Walleye pollack (*Suketoudara*) fishery management in the Hiyama region of Hokkaido, Japan

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1. INTRODUCTION

The fishery for walleye pollack (*Theragra chalcogramma*) is important in Japan. The roe is a popular part of the Japanese diet, often prepared either by salting (*tarako*) or by marinating with hot chilli pepper (*mentaiko* or *karashi-mentaiko*). The flesh is used for *surimi* products and is exported to China and Korea. After stock levels and harvests of walleye pollack declined, the fishery was included as one of seven species regulated by the total allowable catch (TAC) system set by the central government.

Walleye pollack are harvested mostly in northern regions of Japan, with Hokkaido producing the most fish. There are four different stock groups of walleye pollack in Hokkaido waters: Japanese Pacific, northern Japan Sea, southern Okhotsk Sea and Nemuro Straight. The Hiyama region is located in southwestern Hokkaido island facing the Japan Sea (Figure 1) and its near-shore area is known as the main spawning ground for the northern Japan Sea stock.

This paper describes co-management of the walleye pollack fishery by a subgroup of fishers who belong to the Hiyama Fishery Cooperative Association (FCA). The Hiyama FCA consists of several "sections" defined according to geography and each section co-manages its fisheries. This paper focuses specifically on the Nishi section, in the middle of the Hiyama fishery (light-shaded areas in Figure 1). The Nishi section harbours the main spawning ground for the walleye pollack, which is an important advantage since the main target of walleye pollack fishery in Hiyama region is its roe. The Nishi section produced 77 percent of total walleye pollack landings by weight in the Hiyama region in 2005 (Watanobe, 2007).

The co-management group in the Nishi section is distinguished by two characteristics. First, the Nishi group emphasizes pre-harvest equity through a sophisticated fishing-ground rotation scheme. Second, walleye pollack migrate along the coast and many other regions of Japan are engaged in fisheries that target the same stock. While successful fishery co-management is often thought to be restricted to sedentary species,

FIGURE 1
Hiyama region in Hokkaido, Japan

or those with limited migrations so that single groups have nearly exclusive access to the fish stock, this case arises in a widely shared stock.

2. DESCRIPTION OF THE FISHERY

2.1 Biological characteristics of walleye pollack

Walleye pollack are found in northern waters of the Japan Sea, the Pacific Ocean, the Okhotsk Sea, the Bering Sea and along the Alaskan coast. The northern Japan Sea stock inhabits waters that extend from the southwestern tip of Sakhalin in Russia, along the western coast of Hokkaido, to Noto Peninsula in the Ishikawa prefecture. The fish are found from near the surface to a depth of 400 metres.

Walleye pollack reach maturity at three to four years, when they are approximately 33 cm long and weigh 230 grammes. (Photo 1) About one-third of the three-year cohort is mature and by six years nearly all fish are mature. At six years, pollack on average are 42 centimetres long and weigh 485 grammes. Their life expectancy is unknown; most of the fish exceeding ten years of age have been found in the Hiyama region.

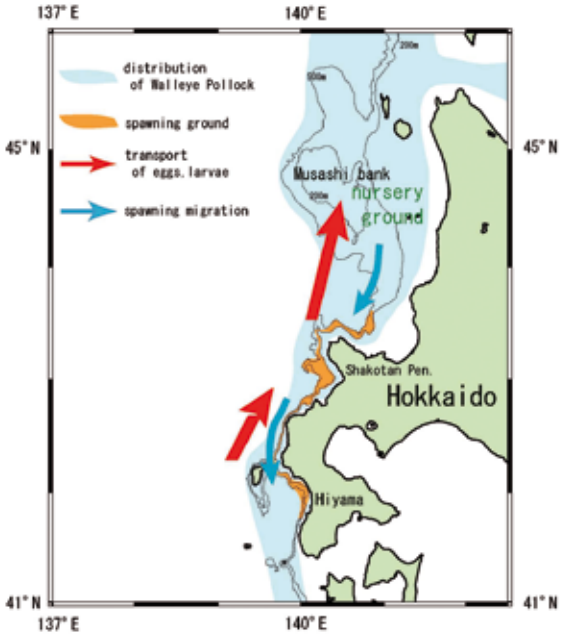
The walleye pollacks' spawning grounds once encompassed the western coast of Hokkaido, but major spawning activity during the past few years has been confirmed only in the Hiyama region. Overharvesting and depleted fish stocks are thought to be the cause of shrinking spawning grounds (Honda and Yabuki, 2006). Hatchlings and juveniles are carried north by the current to an area known as the Musashi Bank and onto the continental shelf off northern Hokkaido (Figure 2), where they grow and mature. The majority of walleye pollack harvested near Musashi Bank and regions north of Shakotan Peninsula are between one and four years of age (mostly young and immature adults). As they mature and become reproductive, they migrate southward. Young adults spawn for the first time around the Ishikari and the Iwanai region, which lies about 100 kilometres north of Hiyama. The migration continues until the pollack reach the Hiyama region, where fish that are five years or older predominate. The peak season tends to be earlier in southern areas and later in northern areas (Hokkaido Central Fisheries Experiment Station, 2005).

