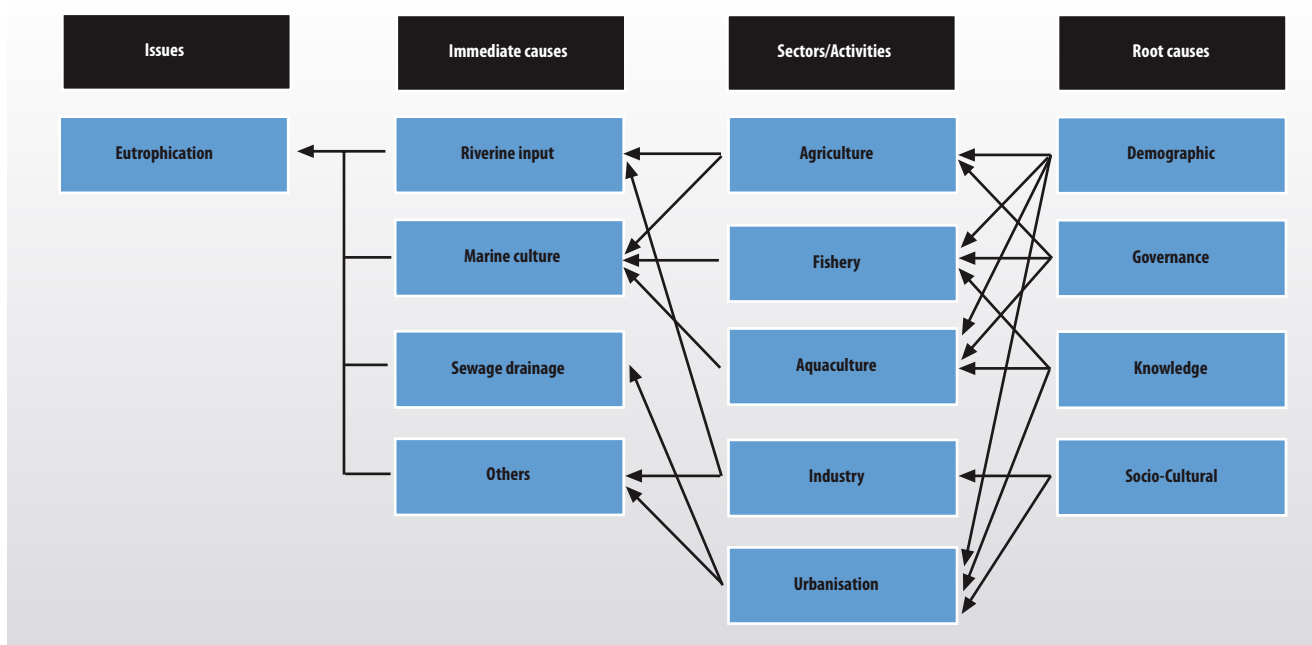


Figure 33 Causal chain diagram illustrating the causal links of eutrophication in the Yangtze River estuary and the adjacent inner shelf.

Data on non-point sources of nutrients can be obtained from riverine monitoring upstream of the estuary. These sources are integrated and show the overall discharge into the coastal environment. The application of chemical fertilisers may not necessarily induce increased coastal eutrophication, because nutrients are required for the annual growth of crops which in turn fix the nutrients in the watersheds, as long as the application of fertiliser does not exceed plant demands and the fertilisers are not washed out just after use. Point source inputs of nutrients to the marine environment are closely related to human behaviour in the coastal region. The coastal provinces and municipal cities cover a surface area of about 5% of the country's land area, but the residential population accounts for about 50% of the national population. The discharge related to human settlements is believed to be the main source of nutrient concentrations in some areas of the East China Sea coast. Sewage treatment capacities are generally low and are only able to treat about 50% of the total sewage production and daily sewage water from Shanghai, which reaches ca. 5 million tonnes. It is believed that a significant part of this contribution could be avoided with reforms, and by improving the area's sewage treatment capacity. Improvements to the existing water supply and drainage system, along with social and economic reforms, should be initiated to ensure that human waste will not enter the coastal waters without proper treatment.

