

Impacts of global warming on bio-products of marine and coastal system

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Both environmental and human factors affect the bio-products in ocean and coastal ecosystems. Recent decades have seen more frequent and stronger climate variations and changes compared to the relative stability of the climate from 1840. Ocean warming have direct consequences for species distribution and habitats and also indirect consequences for food web in marine ecosystems.

Understanding the functioning of marine ecosystem and how they respond to global change is essential to manage marine living resources such as fisheries effectively, to the sustainable development.

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- **Physical oceanography and climate variations to induce changes of marine ecosystems**
- **Living resource dynamics in relation to ocean and climate**
- **Climate-induced change in small pelagic fish productivity in Chinese waters**
- **Decadal-scale variation of ecosystem productivity and control mechanism**
- **Main scientific issues essential to be address**

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➤ Physical oceanography and climate variations to induce changes of marine ecosystems

Long-term variations of physical environment parameters in the ocean plays an important role on influencing the marine ecosystem dynamics.

Oceanic temperature variation not only affects directly the metabolic rates of the organisms but also influences other oceanic states, such as sea level and therefore local currents.

Variations of oceanic temperature can influence the substrate structure, photosynthetic light intensity, water-column stratification and nutrient cycling and therefore productivity of living marine resources.

➤ Physical oceanography and climate variations to induce changes of marine ecosystems

Climate changes impacting the ocean ecosystem can be marked by the air temperature (AT), monthly mean sea surface temperature (SST) and sea surface salinity (SSS). Investigations of the Bohai Sea ecosystem shows that population of phytoplankton and zooplankton, benthic community biomass, fish resources and species diversity change with influence of AT, SST and SSS.

In 1992-1993, the total biomass had decreased by 30% and the total biomass of phytoplankton and zooplankton had decreased by 50% compared with 1982-1983.

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➤ Living resource dynamics in relation to ocean and climate

Nature factors impact an important long-term changes on biomass yields of resources populations in the ocean and coastal ecosystems. The altering in the abundance of the species of various ecotypes are correlated with climate change. Small pelagic fish and shellfish species, such as Pacific herring and prawn, are more sensitive to climate change. The Yellow Sea ecosystem study is an example of the impact.

➤ Living resource dynamics in relation to ocean and climate

Yellow Sea ecosystem:

- 1) primary production $60\text{gC}\cdot\text{m}^{-2}\cdot\text{yr}^{-1}$, relative low
- 2) phytoplankton biomass relatively stable over the past 30 years
- 3) zooplankton annual biomass declined by amount 50% from 1959 through 1986. There is a similar trend in the East China Sea.

➤ Living resource dynamics in relation to ocean and climate

Extreme overexploitation is one factor causing decline in abundance for the most important commercial demersal species in the Yellow Sea, such as small yellow croaker, hairtail, large yellow croaker, flatfish and Pacific cod. The fluctuation in abundance for some demersal species may be affected by both natural force and human activities.

Biotic communities of the YS ecosystem are complex in species composition, spatial distribution, and community structure with the marked seasonal variation.

➤ Living resource dynamics in relation to ocean and climate

Fish resources in YS ecosystem are multi-species. Warm temperature species are the major component, accounting for about 60% of the total biomass of the resources. Warm-water species and cold temperature species account for 15% and 25 % respectively. Demersal and sem-idemesal fish species account for 58% and pelagic species for about 42%.