PHOTO 1
Walleye pollack
*(*Theragra chalcogramma*)*

COURTESY OF HOKKAIDO HAKODATE FISHERIES EXPERIMENT STATION.

Like many other fish species, walleye pollack aggregate in dense groups when they arrive at Hiyama's shores to spawn. The aggregations tend to shift rapidly in depth and area and, as a consequence, two vessels fishing next to each other can harvest significantly different amounts of fish.

FIGURE 2
Migration pattern of Japan Sea walleye pollack



Source: Hokkaido National Fisheries Research Institute. Original diagram was modified by the author with permission.
Note: Contour lines are shown at 200 and 500 metres.

2.2 History of the walleye pollack fishery

The walleye pollack fishery in the Hiyama region has experienced a typical boom and bust. The shift toward implementing rigorous fishery management was a response to the bust. (Much of the following historical information comes from Hanashi [1984].)

Fishing for walleye pollack in Hiyama started around 1910 in response to declining harvests of herring. It started slowly as a low-valued fishery. But when a new demand for dried pollack emerged in Korea and China around 1921, it began to flourish. By 1926, nearly all of the local fishermen were engaged in walleye pollack fishing; vessel and engine size became bigger and the fishing season was prolonged. This trend, however, was halted rather abruptly in 1952 and 1953, when migrating walleye pollack stopped arriving. The livelihoods of pollack fishermen suffered. They were forced to work elsewhere during the pollack season, which is in winter months. This experience – cold, harsh weather conditions and living in temporary housing in an unknown land for some fifteen years – led fishermen to implement a rigorous fishery management regime when walleye pollack began to reappear in the mid-1960s. By the early 1970s, the fishery had been re-established in the region. The number of vessels began to increase again for several years during the late 1970s, but decreasing stocks and rising costs rendered the fishery unprofitable for numerous vessels in recent years. The number of vessels today in Hiyama region has decreased to 94.

2.3 Status of the resource stock

According to a stock assessment report provided by the government, the stock level of northern Japan Sea walleye pollack is estimated to be low and continues to decline. Stock levels between 1987 and 1991 were high, with estimates ranging between 722 000 and 868 000 tonnes. The declining trend began in 1992 and as of mid-2006 the stock level was estimated at 147 000 tonnes. The 1998 cohort was expected to yield a high level of stock, but in 2002 it was so extensively harvested that it ultimately produced no more fish than from other cohorts. The recruitment per spawning stock biomass (RPS) has been declining since 1989, which resulted in 2003 posting the lowest recruitment level in more than twenty years (Honda and Yabuki, 2006).

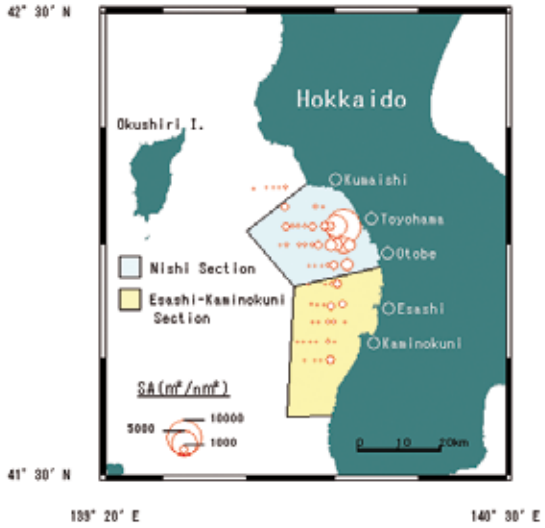
2.4 The fishery

The gear used in Hiyama walleye pollack fishing is longline (Photos 2 and 3). The longline is favoured, rather than the trawl gear used for younger pollack in northern regions of Hiyama, because fishers believe that compressing fish inside a net damages the quality of the roe. The longline is set in a straight line; its length varies from 3 472

COURTESY OF THE HIYAMA FCA

PHOTOS 2 & 3
Hauling the long line (left) and caught walleye pollack brought on board (right)

FIGURE 3
Distribution of walleye pollack measured in early February 2007



Source: Hokkaido Hakodate Fisheries Experiment Station, 2006.

to 5 788 metres, depending on the size of the vessel. There are 100 hooks per "basket" (the fishing lines are coiled in a basket) and pieces of frozen saury and squid are used as bait. The average percent of hooks that catch fish is approximately 50 percent but can rise to 70–80 percent when the catch is good.

