

# 10 Seto Inland Sea

## Overview

The Seto Inland Sea is the largest inland sea in Japan. Ten prefectures border it, and 3 additional inland prefectures are close to it on the islands of Honshu, Shikoku, and Kyushu. The Sea stretches up to 450 km east to west, and 15 km to 55 km north to south. It is connected to the Pacific Ocean through the Kii Channel on the east and to the Sea of Japan through Bungo Channel and Kanmon Strait on the west.

## Location



### Basic information

Surface area : 23,203 km<sup>2</sup>

Volume : 8,815 km<sup>3</sup>

Average depth : 38 m

## Nature

### < Background >

The Seto Inland Sea is the largest inland sea in Japan and is connected to the Pacific Ocean and the Sea of Japan through narrow channels and straits. Numerous straits, coves, and reefs of various sizes are scattered along the rugged coast. The total length of this coastline is 6,868 km. Many islands are scattered throughout the Sea and provide world-famous picturesque scenery. Although the Sea itself connects to the open ocean on the east and west, the many shallow areas give it the character of a semi-enclosed sea. It lacks the physical constancy of the open ocean and there are strong, tidally-induced currents in the straits that connect to the ocean.

### Topography

Most parts of the Sea are relatively shallow, with 98 per cent of the area being less than 70 m deep. Only some areas, close to straits and channels, are over 100 m deep. The maximum depth is found at Hayami-Seto, a deep basin north of the Bungo Channel.

### Hydrology

Currents are strong in the Sea due to the large tidal range, complex topography, narrow channels and narrow straits. The tidal range is between 1 and 3 m in the east, and 3 and 4 m in the west. Tides easily produce currents of a few knots. In the narrow channels, such as Naruto and Hayami-Seto Straits, the current

speed may be up to 10 knots.

### < Surrounding environment >

The Sea has a temperate climate that is warm and humid. The mean annual air temperature is 15 and the annual precipitation is between 1,000 and 1,600 mm. Numerous islands, white-sand beaches and terraced fields form a representative image of the area.

#### *Amphioxus*<sup>1</sup>



Seaweed beds and tidal flats are widely distributed, making the area home to various organisms, including rare species such as the Indian porpoise, horseshoe crab and arrow worms in the genus *Amphioxus*.

#### Whirlpool at Naruto Strait



<[http://www.seto.or.jp/setokyo/kankou/panf/seto\\_panf/seto\\_nigongo/j\\_page5.htm](http://www.seto.or.jp/setokyo/kankou/panf/seto_panf/seto_nigongo/j_page5.htm)>

#### Tidal flats and seaweed beds

Over 26,424 ha of seaweed/seagrass beds are found in the Sea. Tidal flats have a total area of 11,734 ha, about half of which are found in Suo-Nada in the west.

#### Seto Inland Sea National Park

Many parts of Seto Inland Sea are designated as national or semi-national parks, and these areas are considered as some of the most beautiful sites in Japan. Among these, Seto Inland National Park, one of the oldest national parks, has been highly praised for its picturesque landscape.



### < Tourism >

The coastal areas are major recreational and tourist destinations for the local residents, as well as for many domestic and international visitors. Twenty-five per cent of the Sea coastline is designated as part of Seto Inland National Park. Various recreational facilities have been installed in the Park to increase enjoyment of the surrounding nature. In 2000, approximately 42 million people visited the national park. Of the 28 Japanese national parks, this is second only to Fuji-Hakone-Izu's 99 million visitors per year.

#### Itsukushima Shrine (a World Heritage site in the Seto Inland area)

Itsukushima Shrine was built in the 12th century by Taira-no-Kiyomori, one of the men in power during the Heian Period. The shrine stands in the sea and is surrounded by steep lush mountains in the background. It is highly appreciated for its unique and beautiful Japanese-style architecture, and was declared as a World Heritage site in December 1996.

#### Itsukushima Shrine



<<http://www.tanoshimimura.com/photo/hiroshima/miyajima.htm>>

## History and Culture

### < Formation of Seto Inland Sea >

Approximately 1.5 million years ago the Sea began to form its present shape. The process ended only around 10,000 years ago.