In China, the production of coastal mariculture increased by 50% in the late 1990s and reached ca. 11 million tonnes in 2001, which is a level comparable to the fish catch. It was estimated that production in the tidal flat accounts for 47% of this increase, while the shallow water areas account for 4% and the bay for 7% (State Oceanic Administration 2004c). It is possible that a significant nutrient load has accumulated in concert with mariculture development in the coastal region, together with organic wastes, because aquaculture requires the use of a large amount of organic substances, which have a high of carbon, nitrogen and phosphorus content. Although at present it is difficult to estimate the quantity of nutrients and organic carbon discharges related to mariculture, its contribution to the development of coastal eutrophication may be comparable to that from the direct discharge of domestic waters. Another important source of pollution comes from the discharge of ballast water, as the East China Sea is an important waterway for cargo transport and a number of harbours are located along the coast. The discharge of ballast waters may also introduce HAB species from other regions.

Root causes

Based on the previous discussions, the immediate causes of eutrophication in the East China Sea coastal waters can be summarised

as follows: non-point sources, with riverine input of terrestrial plant nutrients either from soil erosion or fertiliser use, or both; point sources, which come from sewage discharges, and releases from mariculture.

Additional sources may be atmospheric deposition (dry and wet) of nutrients and other pollutants. Concentrations of ammonia can be higher than nitrates in rainwater, and the N/P ratio of rainwater can be high. In the middle shelf area of the East China Sea, contributions from atmospheric deposition can be greater than land-source (e.g. river) influences (Tang & Su 2000).

Demographic

Coastal eutrophication is positively correlated with the increase in population in the coastal area, both as a consequence of urbanisation and as a result of the effort to reduce offshore fish catch in recent years and the subsequent increase in mariculture production.

Knowledge

Fertiliser is used extensively in agriculture, because of the need to boost production in response to population increases and the associated demand for agricultural products. Inadequate knowledge about the use of fertiliser and traditional agricultural practices both contribute to the increasing nutrient loads in surface waters. Failures in sewage treatment have the same effect. In many settlement centers, the sewage treatment capacity is not up to international standards and/or sewage is discharged without proper treatment. The population is not well educated in rural and some urban areas about the links between land-source pollutants and harmful effects on the coastal environment.

Socio-cultural

Sewage may be directly discharged without proper treatment to reduce costs to industry, or it may result from a simple lack of adequate capacity, because population growth has outstripped the ability of municipalities to build treatment facilities in a timely manner. The removal of vegetation from coastal wetlands for mariculture (e.g. shrimp ponds) has also become common practice, which eliminates the ability of this vegetation to absorb nutrients. Other traditional activities, such as fishing, suffer from the deterioration of product quality (from disease) while recent advances in sciences and technology are not well understood among fishermen.

Governance

There is a lack of follow-up with respect to regulations that limit nutrient drainage to the coastal waters, because it is believed that the most efficient way to reduce coastal eutrophication is to have sound environmental management of the watersheds, following principles of sustainable

development. Although there are national laws for the protection of the marine environment, oversight and management of offshore activities are often inefficient. Catchment areas and marine waters must be managed together using a participatory approach that includes all stakeholders from both terrestrial and marine environments, combined with an integration of the effects from both public and private sectors. The study of marine environmental management and protection should be a required part of future industrial and agricultural development plans, with these new requirements accommodated for and/or mandated by law, in accordance with United Nations Conventions.

marine habitats are irretrievably being lost owing to the construction of harbours and industrial installations, tourist facilities, aquaculture, and from the growth of settlements and cities; (2) severance of the links among lakes, rivers and sea channels by construction of sluices and dikes has led to the impoverishment of the natural fisheries resource, especially for migratory fishes, causing a shortage of large-sized economic fish species that are mostly migratory among lakes, rivers and the sea; (3) estuarine and embayment habitats have been modified considerably, so that wetlands areas have been narrowed, and the natural environment of the estuaries and embayments has been altered by the conversion of beach and wetlands to farmland.