Pollack are unevenly distributed (Figure 3) along the coastline, presenting the major challenge in this fishery. Longline fishing in a relatively small area creates serious problems with entangled lines and hooks. To avoid this, vessels in the Hiyama region line up at the "starting line" spaced 150–200 metres apart from each other and set their lines parallel to each other as they move straight outward to sea. High concentrations of spawning fish are often observed where the ocean floor rises steeply towards the continental shelf, at a depth of approximately 200 metres. Concentrations of fish become more sparse as one moves away from the coast.

As of June 2006, there were 51 vessels in the Nishi section (out of 94 in total in Hiyama region). There has been a trend toward retiring smaller vessels and replacing them with larger ones. While the number of vessels is declining, the number of crew members has remained the same and has even increased slightly as the number of crew per vessel has increased from three to five. As of mid-2006, there were three small vessels (less than 6 ton) and three mid-sized vessels (7–8 tons); the rest exceeded 9.9 tons with some as large as 19 tons. Large vessels (more than 10 tons) accounted for more than 70 percent of the total landing volume in the 2005 season.

No fees are imposed on fishing licences that are issued by the government, either at the central or local level.

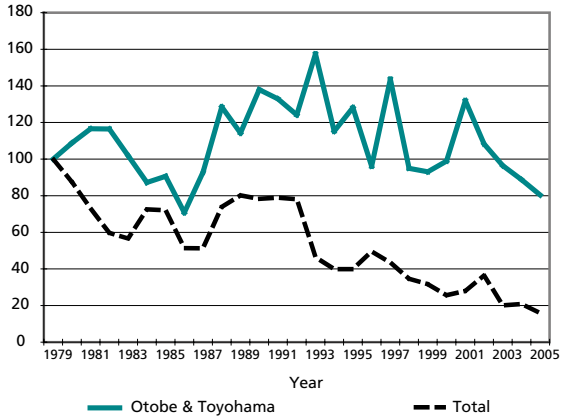
Harvest volumes in the Nishi section have fluctuated between 3 000 and 7 000 tonnes since 1979. Harvest volumes have remained near the 1979 level, although a decreasing trend is apparent in the years following 2001. Figure 4 presents a scaled comparison of the trend in landings for two of Nishi's three districts to landings in the northern Japan Sea area. The Nishi section stands in stark contrast to a clear decreasing

trend for northern Japan Sea walleye pollack. The total harvest in 2005 for Japan Sea pollack was only 16 percent of the total in 1979, while harvests for the Hiyama region remained at 80 percent. Hiyama region's 2.8 percent share of the total harvest volume of Japan Sea pollack in 1979 has risen to an all-time high of 14.3 percent in 2005. While this difference may not be solely attributed to the management effort by Hiyama fishers, it certainly encouraged them to maintain their management regime.

Decreasing stocks and harvest volumes are raising concerns for owners of larger vessels. Fishermen interviewed by the authors stated that while vessels larger than 19 tons are better for winter fishing (for their stability during rough weather), 10 tons is an ideal vessel size in terms of profitability given the current resource conditions. Larger vessels once caught as much as twice the volume of smaller vessels. Daily vessel catches for larger vessels have since decreased from 2 500 kg to 1 765 kg, while catches of smaller vessels have remained at an average of around 1 500 kg (Figure 5). Such a change has most likely been accompanied by a decrease in profitability for larger vessels.

