FISHERIES MANAGEMENT UNDER SPECIES ALTERNATION: CASE OF THE PACIFIC PURSE SEINER OFF JAPAN

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ABSTRACT

In the northwestern Pacific area, the fish alternation phenomena amongst sardine, anchovy and chub mackerel have been observed in the cycle of about fifty years. The sardine biomass has been drastically increased in 1930s and 1980s. Chub mackerel biomass has in 1970s, and anchovy has in 1960s and 1990s. It has been gradually clear that these phenomena are as a biological response to the atmospheric and oceanographic regime shifts. In order to derive fisheries management theory under these situations, we analyzed the inter-relationships amongst resource dynamics of the species, economic dynamics of purse seine fishery, and fisheries production. We found that the intensive capital investment during the sardine-abundant periods (1980s) had became economic burden after sudden declines of sardine in 1990s, and prevent the broom of chub mackerel in 2000s. In order to discuss management options which take species alternation into account, we estimated the effects of hypothetical governmental interventions around the sardine-abundant period (1980s) in terms of fish biomass, economic efficiency, and food supply in the later years.

Keywords: fisheries management, species alternation, sardine, mackerel, northwestern Pacific, purse seiner.

INTRODUCTION

History of purse seine fishery in Japan

The Japanese purse seine fishery started at the central part of Japan in the early 17th century. The net was about 600m length, and operated with nine boats with more than fifty fishers (Oh-unabara 1980). In the middle of Meiji Era (1868-1912), a new purse seine technology was imported from the United States, and was improved to fit the Japanese operational style. It was called “improved purse seine fishery”, and this is the direct ancestor of the today’s purse seiners in Japan. The operation size of improved purse seine fishery was relatively small compared to the original Japanese purse seine in the Edo Era, and required only 26 personnel with a net of about 200m. The development of domestic cotton industry at the same period considerably cut the price of net, and accelerated the speed of proliferation of the improved purse seiners.

There was another huge technological progress. Until this time, all the fishing boats in Japan were human or wind-powered. In 1906, the first engine-powered fishing boat was launched. Introduction of this new technology was financially supported as a national fisheries policy by the then government, and prevailed in the 1920s. The engine-powered purse seiner rapidly developed all around Japan, and their fishing grounds finally expanded to the areas around the Korean Peninsula. In 1941, about 77% of the total sardine catch (970 thou-sand tons) in Japan was harvested by purse seiners. Also, in this time, mackerels became another important target species for purse seiners.

During the WWII, a lot of fishers as well as purse seine boats were sacrificed by the battles, and the total production of Japanese purse seiners was drastically decreased from 845 thousand tons in 1941 to 189 thousand tons in 1945. In order to deal with domestic food shortages, the recovery of purse seine fishery was very quickly achieved with various legal and financial supports from the government. In 1952, the Fisheries Agency promulgated a new regulatory rule for purse seine fisheries based on the Fisheries Law of 1949, and established the Minister Licensed Purse Seine Fishery. Basically, this manage-ment framework is inherited to today.

Purse seine fisheries using a net boat bigger than 15 gross tons in the Northern Pacific area is now categorized as the Middle- and Large-scale Purse Seine Fisheries, and licensed by the Minister of MAFF. Its license period is five years. There are eight jurisdictional sea areas defined for the management of purse seine fishery. The Northern Pacific area, which is the Pacific offshore from Chiba Prefecture to Hokkaido Prefecture, is the most productive for Japanese purse seiners.

Species alternation phenomena

The catch composition by the purse seiners operating in the Northern Pacific area changes periodically, because of the natural fluctuations in resource abundances. It appears that sardine, anchovy and mackerels show the species alternation phenomena of about 40-50 years cycle (Figure 1). In this study, we assume that this phenomenon is a kind of natural fluctuation in the north Pacific marine ecosystem. So, it should be left as it is, and should not be flattened by human interventions.