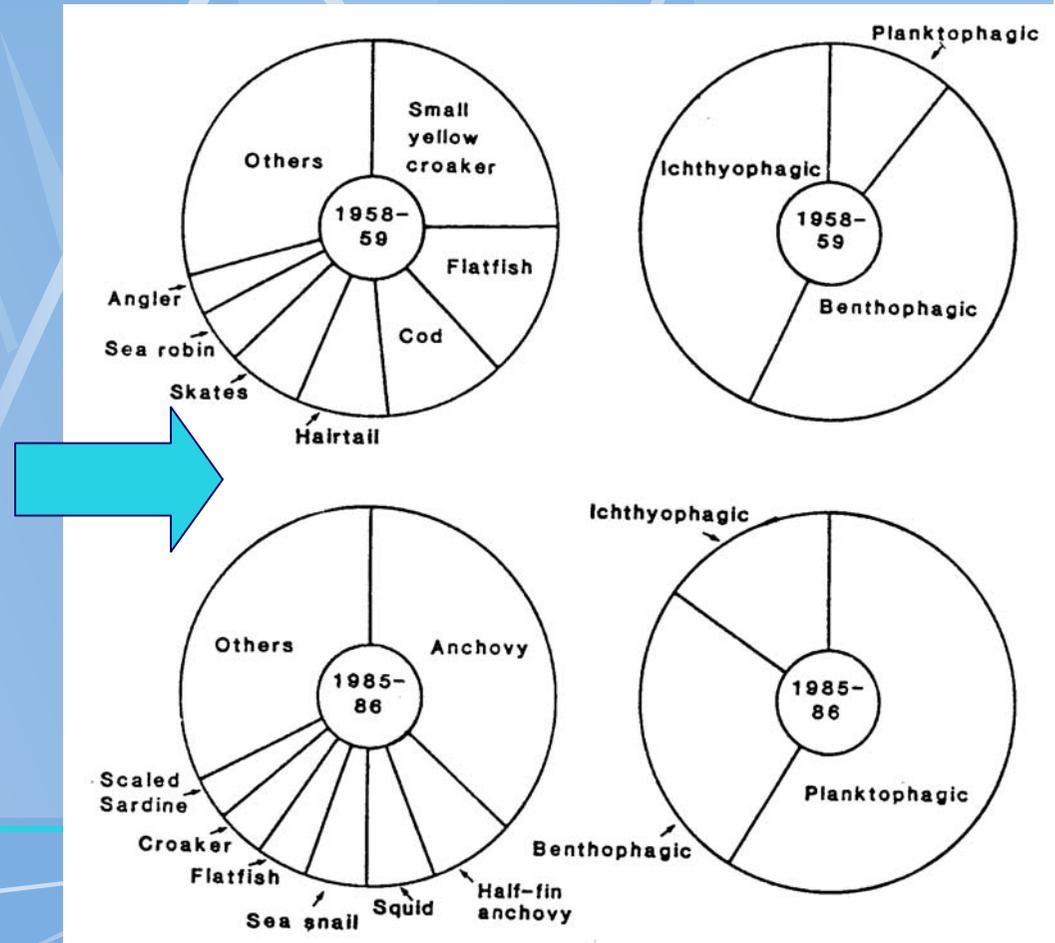
➤ Living resource dynamics in relation to ocean and climate

About 20 major species account 92% of the total biomass of the resources population and about 80% species account for the other 8% population. The dramatic shifts of species dominance in the ecosystem occurred from the 1950s through the 1980s. The dominant species in the 1950s and early 1960s were small yellow croaker and hairtail, while Pacific herring and chub mackerel became dominance in the 1970s. Some small-size, fast-growing, short-lived and low-value species such as Japanese anchovy and half-fin anchovy increased markedly in abundance in the 1980s and have taken a prominent position in the ecosystem resources.

➤ Living resource dynamics in relation to ocean and climate

Rainfall, wind and daylight appear to be the major factors affecting fluctuations of recruitment. The long-term changes in herring abundance may be correlated with the 36-years cycle of dryness-wetness oscillations in eastern China.