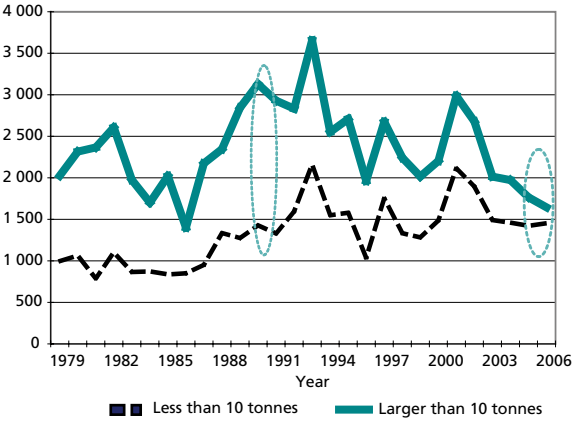
A vessel owner's average revenue is approximately 20–25 million yen (US$180 000–227 000), which, after costs are deducted, is typically not enough to provide a livelihood for an entire year. Nearly every fisherman must find additional income sources during the off-season. Some fishermen, typically those in Otobe, fish for squid during the spring and summer months. Fishermen in Kumaishi typically engage in set-net and abalone fishing and those in Toyohama travel to Alaska to work as long-line technicians. Many crew members from all three districts also go to Alaska.

FIGURE 4
Change in total harvest volume index with base year 1979 as 100



Data source: Hokkaido Hakodate Fisheries Experiment Station and Honda and Yabuki (2006).

FIGURE 5
Catch volume per day per vessel by vessel size



Data source: Hokkaido Hakodate Fisheries Experiment Station.

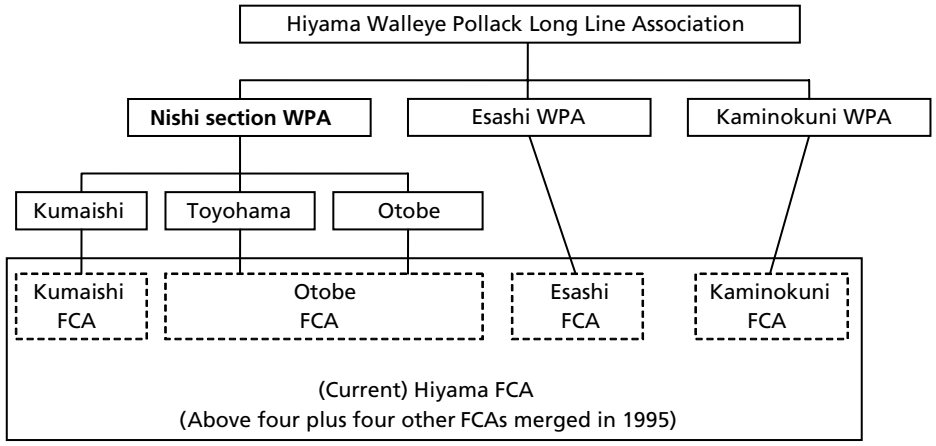
Despite rigorous management aimed at creating a sustainable fishery, lack of successors is an issue in the Hiyama region. The average age of fishermen in the region is in their 50s, ranging from the youngest in their 30s to the oldest in their 70s. As one fisherman noted, the declining stocks of walleye pollack are dampening future prospects for this fishery.

3. REGULATIONS

3.1 Government regulations

Walleye pollack is one of seven species regulated under the national total allowable catch (TAC) system introduced in 1997. The TAC is divided between offshore trawlers, administered by the Ministry of Agriculture, Forestry and Fisheries and other gears administered by the Hokkaido prefectural government. The long-line fishery in the

FIGURE 6
Organizational structure of Hiyama's regional fishery co-management system



Note: WPA stands for Walleye Pollack Association.

Hiyama region falls into this second category. For 2006, the TAC for walleye pollack was set at 247 000 tonnes, of which 146 000 tonnes were allocated to offshore trawlers and 98 000 tonnes were allocated to other sectors in the Hokkaido prefecture (Fisheries Agency of Japan, 2007). The allocation to Hokkaido prefecture for the 2007 season was reduced to 86 000 tonnes, reflecting the decline in stocks. Twelve thousand tonnes were allocated to the Japan Sea area, of which 8 300 tonnes were given to longline and gillnet fisheries in the area (Hokkaido Government, 2006).

The effectiveness of the TAC system, however, is questionable. The walleye pollack stock is declining, which suggests that a more conservative TAC should be set. But only 73 percent of the TAC was caught in the 2004 season and 70 percent in the 2005 season (Japan Fisheries Information Service Centre, 2006). The continuing decline of stocks and the fact that the quota limit is not limiting the catch suggests that the catch limit has been overly generous.

