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Management of declining Japanese sardine, chub mackerel and walleye pollock fisheries in Japan

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ABSTRACT

Japanese sardine (*Sardinops melanostictus*), chub mackerel (*Scomber japonicus*), and the northern Japan Sea of walleye pollock (*Theragra chalcogramma*) stocks have fallen to very low levels in Japan since the early 1990s. We review existing management measures for these stocks from the view point of an ecosystem approach. Tosa Bay is one of the main spawning areas for Japanese sardine; it has been declared a partial protected area and large-scale purse seine fisheries are prohibited. However, recovery of the reproductive capacity and the full age composition of Japanese sardine is also needed, because the spawning stock biomass (SSB, 0.073 million tons) is below its limit reference point (B_{limit}, 0.222 million tons) and the catch is composed mainly of 0- and 1-year-old fish. For chub mackerel, measures to reduce effort and promote stock recovery have taken place since November 2003. As with Japanese sardine, recovery of the reproductive capacity and age diversity of this stock are still needed because SSB (0.11 million tons) is below the limit reference point (B_{limit} of 0.45 million tons), and the catch is also composed mainly of fish of 0- and 1-year-old. Allocation of the catch between purse seine and dip net fisheries is also needed. In the case of walleye pollock, measures to protect immature and mature fish are being implemented. However, recovery of the reproductive capacity of the northern Japan Sea stock is needed because the SSB (0.085 million tons) is below the limit reference point (B_{limit} of 0.14 million tons). Maintaining the reproductive capacity of the Japanese Pacific stock is needed, because the SSB (0.237 million tons) is above but close to the limit reference point (B_{limit} of 0.16 million tons). Allocation of the catch among trawl, longline, and gillnet fisheries is also needed. For all three species, protection of young, small fish is an essential measure for stock recovery. Partial marine protected areas (MPAs) should be set in other areas such as the offshore area for walleye pollock, the wintering area off Joban for chub mackerel, and the area off Joban in summer for Japanese sardine. To give incentives to fishers to accept these partial MPA measures, it is necessary for scientists to estimate how much additional production and economic value can be expected through these partial MPA measures. It is also necessary for the stakeholders to be involved and to reach consensus on the management goals for declining stocks, and to provide incentives to encourage fishers to carry out the proposed measures.

1. Introduction

Fisheries need to be managed in an ecosystem context, because they have a direct impact on the ecosystem and interact with the effects of other human activities. There are many scientific papers on "ecosystem approaches to fisheries" (EAF) (e.g. Roberts et al., 2001; Garcia et al., 2003; Halpern, 2003; Browman and Stergiou, 2004; Pikitch et al., 2004; Grafton et al., 2006; Marasco et al., 2007), but the justification of EAF is evident in the characteristics of an exploited ecosystem and the impacts resulting from fisheries and other activities (Garcia et al., 2003). The EAF is a new direction for fishery management, essentially reversing the order of management priorities so that management starts with the ecosystem rather than a target species (Pikitch et al., 2004). A key component of this approach is the conservation and protection of key habitats (marine protected areas; MPAs) that are critical for ecosystem and population processes (Roberts et al., 2001; Halpern, 2003; Browman and Stergiou, 2004). However, MPAs do not provide incentives for fishers to modify their fishing practices to lessen their impacts on fish stocks and habitat conservation (Grafton et

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al., 2006). Other aspects of EAF include the use of the precautionary approach and the management of target and non-target species within the broader context of overall marine ecosystems, paying particular attention to bycatch, discarding, and habitat destruction (Garcia et al., 2003; Grafton et al., 2006).

The traditional approach to commercial fisheries management restricts fishing inputs and imposes total catch limits to control fishing mortality. For example, in Canada's northern cod (*Gadus morhua*) fishery, concerns that reduced harvests would generate bankruptcies and unemployment, coupled with uncertainties over the status of stocks, resulted in the total allowable catch (TAC) being set too high and was a major contributor to the collapse of this stock in the 1990s (Hutchings and Myers, 1994; Grafton et al., 2006). A similar story can be told in many other developed fisheries, even when the primary stated objective of management is to conserve fish stocks. Also, all fisheries are subject to irreducible uncertainties that make it difficult to set sustainable harvests and to understand the long-term impacts of fishing practices (Ludwig et al., 1993). Hilborn (2004) stated that the failures of fisheries management were due to failures to recognize the importance of people and people management, rather than a failure of single-species management. However, he also supported a view of ecosystem management that recognizes the institutional dynamics between harvesters, managers and scientists, and that stops the race-for-fish and overcapitalization through incentives rather than through centralized top-down control.