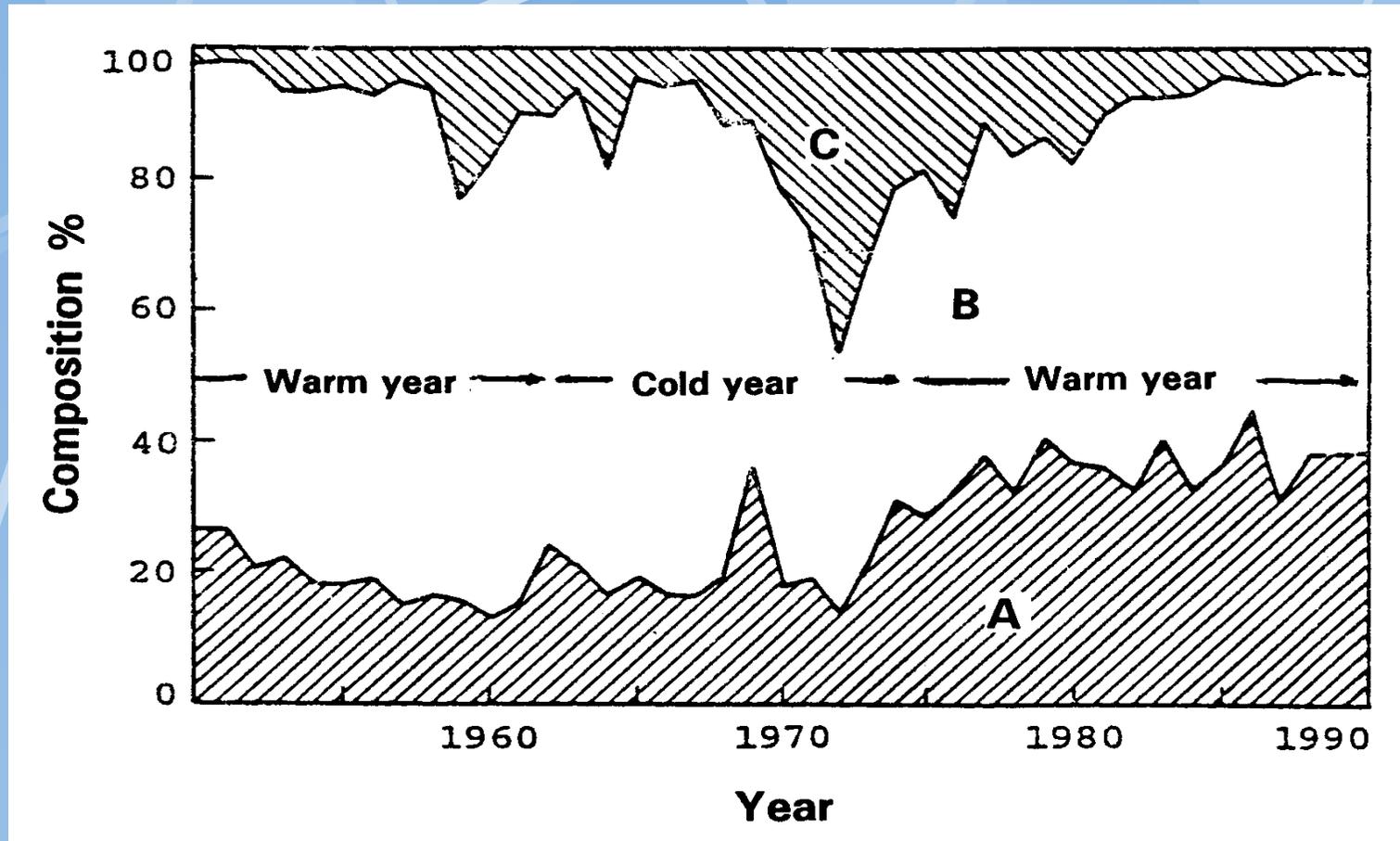
Proportion of major species and feeding habits in the biomass yields, based on the Yellow Sea surveys in 1958-1959 and 1985-1986.