3.2 Self-imposed regulations

3.2.1 Organisational structure

The Hiyama Walleye Pollack Long Line Association consists of three sub-organizations: the Nishi Section Walleye Pollack Association, the Esashi Walleye Pollack Association and the Kaminokuni Walleye Pollack Association. (The Esashi-Kaminokuni section lies to the south of the Nishi section; see Figure 6). The Nishi section brings together three groups that correspond to the townships in which they are located: Kumaishi, Toyohama and Otobe (Figure 6). The members of each organization are vessel owners.

Leaders from each of the town groups meet about ten times during the season to make adjustments to operations and the rules. Members are informed each morning before going out about the details of that day's fishing operation. Monitoring is done by the members. One member from each district is responsible for monitoring the group's operations and penalizing violators, which has been necessary several times in the past.

Self-imposed regulations by the Nishi section's walleye pollack fishermen can be divided into three main categories: fishing-ground rotation, pooling arrangements and other operational regulations that overlay government-imposed ones. We first describe the other regulations briefly, as many of them are related to how the two remaining measures are carried out.

3.2.2 Other regulations: seasons, no fishing area and gear restrictions

The official fishing season set by the Hokkaido prefectural government is November through March. These months correspond to the spawning season of walleye pollack, when the fish appear near shore. Hiyama fishermen set their own fishing season within the official period based on weather, conditions of other fisheries and the quality of the walleye pollack's roe. In the early 1980s, the season opened in early December and continued until late March. In recent years, the fishery has opened in early November and closed in early February. The average season length within the official five-month period is 93 days. The average actual number of fishing days is 61 days, or 65 percent of the season. Larger vessels tend to spend more days fishing (50–60) than smaller vessels do (40–45 days).

There are two primary reasons for this seasonal restriction. The most valuable product is roe which has peak quality when it is just ripe. Both not yet ripe and overly ripe roe (called *mizuko)* are considered to be low quality. The yield of mizuko begins to rise in late January to early February, which is one reason to stop harvesting. Another reason is that the survival rate of fertilized eggs is enhanced when the water temperature drops below 10 °C, which typically occurs in early February. Thus, the motivation for the voluntary seasonal closure is the combination of a marketing decision and an effort to enhance successful reproduction.

Another effort to conserve the stock was the establishment of a no-fishing area in the mid-1990s. The location, west of the town of Toyohama, was chosen because the area is a prime spawning ground for walleye pollack (Maeda , Kakahashi and Nakatanil., 1988). Areas within, and near, the no-fishing zone have the densest schools of walleye pollack (see Figure 3). Rather than concentrating their fishing efforts at this hot spot, the fishermen chose to set in the area aside as a way of contributing to rebuilding the Japan Sea walleye pollack stocks.

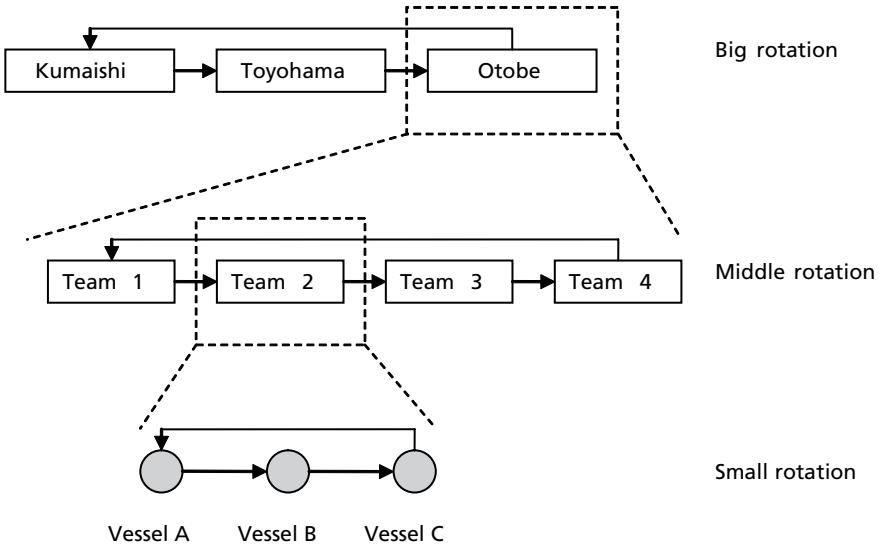
Fishing gear is also regulated. No more than 100 hooks can be attached to the line in each basket. Each vessel is limited to 25 baskets a crew member, so smaller vessels (6 tons or less), which typically have a crew of three, can take up to 75 baskets while larger vessels (10 tons or more), which typically have a crew of five, can take up to 125 baskets.