Habitat and community modification in coastal waters

The environment of the East China Sea has been faced with serious problems from pollution from the Yangtze River drainage basin and areas along the coasts where the local economy has expanded. Improper use of natural resources and a short-term economic outlook have resulted in environmental degradation over a fairly short time frame, and degradation has now reached a level at which the health and resources of the coastal region have been damaged.

In the last four decades, rapid industrialisation, combined with economic and social development in the coastal area of the East China Sea have produced three kinds of environmental problems: (1)

An analysis of the Causal chain from immediate causes of habitat and community modification to root causes is shown in Figure 34.

Immediate causes

Loss of wetlands

The wetlands in the East China Sea coastal areas include fragments in the mud flats along rivers. The dominant species in wetlands are fresh and marine water benthos, fish, shrimp and aquatic plants. These wetlands are feeding and spawning grounds where fish and other aquatic animals live. Modification of aquatic habitats is one of the most important problems resulting in the degradation of the fisheries resource. Water pollution is an important source of toxic pollutants in wetland ecosystems.

Extensive reclamation of farmland from the sea is also a serious problem in China. Thousands of hectares of shoals have been reclaimed in the

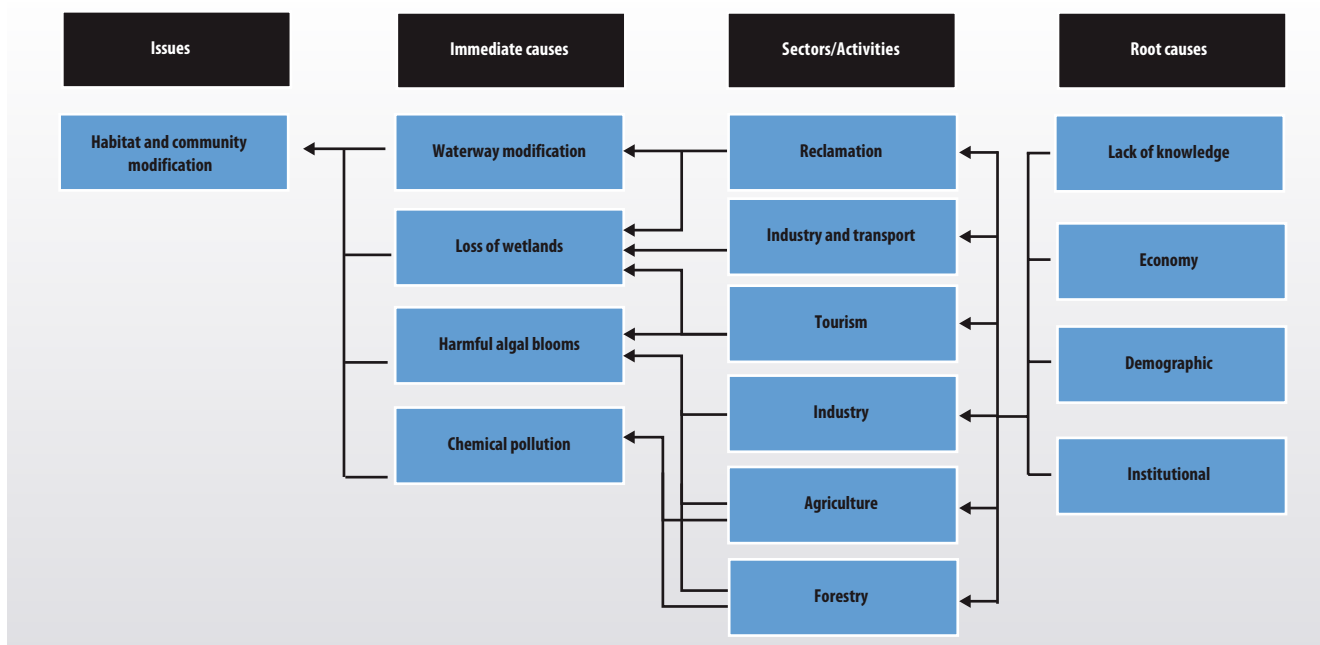


Figure 34 Causal chain diagram illustrating the causal links between habitat and community modification in coastal waters.