➤ Living resource dynamics in relation to ocean and climate

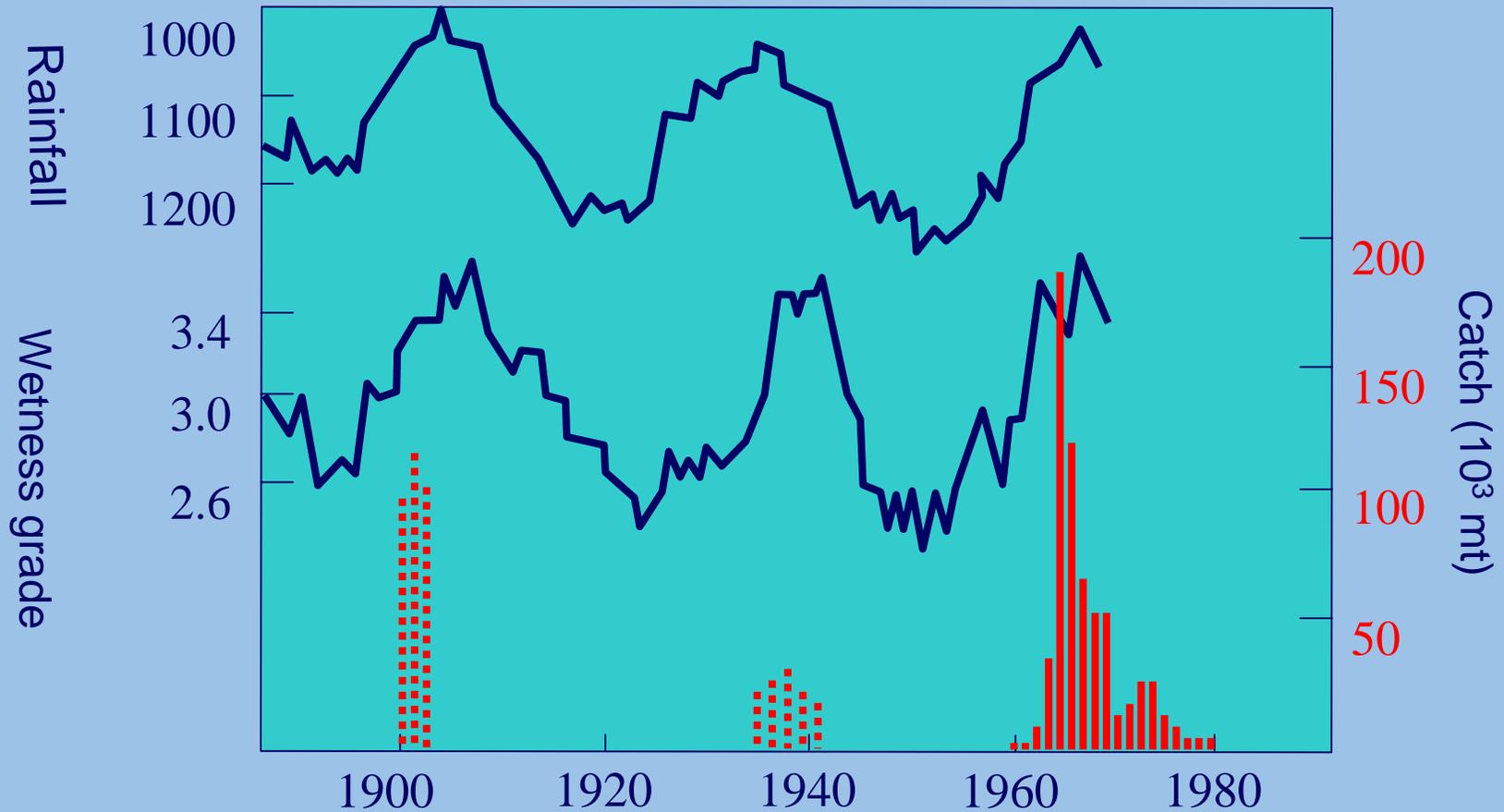
Two types of species shifts in the ecosystem resources are systematic replacement and ecological replacement. Systematic replacement occurs when one dominant species declines by overexploitation and another competitive species increase. Ecological replacement occurs when minor changes in the natural environment impact stock abundance, especially small pelagic species. The natural environment variations have an important effect on long-term changes in dominant species of various ecotypes.

➤ Living resource dynamics in relation to ocean and climate



The warm and temperate species (A and B) increase during warm years in 1960s and 1980s. Boreal species (C) trend to increase in cold years as 1970s.