3.2.3 Fishing-ground rotation

Fishermen in the Nishi section have developed one of the most sophisticated fishing-ground rotation schemes in Japan. Similar schemes are observed in neighbouring walleye pollack fisheries, such as those in the Iwanai region (see Figure 1) (Hirasawa, *et al*., 1985). The rotation scheme was implemented soon after the walleye pollack stock reappeared in the Hiyama region in the mid-1960s. The main objective is to avoid congestion at fishing grounds and the consequent costs, such as gear damage, while maintaining fairness. Fairness is defined differently than it is in other fisheries in Japan, such as the system used by sakuraebi fishermen in Suruga Bay (Uchida and Baba, this volume). In the sakuraebi fishery, fishermen sought post-harvest fairness by adopting a pooling arrangement. In the Nishi walleye pollack fishery, fishermen sought pre-harvest fairness by rotating access to the fishing grounds.

There are three layers of rotation: groups, teams and individuals (Hamada, 2001). Nishi fishermen are divided into three groups based in the town where they are based. In 2006, the Kumaishi group operated 17 vessels, the Toyohama group had 15 vessels and the Otobe group had 19 vessels. The Nishi section is divided into three segments of coastline from north to south (commonly called the top, middle and bottom). Each group rotates through the segments on successive days, so each group is granted access to all of the segments of coastline (the big rotation is shown in Figure 7). Each group consists of several teams and each team consists of several individual vessels. Within the big rotation, teams also rotate within their group (the middle rotation). Further, individual vessels rotate within a team (the small rotation).

FIGURE 7
Schematic of rotation scheme adopted by Nishi fishermen in the Hiyama FCA



The number of teams and vessels are for illustration purpose only; the actual configuration may differ.

This layered rotation equalizes fishing opportunities at the vessel level over the course of the season. In practice, the rotation scheme gets more complicated, because the Nishi WPA sometimes adjusts the rotation to better equalize opportunities for individual vessels. However, even if opportunities are equalized, the actual catch at the same location will differ depending on when one fishes. Hiyama fishers have long regarded such stochastic fluctuations, or luck, as part of fishery's nature and no further adjustments were made – until recently.

3.2.4 Pooling arrangements

There are several limitations to the rotation scheme due to the rigidity of assigned locations. While schools of walleye pollack shift along the coastline from day to day, the location coordinates of the vessel rotations are largely fixed. In the situation depicted in the left panel of Figure 8, vessel A will harvest few or no fish while vessel C can expect to have a fair catch. For the group, the total harvest will improve if the three vessels adjust their positions as depicted in the right panel of Figure 8. Under the rotation rule, this kind of adjustment is not allowed, since vessels adjusting their locations to areas where the fish schools are dense undermines the purpose of the rotation scheme and congests those areas.

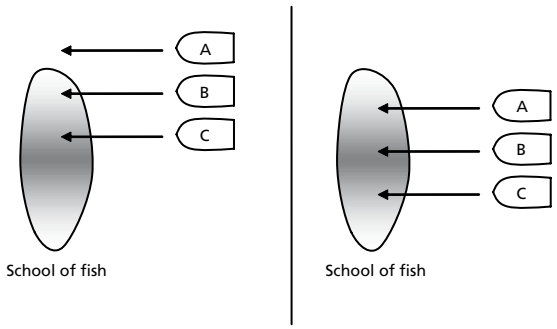
A related inefficiency is that some vessels must travel long distances to reach their assigned fishing area. For example, once every three fishing days some Otobe vessels must travel to the northern edge of the Nishi section (Figure 3). This is not an efficient use of vessel time and the price of the inefficiency has become apparent and acute as fuel prices have soared. This has led to the adoption of a section-wide pooling arrangement in the Nishi region.

The Nishi section-wide pooling arrangement was implemented as a trial at the beginning of the 2005–06 fishing season. Preseason fish-stock and fishing-ground assessments indicated that the walleye pollack schools had declined significantly. This led to the necessity of location adjustments, as described in Figure 8 and implementation of a pooling arrangement. The Nishi section's distribution rule is simple and incorporates the heterogeneity of the size of both vessels and crew members, i.e. each vessel's share is determined by the number of baskets of longline. Earnings are calculated daily;

only vessels that go out fishing that day get a share.

Once the pooling arrangement was implemented, the Nishi group made several changes to enhance efficiency. Joint surveillance of fishing grounds is conducted daily and the results are disclosed to all members. They also can adjust the location assignments while fundamentally maintaining the rotation pattern. In addition to the adjustments depicted in Figure 10, adjustments are made based on the characteristics of each vessel type. For example, when operating in relatively high waves, larger vessels operate upwind of smaller vessels so that they block the high waves, making it safer for smaller vessels to operate.