Yangtze River Estuary and other river coastal regions of the East China Sea, especially on Chongming Island, and in the Nanhui district of Shanghai, as well as Ningbo, Shaoxing, Zhangzhou and Zhoushan Island. Zhejiang Province is in the process of reclaiming 20 000 ha of shoals. Local governments are eager to have more land to improve the coastal economy, rather than protect living resources. This is the reason behind much of the wetland conversion into farmland.

Harmful algal blooms

Coastal China is an important economic area characterised by rapid economic development and a growing population. This has led to a significant increase of wastewater and sewage discharges directly into the East China Sea, resulting in eutrophication and harmful algal blooms. Fisheries resources and aquaculture operations are affected by these HAB events and eutrophication, which can lead to a reduction in ecological diversity, and human health problems.

Waterway modification

Construction of dams and dikes among lakes, river and sea has led to the destruction of the lake-river-sea ecosystem by severing the interconnections that are important for some migratory fish species. This has caused lakes to be dominated by species of small size and has diminished the populations of migratory species by limiting their ability to reproduce.

Chemical pollution

There are two separate threats that are currently being faced by the East China Sea as a result of the increased discharge of agricultural chemicals. Firstly, pollution from chemical fertilisers that are now widely and indiscriminately used on farmland results in direct damage to marine ecosystems, by causing eutrophication and harmful algal blooms. Secondly, overuse or misapplication of pesticides harms the biota and the ecological balance of the marine environment. More serious but indirect physical damage to the coastal and marine ecosystem results from soil erosion following deforestation, which is a major outcome of the unsustainable exploitation of forest products, which itself has caused over 1.1 million ha, or about 1%, of the region's forests to disappear due to overextraction. For example, cutting trees reduced forest coverage in the upper reaches of the Yangtze River from 30 to 40% in the 1950s to only 10% by 1998 (NBSC 2001).

Root causes

Demographic

The dense population in the coastal area of the East China Sea has inevitably resulted in great pressures on the coastal environment and its resources. The most problematic pressures are: 1) increased volumes of

both domestic and industrial waste, 2) increased requirements for land, 3) increased discharges of agricultural chemicals and, 4) increases in construction, tourism and transportation. Problems, such as insufficient financial resources for environmental management, and the need to build institutional capacity to manage these problems, militate against implementing solutions.

Because domestic and industrial effluent discharges, atmospheric deposition, oil spills and other contaminants from manufacturing wastes, shipping, coastal tourism and other economic endeavours are increasing, marine pollution has become a very serious problem in the coastal region. Most of pollutants are composed of nutrients, toxic chemicals and oil from land-based sources. With the developing economy and increasing population, the concomitant pollutant increase from these land-based sources now affects not only on the shallow inshore habitat but also the deeper/wider ocean ecosystem.

Economic

Development along the coast of the East China Sea depends heavily on the shared resources of the sea and the coastal land base. The demand for more land motivates local governments to reclaim coastal wetlands for industry, ports and tourist facilities, in spite of efforts to conserve wetlands. These activities have caused direct harm to coastal habitats, particularly in the estuarine and coastal systems. The need for land results in the loss of biological habitats. The problem is so widespread that it is difficult to estimate its significance.

Institutional

The desire to address marine pollution and other environmental problems is often hampered by the lack of sufficient financial resources. The problem is particularly acute in China where insufficient budgetary allocations are made to control marine pollution and modification of biological habitats. At present, the constraints on the management of environmental problems in China result from insufficient resources (equipment, personnel, training) and inadequate allocation of financial resources for environmental protection. Funds for garbage collection, illegal logging and dumping of wastes, operation of existing sewerage and sewage treatment facilities are simply unavailable at the levels required for environmental protection.