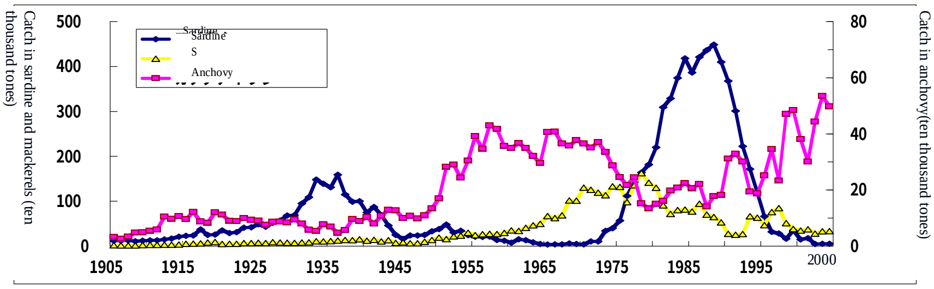


Figure 1. Changes in Japanese catch (Source: MAFF 1905-2005)

Assuming the species alternations between 3 species are true, the catch in mackerels should have been increased since around the end of the1990s. However, we have not observed such an increase in the mackerel’s catch. Therefore, it could be understood disruption of the fish alternation phenomena occurred in the northwest Pacific.

ECONOMIC RELATIONSHIPS BETWEEN PURSE SEINERS AND SPECIES ALTERNATION

Sardine broom and decline in the 1980’s

In the northern Pacific area, the main producer of sardine, mackerel and anchovy has been the middle- and large-scale purse seiners. This is one of the biggest fisheries sectors in Japan, and in the mid ’80s, about 72 operation units harvested 2.0-2.4 million tons per year. Under the Fisheries Law of 1949, this fishery is managed by the license from the Minister (5 years).

The peak in catch value by the purse seiners operating in the northern Pacific area was JPY 67.3 billion in 1983. On the other hand, the peak in catch volume was 2.4 million tons in 1986 (Figure 2). The majority of catch in the 1980’s was sardine, and the price of sardine around 1986 was about the half of that in 1983. In this period, too much sardine sometimes broke purse seine nets.

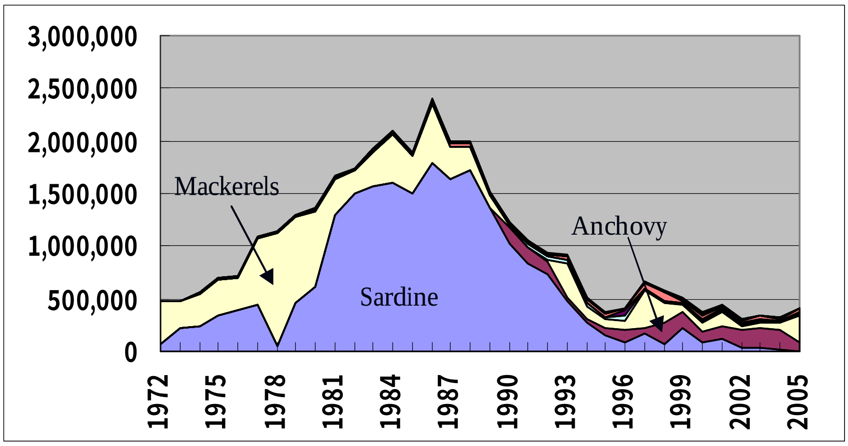


Figure 2. Composition of Purse Seine Catch (tons) in the North Pacific area (source: Association of Purse Seine Fishery in the North Pacific area 2008)

The business situation between 1983 and around 1986 was as follows; there were so many sardines in the northern Pacific area but the market price was very low, and the total revenue was continuously decreasing. So, intuitively, the purse seiners' natural response would be to increase the number of operation units to catch more sardine. However, the total number of nets (operation units) was regulated by the licenses from the minister; so they cannot invest to build new operation units.

Therefore, purse seiners' response was to construct large-scale transport ships (the 330 tons type) from around the peak in catch volume. Figure 3, the total tonnages of transport ships by size class, supports this fact. According to hearing interviews to local fishers, the depreciation period in this time was about 3-4 years. Also, the Japanese economy was in the economic bubble, and banks were very happy to lend money for purse seiners.

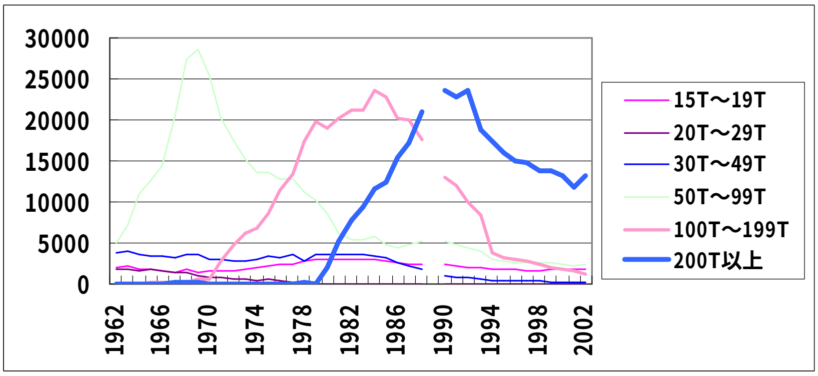


Figure 3. Total gross tonnes of transport ships by size class (MAFF 1962-2002)

In 1988-9, suddenly, the oceanographic conditions around Japan had changed, and sardine was gone since 1989-90 (Figure 2). In the end, too much capitals (especially, transport vessel) and high costs left with no sardine in the sea.