➤ Living resource dynamics in relation to ocean and climate



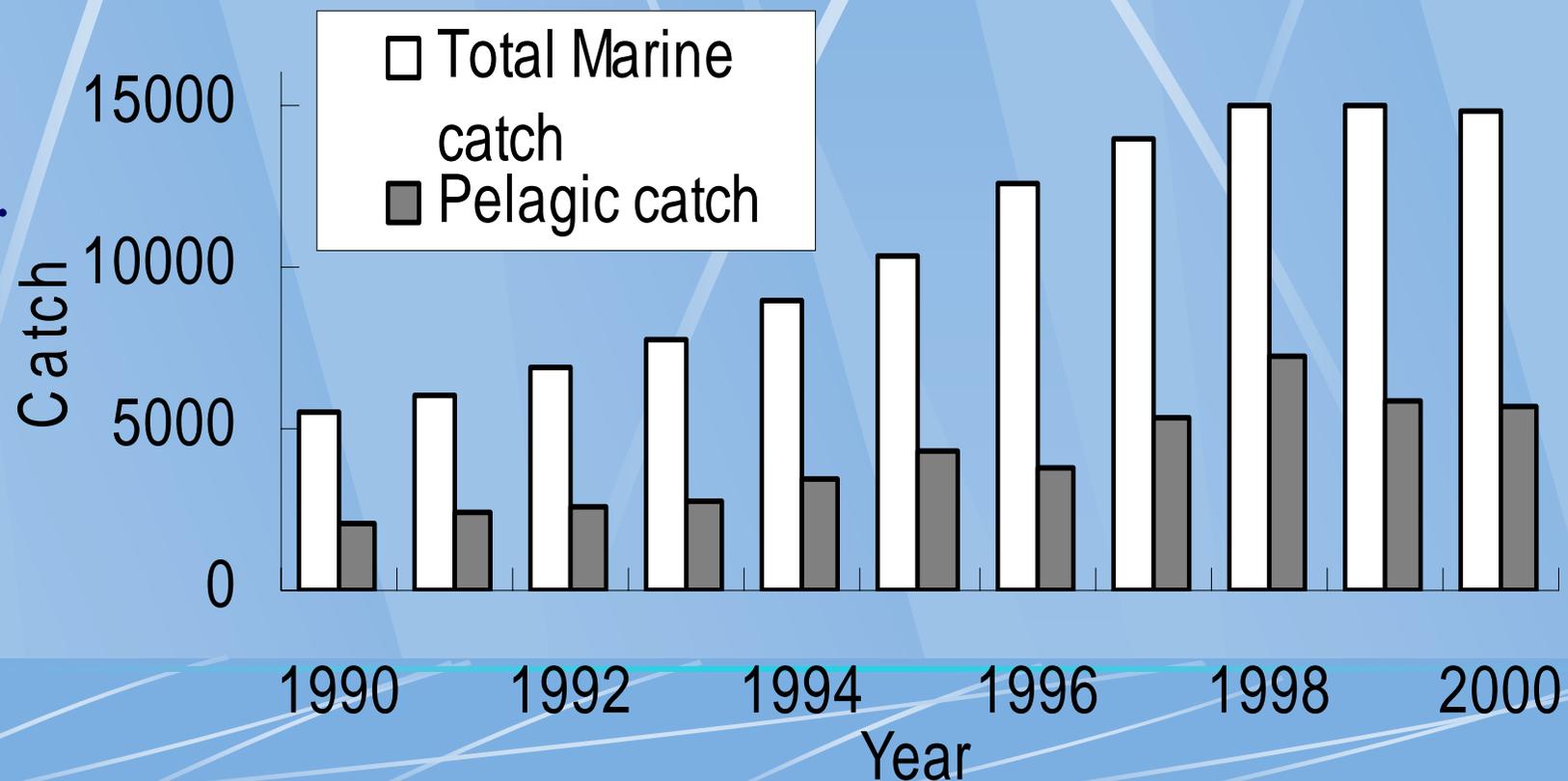
Relationship between the fluctuations in herring bundance of the Yellow Sea and the 36-yr cycle of wetness oscillation in eastern China.

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➤ Climate-induced change of small pelagic fish productivity in Chinese waters

Resources of small pelagic fish are abundant in China coastal waters and offshore. The mean annual catch accounted 39% in total marine catch in last decade. The highest production is 7.18 million tons in 1998.