Lack of knowledge

A major problem confronting the countries of the East China Sea is the lack of skilled staff to undertake monitoring, surveillance and enforcement of environmental regulations. Some problems can be attributed to the fact that local environmental bureaus have helped

firms obtain permission to build factories and projects beyond what is normally permitted to protect local economies or even because of corruption. Effective law enforcement is essential for the protection of resources and the control of water pollution. In addition, a lack of education and jobs, and the growth in population in the basin are also the root causes of the problems in the marine environment.

Habitat and community modification in inland systems

Reclamation of land from lakes in the middle and lower reaches of rivers, combined with the construction of dams in the first-order tributaries have resulted in serious environmental problems and greatly modified habitats and communities that many species depend on. Central and local governments have paid more attention to these problems in recent years.

Changes in hydrological regimes and reduced winter and spring run-off result in both decreased depth of river delta waterways, reduction in delta vegetation (e.g. reeds) and saltwater intrusions. As the winter and spring water flows are reduced, the salt water of the East China Sea will move backward to the estuary of the Yangtze River longer periods of time, which in turn limits freshwater resources for domestic consumption. Furthermore, migration of fish to upper reaches of the river for spawning is impeded by reductions in river flow and essential nursery areas become inaccessible for adults. The construction of dams also destroys spawning sites. Spawning grounds for migratory species are also lost when delta vegetation is reduced. These factors have caused a drastic reduction in numbers of some species of fish, even leading to extinction of some species.

There are also concerns that the Three Gorges Dam, 2 000 km upstream from the river mouth, will cause serious negative impacts on the environment of the Yangtze River Basin. In addition, large-scale water diversion projects are under consideration for the transport of water to the Yellow River, which may cause further water shortage problems. Scientific research is essential, together with monitoring and an understanding of the effects of climate changes and anthropogenic activity at a subcontinental scale associated with such changes in hydrological cycles.

Draining and land reclamation have many adverse influences on the functions of lakes, like the Poyanghu Lake. Because of reclamation, the area of the Poyanghu has been reduced by 1 300 km² from 1954 to 1995 (Table 18) and its capacity has been reduced by 8×10⁹ m³, with the regulation coefficient decreased from 17.3% in 1954 to 13.8% in

Table 18 Changes in the area of Poyanghu Lake since 1954.

Year	Area (km ²)	Coefficient of regulation (%)	Drained areas (km ²)
1954	5160	17.3	0
1957	5004	16.9	154
1961	4720	16.0	440
1965	4410	15.2	750
1967	4128	14.2	1040
1976	3914	13.8	1246
1984	3890	13.8	1270
1995	3860	13.8	1300

(Source: Min 1999)



Figure 35 Three Gorges Dam.

1995, while the Poyanghu has been filled with 0.62×10⁹ tonnes of sands from 1954 to 1997. These activities not only reduce the area of the Poyanghu and change the lake's shape, but also elevate flood levels and degrade water quality. Land reclamation may heighten the water table during flood peak, lengthen the duration of high floods, and increase the probability of disasters (Min 1999). Aquatic vegetation and fish species are greatly affected by the associated loss of habitats and/or ecotones.

Almost all the large rivers that flow into the East China Sea have been dammed (Figure 35), particularly in the Yangtze River drainage system, to produce energy, prevent floods and improve navigation. In the headwaters of Yangtze River, more than 10 000 dams have now been constructed. As a result, plankton, benthos, birds and fish communities in rivers are affected by these reservoirs. Because of dam construction, large terrestrial areas have been inundated, which has caused a loss of terrestrial habitats. The primary production of the East China Sea has changed as a consequence of the changed patterns of river discharge and organic loads. The dams have also blocked migration routes and destroyed spawning grounds for anadromous fish.

Figure 36 summarises the major characteristics of the causal chain analysis with regards to loss of ecosystems or ecotones and modification of ecosystems or ecotones in this region, linking the problems of land reclamation and changes in stream flow with immediate and root causes.