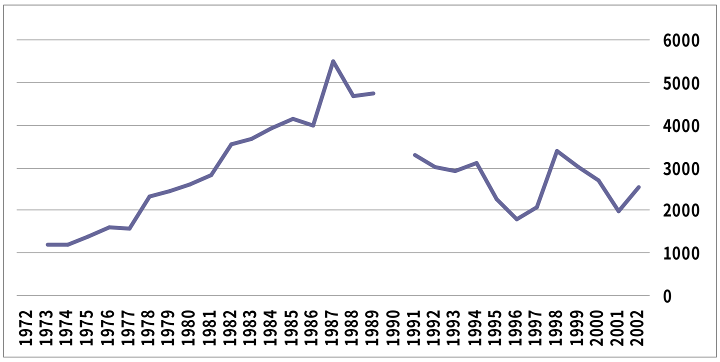


Figure 4. Average annual catch (tons) per one transport ship (MAFF 1962-2002)

Effects to mackerel

After sardine had gone, purse seiners still had to pay back the debt. In order to avoid bankruptcy, they had no choice but to increase fishing efforts toward mackerels in the 1990's. In '92, '96, we had strong year classes of chub mackerels, which seemed to be strong enough to bring the species alternation. But most of them are harvested at young ages before the maturation, and did not lead to resource increase (Figure 5).

To sum up, resource fluctuation of sardine and fishing fleet dynamics are closely related to the current resource level of chub mackerels. There were enough anchovy in 1990s, but the price of anchovy was much cheaper than small mackerel (about a half). This economic condition prevented anchovy from being the economic substitute for sardine and chub mackerel.

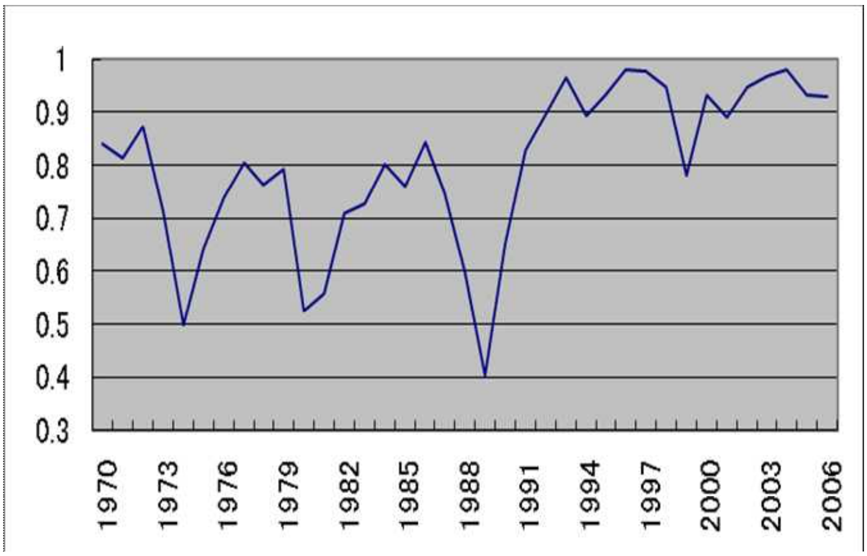


Figure 5. Ratio of the small mackerels (0~2 years; pre-matured) in the catch
(Source: FRA 2009)

ESTIMATION OF POLICY INTERVENTIONS EFFECTS

Model and data

Based on the above understandings on the inter-relationships between resource dynamics and purse seiners' economic behaviors, what could we have done to keep the species alternation continuing? In other wards, what could we have done to make the mackerel's broom happen? In this study, we assumed combinations of two management measures by the government.

The first measure is the regulation on transport vessel constructions during the license period of 1987-1991, which was just after the peak in catch volume in 1986. This leads to reduction in both the fishing capacity and the total cost. Note that there was input control measure via minister license, but it controlled only the number of operation unit (i.e., number of nets) and not effective to regulate the size and number of transport vessels.