➤ Climate-induced change of small pelagic fish productivity in Chinese waters

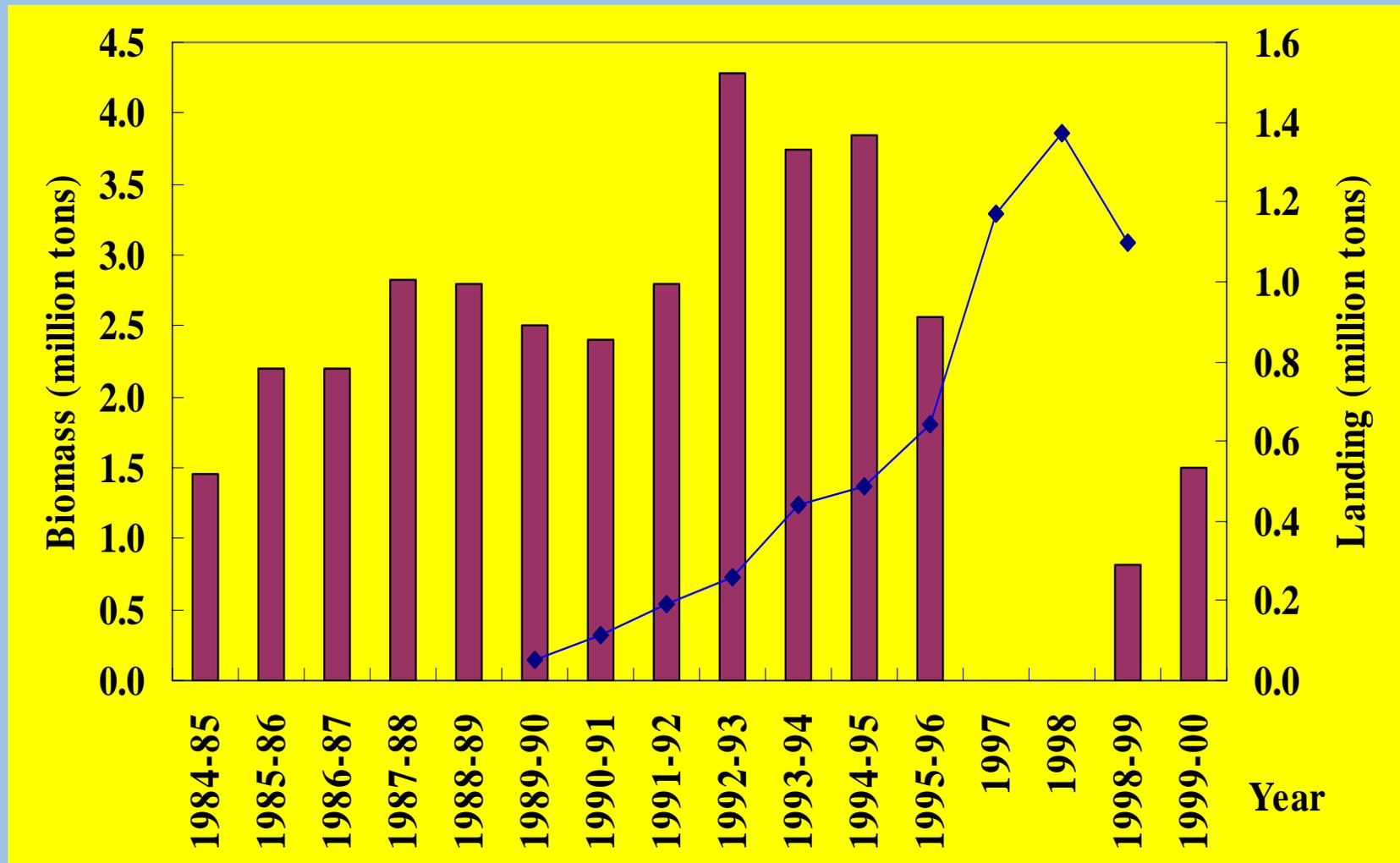
The mean annual pelagic catch of China was 4.15 million tons from 1990 through 2000. 7 species which annual production was ever more than 100 thousand tons. Annual catch of 4 important species 1990-2000 are showed here (1000 tons) .

Species	1990	1992	1994	1996	1998	2000
Japanese anchovy	54	193	439	671	1373	1143
Spanish mackerel	209	147	203	284	517	497
Silver pomfret	83	73	138	220	303	339
Pacific herring	3	2	1	2	21	15
Total pelagic catch	2105	2619	3438	3802	7181	5758

➤ Climate-induced change of small pelagic fish productivity in Chinese waters

Japanese anchovy is the most abundant pelagic species distributed widely in the northwest of Pacific. The anchovy stocks in winter are located mainly in the area of the depths 40-80m with water temperature of 7-14°C in the Yellow Sea and the East China Sea. It's biomass was estimated at the average of 3.0 million tons in the Yellow Sea and East China Sea based on the winter surveys by R/V Dei Dou conducted 1986-1995. The biomass of the stock fluctuated in the levels of 2.5-4.3 million tons. The total Chinese yield of anchovy was 54,000 tons in 1990 and it reached 1,373,000 tons in 1998.