FIGURE 8
An illustration of inefficiency in a rotation scheme



The most prominent change in fishermen's behaviour has been efforts to reduce costs. In rough weather, vessels from each town fish at the nearest fishing grounds. When a low catch rate is anticipated, each vessel takes fewer units of long line. With such efforts to save costs, the 2005–06 season yielded a smaller total harvest and less revenue but equal or slightly greater profit, according to the Hiyama FCA.

The pooling arrangement seems to have brought positive changes, but some members remain unhappy. The effect of a pooling arrangement is a double-edged sword: it can align an individual's incentive to maximize his return with the group's incentive but it also can encourage members to shirk and take advantage of others' effort (Uchida, 2007). The majority of the claims by those dissatisfied with pooling assert that differences in the skill of the skippers should be reflected in what a vessel earns. So far, the issue of shirking members has not surfaced, but frustrated members with legitimate complaints could undermine the entire co-management regime. The Nishi WPA faces the difficult task of finding a balance between the two opposing incentives involved in a pooling arrangement. Nonetheless, early results from the Nishi arrangement were so positive and persuasive that the trial continued throughout the 2005–06 season and was extended to the following season.

3.3 Licensing costs

There is a flat licence fee of 3 150 yen annually, i.e. the vessel size does not matter. The fees collected by management associations (Figure 6) vary and are used to cover costs such as (a) meetings among the members, (b) representatives attending regional meeting of TAC allocation and (c), the hiring of a skipper when a representative attends meetings during the season. These activities are generally related and necessary for the current co-management regime and thus are considered as co-management-related expenses.

The total annual cost to an operator depends on the vessel size and to which regional association one belongs. For example, for a 9 ton vessel whose owner is a member of the Otobe WPA, Nishi Section WPA, and Hiyama Walleye Pollack Long Line Association, the total annual cost is 98 150 yen (≈. $890), though note that the actual fishing season is only three months (Nov~Jan). Some fishers felt this fee to be somewhat of a burden.

4. MARKETING

The FCA also has tried several ideas to obtain higher prices for the group's catches; some ideas have failed but others have been successful. The primary product of the Hiyama region's walleye pollack is roe. The roe is often simply salted to become *tarako*,

TABLE 1
Hiyama region annual walleye pollack fees

Item	Fee (¥)		
	Active	Idle	
Licence fee	¥3 150	¥0	Flat fee
Hiyama Walleye Pollack Long Line Association	¥10 000	¥5 000	< 5 tons
	¥10 000	¥10 000	<9 tons
	¥15 000	¥10 000	≥ 9 tons
Nishi Section Walleye Pollack Association	¥30 000	¥15 000	Flat fee
Kumaishi Walleye Pollack Association	¥30 000	¥0	Flat fee
Toyohama Walleye Pollack Association	¥25 000	¥0	Flat fee
Otobe Walleye Pollack Association	¥50 000	¥0	Flat fee
Esashi Walleye Pollack Association	¥10 000	¥0	Flat fee
Kaminokuni Walleye Pollack Association	¥0	¥0	Flat fee
Example:			
Fisher in Otobe district, 9 t vessel	¥98 150		
Consisting of:			
Licence fee	¥3 150		
Hiyama Walleye Pollack Long Line Association fee	¥15 000		
Nishi Section Walleye Pollack Association fee	¥30 000		
Otobe Walleye Pollack Association fee	¥50 000		

a common side dish in Japan. The retail price is 6 000 to 7 000 yen (approximately US$60) a kilogram. The Hiyama FCA is putting significant effort into promoting its own brand, Beni-Otome ("scarlet lady"), to capture greater profits from its product. The fish are also boxed and shipped. The main markets for pollack fillets are in China and Korea or for surimi, but the Hiyama FCA is beginning to promote domestic consumption.

A current marketing effort samples the roe quality and releases the information to buyers prior to the auction. Uncertainty about roe quality prior to bidding results in weaker bidding. With samples of roe quality, bidders can match bids to quality. This system encourages fishermen to be quality-conscious and the market rewards those efforts.