The second measure is the TACs (total allowable catches) to protect chub mackerel stock. In this study, the TACs are set at the break-even point (no profit, but no negative for the average operator). This measure will lead to mackerel stock protection. Note that Japan introduced TAC in 1997, and there was 3 years transition period. So, the real TAC management in Japan has worked since 2000.

We assumed various strengths and durations of above two policy interventions, and calculated changes in catch, spawning stock biomass (SSB), and total biomass of chub mackerels. In stock dynamics calculation, we applied the calculation formula used in the official stock assessments with full technical supports from the Stock Assessment Team of the Fisheries Research Agency.

The basic structure of the model is as follows. Based on the estimated stock in number at each age and selectivity coefficient used in the official stock assessment, the age composition in the mackerel's catch is estimated. This composition is applied to the price estimation function. Using the estimated price and necessary income from the mackerel, the "break-even catch amount of chub mackerel" in the year is calculated. Then, that catch amount is applied to the resource dynamics formula to calculate the age composition in the next year. We repeated these procedures.

Catch amount of chub mackerel at the break-even point is assumed to be the necessary break-even income from mackerels in each year divided by the estimated price of mackerel in each year. The break-even income in each year is estimated based on MAFF (1980-2008). Estimated price of mackerels is the function of total mackerel catch (tons) and the ratio of small mackerel (less than 2 years old) in number. Volume of mackerel catch at the break-even point in each year is calculated as necessary break-even income from mackerels in each year divided by the estimated price of mackerel in each year. According to the transport vessel reduction level, catches of other species (sardine and anchovy) are assumed to shrink proportionally. Depreciation period for fishing vessel is 20 years.

Natural mortality, selectivity at ages, weight at ages, etc., are according to the official resource assessments. The recruitment-spawning relationship (RPS) was assumed as follows; 1) when SSB in year y is lower than 450 thousand tonnes, recruitment is calculated form the SSB and RPS in year y, 2) when SSB is among 450~1000 thousand tons, recruitment is calculated from the Ricker-type recruit-spawning relationship in 1979 - 1985, 3) when SSB is larger than 1000 thousand tonnes, recruitment is calculated from the Ricker-type relationship in 1970-1978. For more details in the official stock assessment formula for chub mackerel, see FRA (2009).

Results

Figures 6-8 show the 5 results of estimated catch, SSB and the total biomass, respectively, under various management scenarios. We found that just 10% reduction in the vessel construction, and protection of ’92 & ‘96 strong year classes for 2 years each (i.e., total of 4 years) could bring enough recovery to produce species alternation phenomena.