➤ Climate-induced change of small pelagic fish productivity in Chinese waters



Yearly variations of anchovy biomass and landings

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➤ Decadal-scale variation of ecosystem productivity and control mechanism

During past four decades, productivity and community structure of the Bohai Sea ecosystem has been highly variable. Decadal-scale variations are described using the survey data from 1959-60, 1992-93 and 1998-99. Result indicates that a large productivity variation in ecosystem is an important characteristics of coastal ecosystem dynamics. Productivity changes at different trophic levels are described by

- ❖ primary production
- ❖ zooplankton biomass
- ❖ **fish productivity.**

- **Decadal-scale variation of ecosystem productivity and control mechanism**

Primary production

- **It was at a relatively high in the Bohai Sea before 1982**
- **Yearly average abundance of phytoplankton showed an declining trend from 1959 to 1998 and a sharp drop from 1982 to 1992**
- **Phytoplankton abundance in 1998 was about 38% in 1982 In the same period, the number of phytoplankton species also decreased**
- **Peak of primary production season was in summer**
- **A large seasonal variations of phytoplankton abundance occurred in 1992 and 1998.**

- **Decadal-scale variation of ecosystem productivity and control mechanism**

Zooplankton biomass

Secondary production presents the variations of zooplankton biomass in the Bohai Sea. Annually averaged, the zooplankton biomass decreased by about 40% from the late 1950's (107.3 mg m⁻³) to early 1990's (64.0 mg m⁻³). The particularly high values were observed in spring and summer of 1998, but the biomass of zooplankton in 1998 was an exception. The biomass in 1998 accounted for three to six times as much as the mean value at the same season from 1959 to 1982, and four times as much as 1992.

➤ Decadal-scale variation of ecosystem productivity and control mechanism

Fish productivity

The seasonal variations of fish in the Bohai Sea are important. The most species emigrate to the Yellow Sea in late autumn for over-wintering and return to the Bohai Sea in spring for spawning. The catch per hour of hauling data indicated that the top production began to decrease since the 1950's and was serious in the late 1990's. The biomass in 1992-1993 was slightly lower on average than the previous year surveys. The biomass in 1998-1999 was the lowest in all surveys with a sharp decline, accounting for only 5% of the 1959 values.

➤ Decadal-scale variation of ecosystem productivity and control mechanism

The community structure of fishery resources tends to be simple by decreasing of species numbers. The species richness, diversity and evenness also decreased from the beginning of 1980's to late 1990's. The shift of dominant species was observed by the surveys in 1982. Large-size demersal species were replaced by small pelagic species, such as half-fin anchovy (*Setipinna taty*), anchovy (*Engraulis japonicus*), and this replacement has continued thereafter. As a result, the trophic level in the fish productivity decreased from 4.3 in 1959, to 3.8 in 1982-83, 3.6 in 1992-93, and 3.3 in 1998-99.