Research suggests that during the Ulm glacial epoch, nearly 20,000 years ago, the sea surface was 130 m lower than today, and that most of the Seto Inland Sea was above sea level. The low sea level meant that

the Japanese Archipelago was directly connected with the Eurasian continent, such that mammoths and other animals could easily migrate from Asia to Japan. However, rapid climate warming at the end of the glacial epoch accelerated the shrinkage of continental glaciers in Canada and the Scandinavian region, so that sea levels rose all over the world. It was then that the Seto Inland Sea was born and reached the state that it still is today.

< **Cultures surrounding Seto Inland Sea** >

The Sea has served as a crucial place for communication between bordering countries. Consequently, various cultural assets remain along the coasts, both tangible and intangible. Many of the assets are designated as historic and scenic sites, or natural monuments.

Various festivals are centered around the Sea. During the festivals, people express their reverence for the sea and also pray for prosperous fishing.

**Number of areas designated as historic and scenic site or as natural monument**

Category	No. of areas
Historic	40
Scenic	19
Natural monument	33

<<http://www.emecs.or.jp/olcd-rom/section3/seto/gaikyo/bunka.htm>>

**Old Sakai light house in Osaka**

Built in 1887, by the citizens of Sakai City. Designated as a historic site, its beautiful frame still sits at the entrance of Sakai Old Port.



< <http://www.uminet.jp/movearound/gmap/osaka.htm> >

**Kashiwajima Shrine Festival in Hiroshima**

Kashiwajima Shrine is built on a remote island off Hiroshima Prefecture and is a shrine for safe sea travel and fishing. Each year in June, people celebrate the god that lives in this shrine.



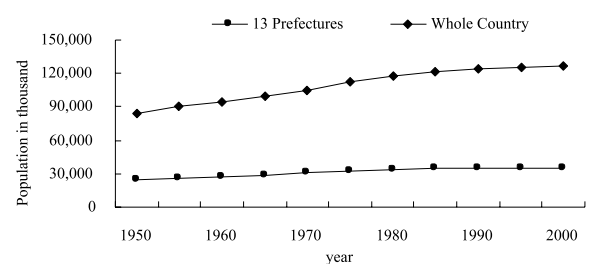
< <http://www.uminet.jp/movearound/gmap/hirosima.htm> >

**Social Environment**

< **Population** >

The Seto Inland Sea area has a total population of approximately 35 million, which is nearly 28 per cent of Japan's entire population. The number has increased 1.5 times since 1950 and is still increasing, although at a slower pace. The population density is 647 inhabitants/km<sup>2</sup>; 1.9 times higher than the nation's average.

**Change in total population of the surrounding prefectures**

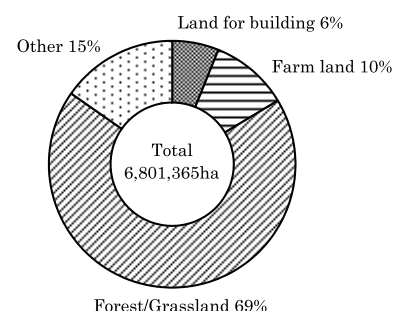


< <http://www.stat.go.jp> >

< **Land use** >

The total area of the 13 prefectures that are closely related to the Sea is 6.8 million ha (census fiscal year [FY] 1999). Among these, forests and plains account for 4,640,000 ha; 69 per cent of the total. Agricultural land and residential and industrial areas account for 700,000 ha (10%) and 410,000 ha (6%), respectively. The remaining 1,050,000 ha (15%) are lakes, rivers, inlets and roads.

**Status of land use in the surrounding prefectures**



< <http://www.stat.go.jp> >

< **Industry** >

Since ancient times, people have gone to the Seto Inland Sea area's for its abundant resources and warm climate. Coastlines have been highly developed, facilitating various human activities in and around the Sea.

Since 1955, the heavy metal and oil industries have built industrial complexes along the coastal zones. The national share of the main industries of the area, the iron-metal working industry, petrochemical industry, and pulp industry, are approximately 46, 37 and 29 per cent, respectively.