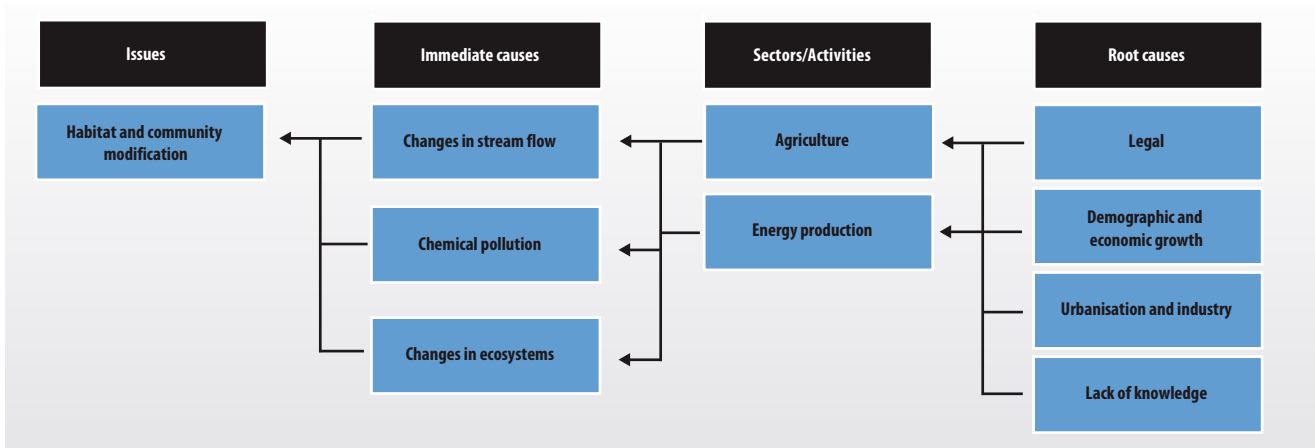


Figure 36 Causal chain diagram illustrating the causal links among habitat and community modification in inland systems.

Immediate causes

The immediate causes behind land reclamation from lakes can be summarised as follows:

- Changes in ecosystems: conversion of ecosystems by changes in land use, for example, conversion of water to farmland, and wetland to urban areas; and flooding of ecosystems as a result of human activities, because of land reclamation, so that the capacity of the Poyanghu to prevent floods is weakened.
- Chemical pollution: unsustainable agriculture practices, such as deforestation and chemical fertiliser use.
- Changes in stream flow: changes in freshwater and sediment supplies due to dams.

Root causes

The root causes that have allowed or resulted in freshwater habitat and community modification are summarised as follows:

Legal

There are no appropriate laws and regulations to control this situation at an international level, and the lack of enforcement of national environmental legislation in regulating the change of stream flow by hydroelectric construction has resulted in freshwater shortages and water quality problems, along with a loss of habitats to a substantial degree. There exist no solutions that can solve the problems of economic development and growth while simultaneously promoting sustainable use of resources.

Demographic and economic growth

The rapid progress in urbanisation and migration of inland population to the coast and the increase in population growth has resulted in the economic development without regard for environment impacts, including, for example, the negative effects of reclamation

for agriculture and settlement. With the increasing population and economic growth, the demand for resources (electrical energy) increases as well. Thus the construction of facilities (e.g. dams and power station) cannot be avoided.

Urbanisation and industry

More and more arable lands have been taken over for infrastructure development and expansion of cities, which has caused irreversible problems in the basin (e.g. loss of habitats and ecotones).

Lack of knowledge

The population is not been well educated about environmental protection, and there is a general lack of awareness of environmental protection. There is inadequate scientific understanding and unreliable information for industry concerning the problem of environmental damage.

Conclusion

Some specialists who deal with environmental protection projects have been frank and open about the problems of pollution from land and the governmental issues that cause them. In the East China Sea, the level of environmental awareness on the part of the population, government officials, and business leaders is ever increasing. The problems enumerated above demand attention. The marine environment in the East China Sea is critical to the environmental and economic health of the region. Technical and human resources and financial assistance are available and should be found, both in China itself and from international support.