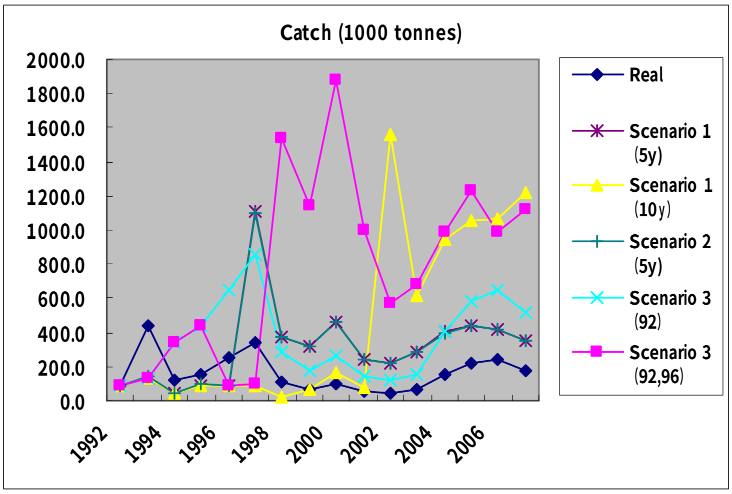


Figure 6. Changes in estimated catch

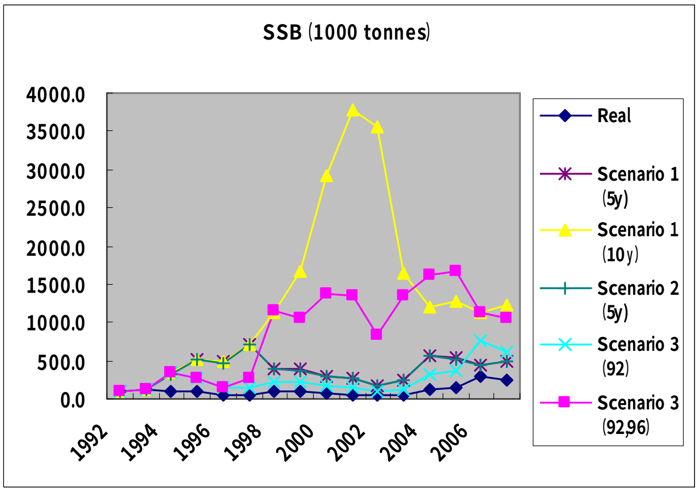


Figure 7. Changes in estimated Spawning Stock Biomass (SSB)

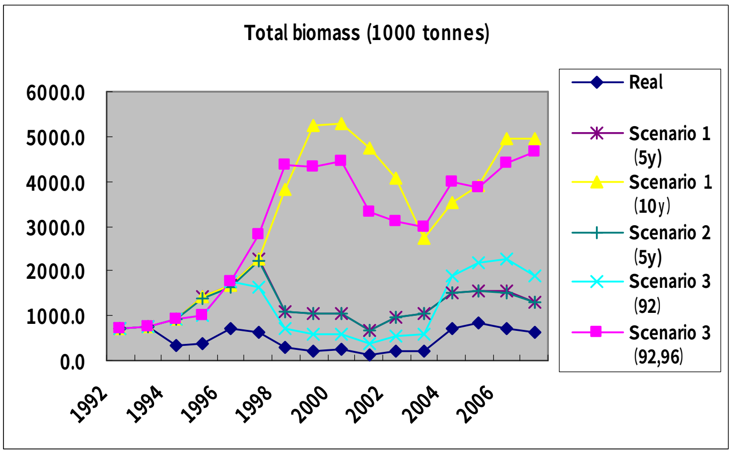
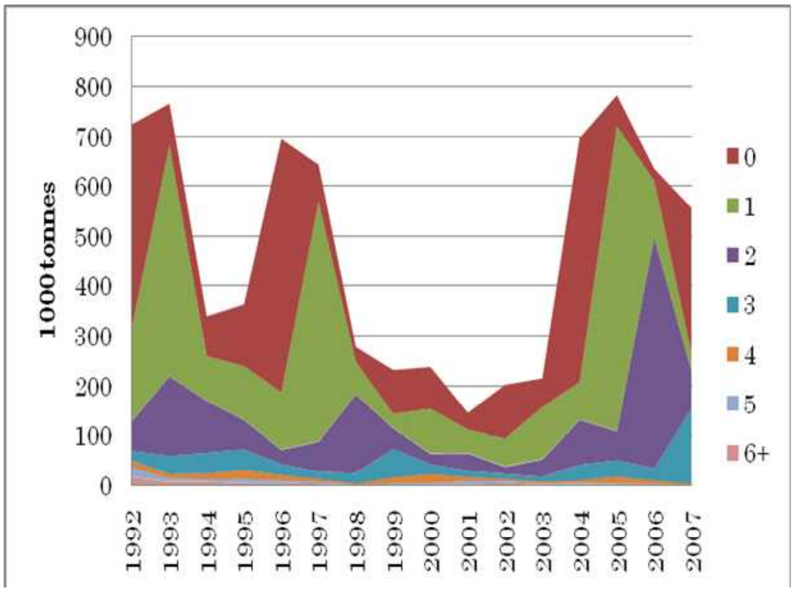


Figure 8. Changes in estimated total biomass

DISCUSSIONS

Under the species alternation phenomena, the combination of; 1) regulation on new vessel construction (capacity regulation) around the species alternation period, and 2) adaptive protection of strong year classes for at least twice, is the best choice in this study. In order to do such management, scientific monitoring to observe changes in oceanographic conditions and occurrences of strong year classes are highly important. In order implement such management, continuous scientific monitoring to observe changes in oceanographic conditions and occurrences of strong year classes are highly important.

TAC was introduced to Japan in 1997 (but there was 3 years transition period, so the TAC has actually worked since 2000). Also, Resource Recovery Plan for chub mackerel started in 2003 and protected strong year class of 2004. Presumably as the results of these two measures, the estimated SSB shows good recovery now (Figure 9). According to the result from this study, protection of one more strong year class would lead to the full recovery, and subsequent species alternation.



Estimated biomass in 1992~2007
(Data from official stock assessment report)

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