In Japan, a TAC system was introduced in 1997 to manage the main commercial fish species such as Japanese sardine (*Sardinops melanostictus*), chub mackerel (*Scomber japonicus*), and walleye pollock (*Theragra chalcogramma*). The Japanese Fisheries Research Agency (FRA) has carried out stock assessments and proposed allowable biological catches (ABCs) and other management measures for these species (Nishida et al., 2006; Watanabe et al., 2006; Honda and Yabuki, 2006; Funamoto et al., 2006). The stock biomasses of Japanese sardine, chub mackerel, and walleye pollock have been at very low levels since the early 1990s, and further measures have been proposed to improve the situation.

In this paper, we review the fisheries management of these species from the view point of an ecosystem approach. We also discuss their food habits and prevailing oceanographic conditions in the context of an ecosystems approach, and propose necessary measures to protect and recover these stocks from their current low abundance levels.

2. Materials and methods

Garcia et al. (2003) listed twenty operational objectives and measures to ensure that an ecosystem approach to fisheries would be more successful than conventional management. However, they also pointed out that these are measures needed in principle, and stressed that not all of these are immediately needed in all fisheries. We considered seven measures as follows: (1) improving the decision-making framework, (2) priority setting or allocation, (3) maintaining biological diversity (here, we consider the diversity in the number of ages comprising a fish stock), (4) maintaining reproductive capacity, (5) reducing uncertainty and risk, (6) protecting selected marine areas or MPAs, and (7) monitoring and indicators. "Marine fisheries stock assessments and evaluations for Japanese waters (fiscal year 2006/2007)", published by the Fishery Agency of Japan (FAJ) and the FRA, were reviewed for Japanese sardine, chub mackerel, and walleye pollock stocks (Nishida et al., 2006; Watanabe et al., 2006; Honda and Yabuki, 2006; Funamoto et al., 2006). Present fishery management measures for these three species in Japan were evaluated according to the seven selected measures, and recommendations were made for future measures following an ecosystem approach.

Stock assessments of these three species were conducted using virtual population analyses (VPA) of catch numbers by age group (Pope, 1972). The following data were used for tuning the VPA. For Japanese sardine, spawning stock biomass (SSB) and recruitment were tuned using egg abundance in coastal waters and the abundance of age 0 fish in the Kuroshio Extension, respectively (Nishida et al., 2006). For chub mackerel, recruitment was tuned by the abundance of age 0 fish in the Kuroshio Extension, offshore waters of Hokkaido, the abundance index of wintering immature fish, and other information (Watanabe et al., 2006). For the northern Japan Sea stock of walleye pollock, tuning was not conducted (Honda and Yabuki, 2006). For the Japanese Pacific stock of walleye pollock, the abundance of age 1 fish was tuned using the data collected from an echo sounding survey in the waters off eastern Hokkaido (Funamoto et al., 2006). Instantaneous natural mortality for the Japanese sardine and chub mackerel was estimated to be 0.4 based on the relationship between maximum age and instantaneous natural mortality (Tanaka, 1960). Natural mortality for the northern Japan Sea stock and the Japanese Pacific stock of walleye pollock for ages 3 and older fish was estimated to be 0.25 per year using data on catch abundance and effort (Widrig, 1954). Instantaneous natural mortality of younger fish was assumed to be higher that of ages 3 and older fish, specifically 0.4, 0.35, and 0.3 for fish of ages 0, 1, and 2 years, respectively (Honda and Yabuki, 2006; Funamoto et al., 2006). Natural mortality for the northern Japan Sea stock of walleye pollock was assumed to be the same as that for the Japanese Pacific stock.

The definitions for several terms used in this paper are as follows. B_{limit} is the limit reference point of SSB at which some management action is taken to recover the stock. The B_{limit} is the point on the SSB-recruitment relationship below which the probability of good recruitment declines (for Japanese sardine, chub mackerel, and the northern Japan Sea stock of walleye pollock) or the point at which high recruitment and high recruitment per SSB are expected (for the Japanese Pacific stock of walleye pollock) (Caddy and Mohon, 1995). The B_{ban} is the limit reference point for stock biomass at which the fisheries are closed and is defined as the lowest stock biomass observed in the historical data through 2005. RPS stands for recruitment (in numbers) per SSB.

3. Results

3.1. General measures

3.1.1. Improving the decision-making framework

In the stock assessment process in Japan, several meetings are held to make decisions at each level. At the regional level, the Stock Assessment Meetings for local areas are held in six regions in July and August every year. The managers of the Fisheries Agency of Japan (FAJ) and prefectural governments, scientists of the Fisheries Research Agency (FRA) and prefectural fisheries experimental stations, fishers, and fisheries organizations participate in these meetings and examine draft reports of the stock assessments. At the national level, the National Stock Assessment Meeting is held in Tokyo in September every year, at which the report is finalized and recommendations are made for ABCs. Based on the ABC and other economic factors, the Subcommittee of Fisheries Management under the Fisheries Policymaking Advisory Board in the Ministry of Agriculture, Forestry and Fisheries of Japan decides on the TAC in November of every year.