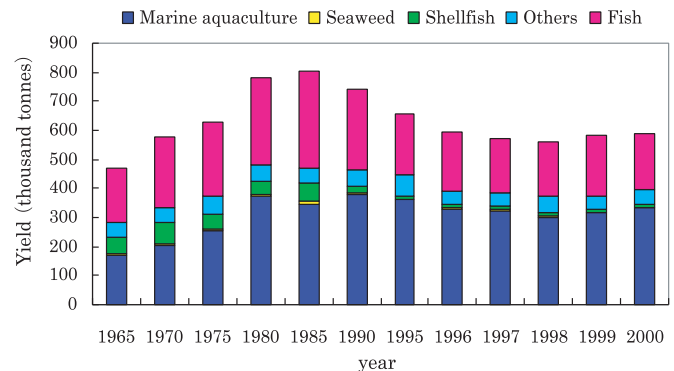
The Sea is also an important region for maritime traffic. The annual cargo tonnage arriving at ports and harbors in the area is 1.6 billion tons; half of the nation's total.

### Fisheries

Biological productivity per unit area is quite high in the Seto Sea. This is due to the Sea's geographical complexity, including many straits, coves and open water areas, combined with rich nutrients inputs from rivers. The result is that the Sea accommodates a diverse number of fish and other marine life.

However, the total fish catch is declining because of urbanization and coastal development that is resulting in the loss of tidal flats and seaweed beds. The overall effect is the degradation of the area's environment. As an alternative, some fishermen have shifted to aquaculture, with seaweeds and yellowfin tuna as some of the major products. Aquaculture has been successful and has maintained high production rates so far.

Change in fishery production in Seto Inland Sea<sup>2</sup>



## Environmental Problems

### < Water and sediment quality >

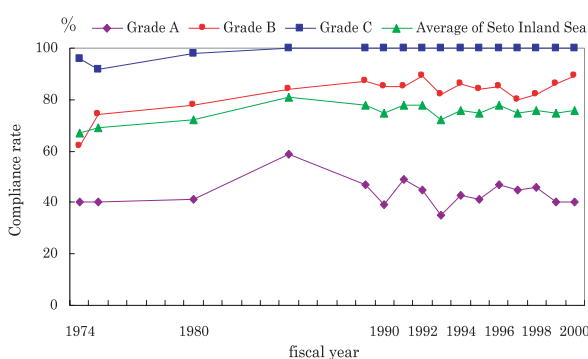
The Sea is greatly influenced by incoming rivers due to its relatively shallow depth. Seasonal fluctuation in water temperature and salinity, influenced by rainfall, makes the area susceptible to episodic events, such as red tides.

During the high economic growth period after World War II, large parts of the shallow coastal areas were reclaimed to construct industrial and residential zones. Large quantities of industrial effluents, as well as domestic sewage, were released into the sea. The water quality rapidly deteriorated in the process and also triggered frequent red tides, resulting in extensive damage to fisheries. The damage was as high as 70 billion yen when many cultured fish died from suffocation. In addition to the deterioration of water quality, huge losses of natural coastlines forced people farther away from the Sea.

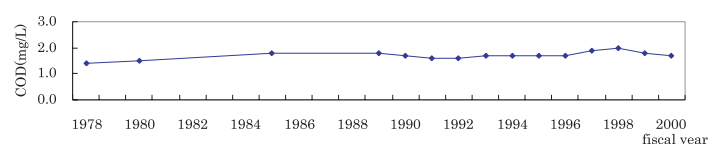
### Water Quality

Levels of COD and total phosphorus have followed a steady decline over the years, whereas total nitrogen has declined very little. When compared with national water quality standards, areas designated as Grade A, where COD values are equal to or less than 2 mg/L, had a compliance rate of 40 per cent.

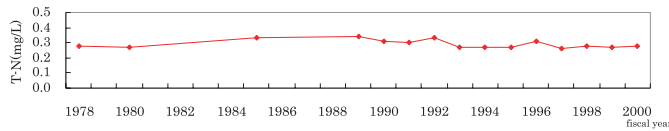
Change in COD compliance rate with the environmental standard<sup>2</sup>



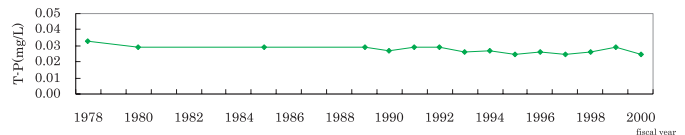
Change in COD concentration in Seto Inland Sea<sup>2</sup>



Change in T-N concentration in Seto Inland Sea<sup>2</sup>



Change in T-P concentration in Seto Inland Sea<sup>2</sup>



**Red tides**



The number of red tides has gradually increased since the 1960s, which coincides with the period of rapid economic growth. The highest annual record occurred in 1976, with 326 cases of red tides.