5. MAINTAINING THE WILL FOR BETTER STEWARDSHIP

Catastrophic events, such as collapse of the fish stock, often result in a paradigm shift by fishers' towards engagement in rigorous fishery management by the fishermen. As described above, the walleye pollack fishery of Hiyama region is no exception; the support for sustainable fishery in Hiyama has its roots in those hard days when literally the entire community had to temporarily migrate for jobs after the pollack disappeared. However, that was more than half a century ago and younger generations – fishermen in their 40s – have not experienced those hardships. Leaders of the Nishi WPA are concerned as to whether younger generations can maintain the will to be good stewards and thereby sustain the co-management regime.

Is such catastrophic event necessary for paradigm shift to occur? Must all generations go through the similar experience to actively maintain the co-management regime that their predecessors established in response to their experience of such hardships? The answer that Hiyama fishers came up with is interesting, particularly because it was initially intended for an entirely different purpose. In the mid-1980s, a group of younger fishermen attempted to establish a hatchery for walleye pollack. In the end, the hatchery project failed due to high mortality for both eggs and larvae. Despite its commercial failure, the hatchery project generated some unexpected benefits. These young fishermen realized how vulnerable the eggs and hatchlings are through

their failed efforts to lower the mortality rate in the hatchery. As one of the project members remarked, the recognition of the fish's vulnerability and fragility convinced his generation of the importance of fishery management. The hatchery project itself has been extended in an effort to learn more about the fish and to keep the motivation for walleye pollack fishery co-management.

6. FUTURE CHALLENGES

Walleye pollack co-management in the Nishi section of Hiyama has been successful thus far. The fishing-ground rotation, though schematically complicated, successfully meets a simple objective: maintain fairness and avoid gear/vessel congestion. The Nishi WPA also has shown remarkable flexibility when faced with low stocks and increasing fuel costs. Members are actively working on both fronts – cost savings and revenue enhancement through marketing. The Nishi fishermen are an encouraging example of how fishery co-management can be effective and sustainable.

From an economic point of view, the question is whether this co-management regime is capable of reducing the fishing effort to an efficient level, in addition to addressing the short-run crowding externalities. Whether the current 51 vessels in Nishi section is near, or far, from an economic efficient level is unknown, but vessel consolidation and fleet reduction is clearly a recent trend. Specifically, smaller vessels are retiring and crew members are transferring to larger vessels. There seem to be several forces behind this trend. First and foremost is the declining fish stock (despite the management) and rising fuel costs. Consolidation can be viewed as an attempt to take the advantage of economies of scale. However, one must not overlook the effect of highly coordinated fishing practices (i.e. fishing ground rotation) and the pooling arrangement. With these two measures, Nishi WPA fishers are operating as a quasi-single operator. It can be argued that such teamwork facilitates the consolidation by easing the negotiation and transition processes.

There are several issues and challenges facing the Nishi co-management group. One is how to incorporate heterogeneity in the skill of skippers in the distribution of pooled revenue. The group could opt not to incorporate skill at all, but the Nishi WPA would probably need to further enhance profitability for that option to address the dissatisfaction with equal sharing. Alternative methods tend to reduce fairness in other ways and/or induce excessively competitive behaviour that would undermine the purpose of co-management.

The Hiyama region's co-management group, including Nishi WPA, also faces some external challenges, particularly the need to coordinate with neighbouring regions that target the same stock. The ideal would be to merge the various management efforts into a single group with authority over the pollack throughout its migration range over the west coast of Hokkaido. The likelihood of establishing such an ideal institution is small. Fishermen in the southern region, who mostly harvest for roe, argue that the collapse of walleye fisheries is due to overharvesting of juveniles by trawlers. Fishermen in the northern regions claim that southern harvesting for roe reduces the number of young fish that migrate northward to their fishing grounds. Both sides are caught in an endless 'chicken-or-egg first' argument.

The TAC system could have provided a region-wide management tool, but it too poses a serious problem that undermines efforts by Hiyama's fishermen. Hiyama fishermen have intentionally reduced catches both to save money and to conserve the stock. However, the annual TAC allocation is based on the catch history from the preceding three years and is weighted toward the most recent catch. This system punishes fishermen in Hiyama for their conservation efforts, something the Hiyama fishermen perceive as unfair.

Co-management by fishermen in the Nishi section of the Hiyama region is notably successful, but the migratory nature of walleye pollack presents a restriction that

Hiyama alone cannot overcome. Given the overall decline of walleye pollack stocks, especially in the northern Japan Sea stock, some kind of overarching management regime is needed. It will be a challenge for all stakeholders, as development of such a regime will require the cooperation among fishers, government officials, buyers and scientists.

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