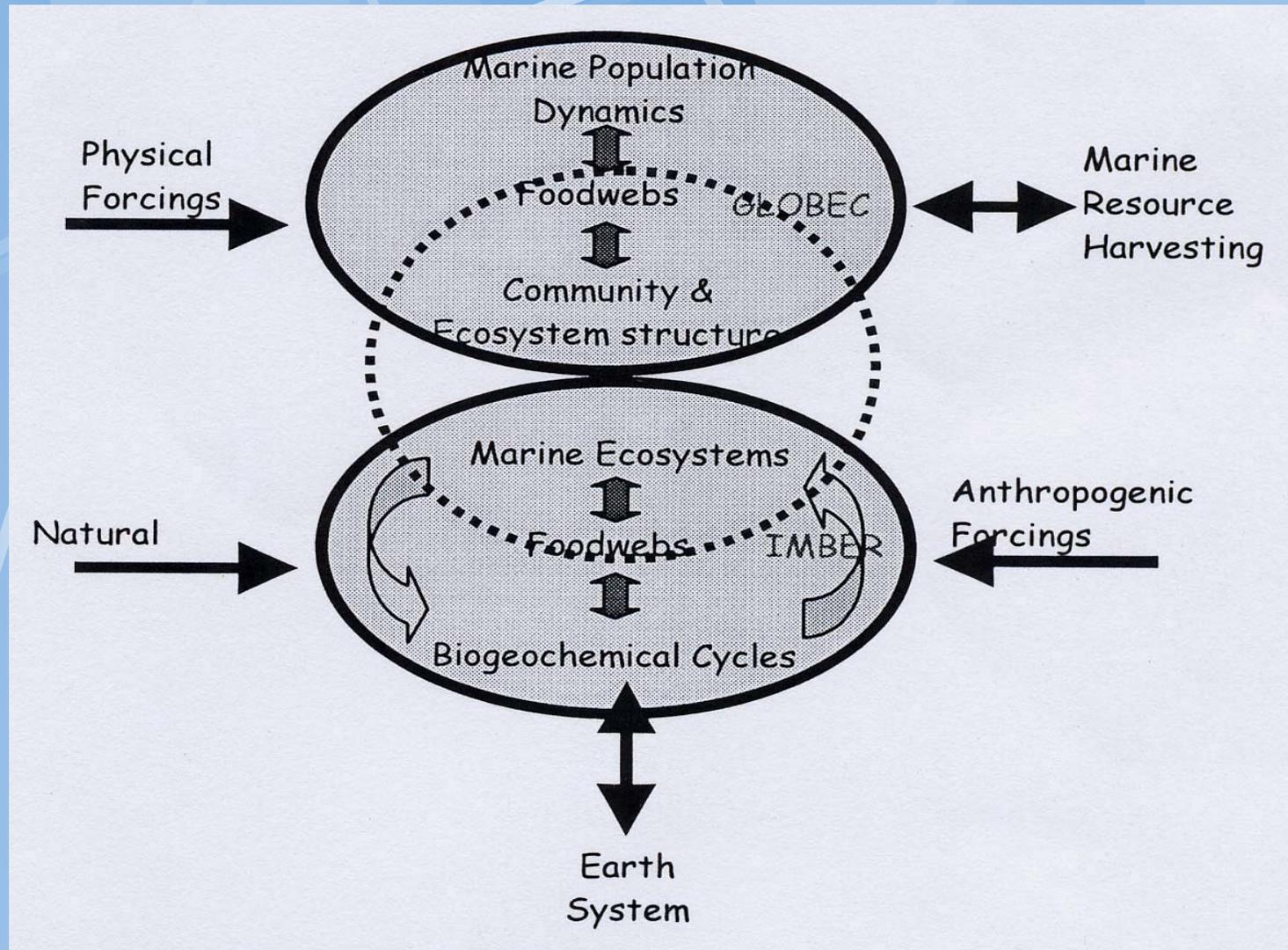
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Some ocean areas are particularly sensitive to gradual long-term changes in climate, and will be subject to intensive studies. They are the continental margins, meso-pelagic zone, intermediate waters, regions of upwelling and deep mixing. The continental margins are a critical boundary because they are most directly relevant to human development. However, marine food webs in continental margins are heavily impacted by fishing activities and closely relate to the biogeochemical cycles. The meso-pelagic zone is an important ocean region for recycling of nutrients and also an important region for pelagic food webs.

➤ Main scientific issues essential to be address



Marine ecosystem intensive studies frame enclosed with food web

➤ **Main scientific issues essential to be address**

Food webs study is very important in marine ecosystem intensive research. GLOBEC and IMBER projects will investigate closely the impact of global change on food web structure and function. GLOBEC has developed a focus on zooplankton that is important prey for fish. Zooplankton forms an important route for the transport of carbon up the marine food webs to higher trophic levels and down the webs in forms of faecal pellets and excretion products. One of the major questions studied by GLOBEC is what are the impacts of global change on fish population dynamics using coupled physical, biological and chemical models linked to appropriate observation systems?

➤ Main scientific issues essential to be address

Study on the East China Sea and the Yellow Sea ecosystem dynamics is focusing on the coupling of physical environment and biological progress. Its goals are to

- ✓ identify key processes of ecosystem dynamics
- ✓ improve predictive and modeling capabilities
- ✓ provide scientific understanding to ecosystems responded to climate change and rational management system of living marine resources.

➤ **Main scientific issues essential to be address**

To understand ecosystem dynamics and its mechanism of living resources, there are 6 key scientific problems in the coastal ocean regions:

- energy flow and conversion of key species**
- recruitment of zooplankton population**
- renovation of bio-elements**
- ecological effect of key physical process**
- coupling of pelagic**
- benthic system and contribution of microbial food loop.**