Phytoplankton such as *Heterosigma*, *Skeletonema*, *Noctiluca*, *Prorocentrum*, and *Gymnodinium*

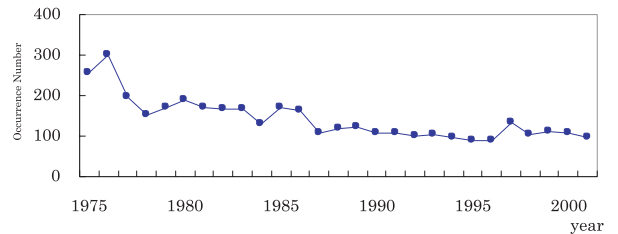
are notorious for causing red tides.

*Chattonella* can

also cause red tides, and outbreaks of these plankton species have caused extensive damage to fisheries and aquaculture, including yellowfin tuna aquaculture.

Efforts at improving water quality have gradually reduced the number of red tides to about 100 cases per year. Red tides are still frequently observed in Osaka Bay, Kii Channel, Harima Sea and Hiroshima Bay, whereas few occur in Iyo Sea and Bisan-Seto Sea.

Trends in red tide occurrences<sup>2</sup>



Areas of red tides recorded in 2001<sup>2</sup>



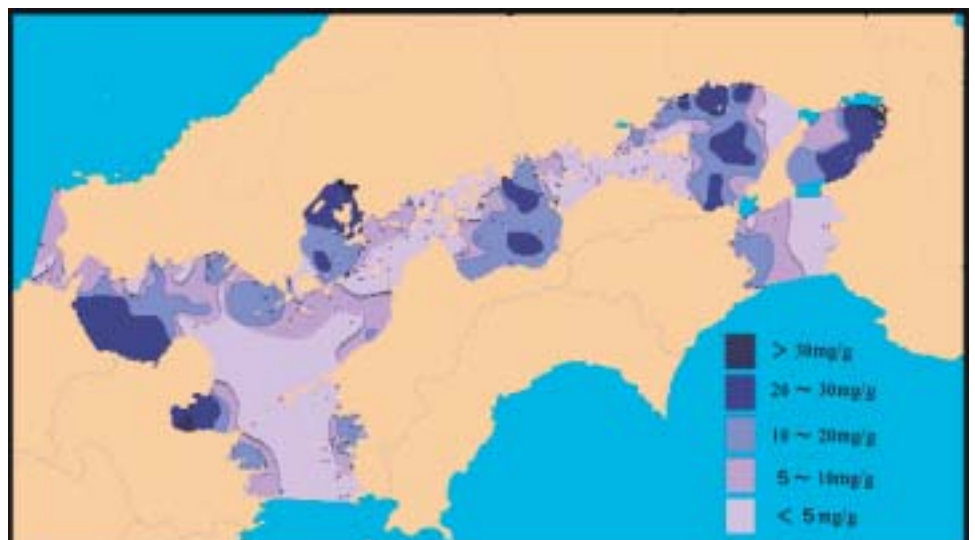
**Sediment quality**

Sediment quality in the Sea is deteriorating, particularly in areas with stagnant water or small tidal movement.

**< Pollution source >**

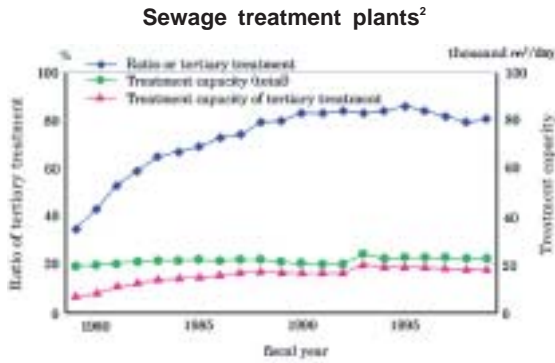
Six hundred and sixty four rivers, including 21 first-grade rivers, flow into the Sea, with a total annual freshwater input of 50 billion m<sup>3</sup>. Pollutants from industrial effluent and domestic sewage are discharged into the Sea through these rivers.

COD concentration in sediments<sup>2</sup>

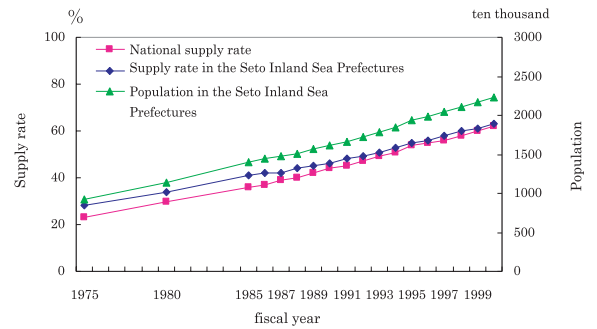


**Sewerage distribution among the coastal area**

According to a survey by the Ministry of Land, Infrastructure and Transportation of Japan, the regional supply rate of the sewerage system was 28 per cent in 1975 (national rate 23%), but increased to 61 per cent by the end of 1999 (national 61%).



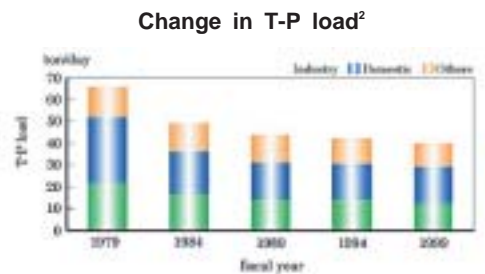
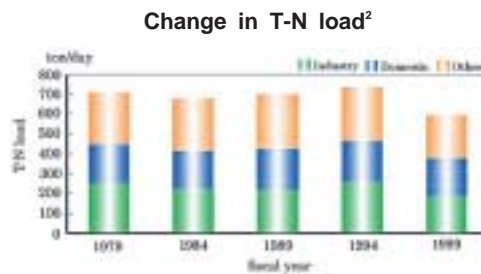
**Supply rate of sewage facility<sup>2</sup>**



After banning the direct discharge of human wastes, several treatment facilities have been constructed. However, some human wastes are still being discharged into the open ocean.

**Pollutant load in the Sea**

Trends in the pollutant load of total nitrogen and total phosphorus are shown in the figures below. There has been a reduction since 1979, when the Environment Protection Agency of Japan implemented phosphorus reduction policies. As of 1999, the total phosphorus load had been reduced by 40 per cent.



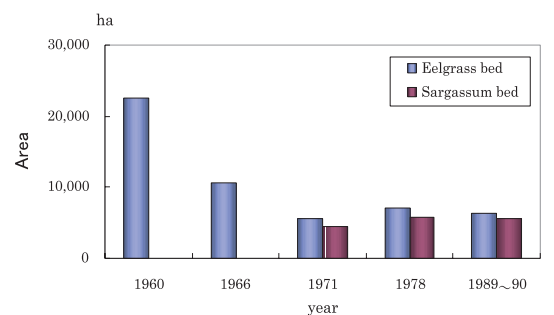
< **Other environmental problems** >

**Reduction of shallow water areas**

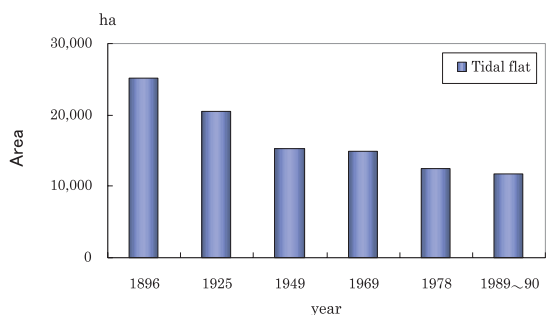
Extensive reclamation activities have been conducted in the Seto Inland Sea, resulting in significant reductions in the areas of seaweed beds, tidal flats and natural coastlines. Today, the remaining areas of seaweed beds and tidal flats are 26,424 ha (including 6,381 ha of eelgrass beds) and 11,734 ha, respectively. Eelgrass beds are now less than 30 per cent of what they were in the early 1960s and tidal flats are half of what they were 100 years ago. Areas where the most drastic losses have occurred since 1978 are in the northern Harima Sea (loss of 377 ha, 41% of the original) and the eastern Bisan-Seto Sea (17.5%) for seaweed beds, and Beppu Bay (281ha: 40%) and the Bingo Sea (13.7%) for tidal flats.

The undeveloped coastline of the Seto Sea extends over 2,538 km, which corresponds to 37 per cent of the total coastline. However, approximately 160 km of the natural coastline disappeared over the 15 years from 1978 to 1993, corresponding to approximately 3 per cent of the total coastline.

**Change in seaweed / seagrass bed area<sup>2</sup>**



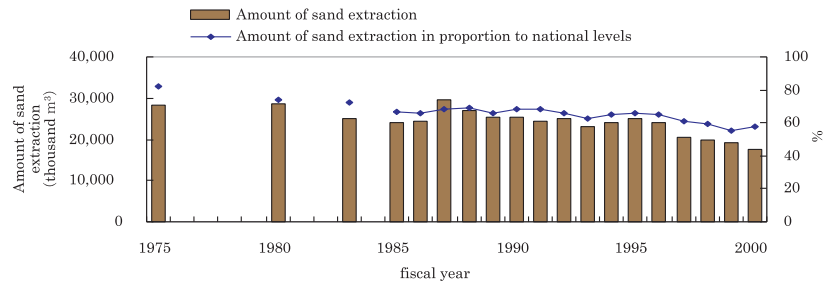
**Change in tidal flat area<sup>2</sup>**



**Mining of sand and gravel**

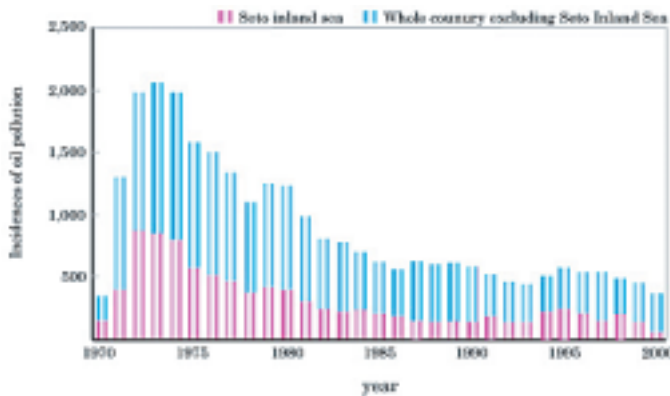
The Seto Inland Sea area is famous for the mining of sand and gravel for use in concrete. Annual production was 20 to 30 million m<sup>3</sup> in FY 2002, which corresponds to nearly 58% of all mining production in Japan. The possible environmental impacts of mining are increased turbidity from the dispersion of fine particles in effluent from transport ships, physical alteration of topography, and direct and indirect damage to marine life, especially those living on sandy bottoms, such as the sand lance.

**Change in sand mining production<sup>2</sup>**



**Oil spills**

**Number of oil pollution incidences<sup>2</sup>**



Oil spills are another concern for water pollution, as the transportation of oil is increasing in the Sea. Since the establishment of the Law Relating to the Prevention of Marine Pollution and Maritime Disasters, great efforts have been made to prevent such spills, through enforcing various control measures and monitoring systems. This has resulted in a drastic decline in oil spills since 1972. However, approximately 10 oil spills still occur in the Sea every year, which is twice as many as the national average.

< **Environmental protection measures** >

Various legal measures have been established to protect the environment of the Seto Inland Sea, such as the Water Pollution Control Law (1970) and the Law Concerning Special Measures for Conservation of the Environment of Seto Inland Sea (1978). Based on the legal requirements, master plans for environmental protection have been prepared at national and prefectural levels.

**Prevention of water pollution**

The Seto Inland Sea, along with Tokyo Bay and Ise Bay, are the major enclosed sea areas in Japan. In order to prevent water pollution, comprehensive reduction plans have been prepared to reduce the COD from domestic sewage, industrial effluent and other pollution sources. A revised plan is due at the end of FY 2004. This plan will include control measures for total nitrogen and total phosphorus load, which should further reduce COD.

**Establishment of national water quality standards for nitrogen and phosphorus**

The national water quality standard for COD has already been established and implemented for public water bodies. In addition, national water quality standards were established in 1993 for the Seto Inland Sea to prevent eutrophication from nitrogen and phosphorus. Furthermore, 88 designated sea areas in Japan (including the Seto Inland Sea area) which are likely to suffer from heavy algal blooms, especially during summer, have emission standards for nitrogen and phosphorus. In compliance with the Law Concerning Special Measures for Conservation of the Environment of the Seto Inland Sea, construction and modification of pollutant-releasing facilities requires permission from prefectural authorities.

**Protection of shallow waters**

Land reclamation must be in compliance with the Law Concerning Special Measures for Conservation of

the Environment of the Seto Inland Sea, and the reclaimed area should be minimized. The law also requires special consideration of environmental protection for reclamation projects. Some of the local governments finally decided to ban mining of sand and gravel to try and reduce dependency of the region on natural resources.

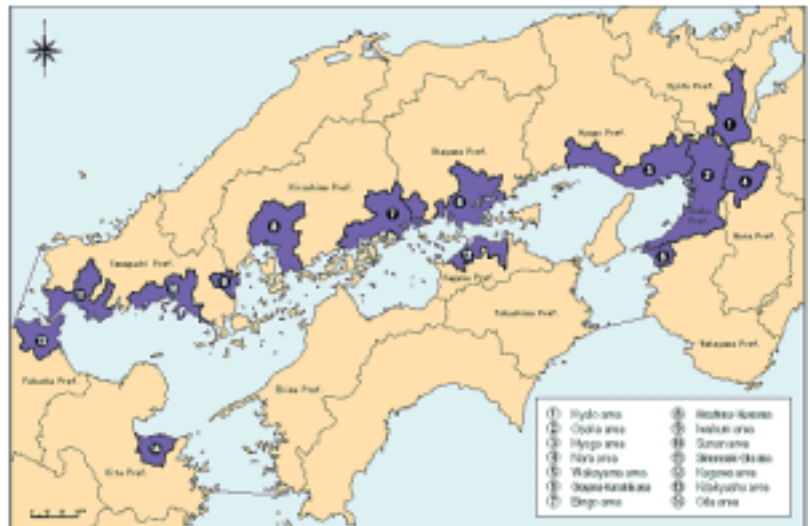
### Regional Environmental Pollution Control Programs

Fourteen regional environmental pollution control programs have been established and implemented by the local governments surrounding the Seto Inland Sea. Some of the projects under these programs are effluent control, further installation of sewerage systems and dredging of contaminated material.

### Other activities

Other projects that are ongoing around the Sea include the preservation of seaweed beds and tidal flats and the preparation of beaches. Small practices at the resident level, such as the promotion of phosphorus-free detergent and beautification of the environment, also contribute to maintaining and improving the environment of the Sea.

Regions conducting Regional Environmental Pollution Control Program<sup>2</sup>



### Related organizations and NGOs

- Statistical Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications  
< <http://www.stat.go.jp/> >
- Land Information Division / Land and Water Bureau, Ministry of Land, Infrastructure and Transport  
< <http://tochi.mlit.go.jp/> >
- Japan Coast Guard < <http://www.kaiho.mlit.go.jp/> >
- The Association for the Environmental Conservation of Seto Inland Sea < <http://www.seto.or.jp> >
- The Setouchi Research Institute < <http://www.dango.ne.jp/sri/> >
- National Research Institute of Fisheries and Environment of Inland Sea, Fisheries Research Agency  
< <http://ss.nnf.affrc.go.jp> >
- Miyajima-cho < <http://www.hiroshima-cdas.or.jp/miyajima/top2.htm> >
- Uminet < <http://www.uminet.jp/> >

## References

1. International EMECS Center, 2001. Environmental Guidebook on the Enclosed Coastal Seas of Japan (88 sea areas). (in Japanese)
2. The Association for the Environmental Conservation of Seto Inland Sea. Environmental Protection in the Seto Inland Sea (Appendix). (in Japanese)
3. Tomotoshi OKAICHI et al. Biological Resources and Environment of Seto Inland Sea. Kouseisha-kouseikaku Corporation. (in Japanese)