How can fishery comanagement groups enhance economic performance? Hints from Japanese coastal fisheries management

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Abstract

Although comanagement is gaining increasing attention as a way to manage fisheries, few studies have attempted to understand quantitatively which factors of comanagement are critical for their success. This study investigates fishery comanagement regimes adopted by coastal fisheries in Japan. Utilizing a wide variety of examples of fishery comanagement nationwide, we search for key rules and measures that underlie traditional, cultural, and social aspects of comanagement. The study focuses on the rules of the game adopted by comanaging groups called fishery management organizations (FMOs). Upon examination of successful fishery comanagement cases, we found two distinctive measures: effort coordination and pooling arrangements. Furthermore, anecdotal evidence suggests that pooling arrangements are vital supporting measure for effective effort coordination, in which case having both of these two measures rather than only either one may be the key for successful fishery comanagement. We test this hypothesis with two sets of data. One is Japan's fishery census, which was published by the government and offers a large sample size but lacks information on effort coordination. Another is data from a survey designed and conducted by the authors to supplement the information on effort coordination and other self-imposed regulations. Our results show that (1) merely establishing comanaging groups such as FMOs has limited effect; (2) FMOs that establish pooling arrangements earn greater revenue from their fishing efforts, particularly when such pooling arrangements are combined with effort-coordination; and (3) pooling arrangements and effort coordination coupled with marketing activities result in the greatest revenue.

1. Introduction

Coastal fisheries worldwide are faced with the challenge of achieving sustainable use of marine resources. Overexploitation of marine resources is a common phenomenon across the globe. In fact, the United Nations' Food and Agriculture Organization (FAO) estimates that more than three quarters of the world's main fish stocks are overexploited (United Nations Food and Agriculture Organization 2004b). The traditional command-and-control fishery regulations imposed by governments (central or local) to reduce overexploitation have been partially effective in protecting the resource stocks but have often failed to improve the fisheries' profitability. In his seminal paper, Gordon (1954) noted that ill-defined property rights over fishery resources were at the heart of the problem. Without adequately defined property rights, users have no incentive to properly manage the resource because the benefits that would result from such management cannot be fully appropriated. The notion and the importance of property rights in fishery resource management were thus brought onto the main stage of the discussion.

A proposal for individual transferable quotas (ITQs) as a rights-based fishery management regime was first put forward by Christy (1973) (as cited in Copes (1986), p. 279). The fact that these quotas are transferable makes them a quasi-property right over the fish they are entitled to harvest. Since then, ITQ regimes have been implemented in countries that have significant fishing resources, including Iceland, Australia, and New Zealand (Arnason 1993; Newell et al. 2005).

At the same time, there has been resistance to wholesale adoption of ITQs in many countries, for reasons that are both spurious and substantive. ITQs have been subject to a fairly constant din of criticism by skeptics. The highly cited Copes (1986) critique offered many reasons why we might expect ITQs to fail in practice, including data fouling, black market off-loading, and high-grading. More recent criticism has focused on “fairness.” The fairness issue cuts across various concerns, including the fairness of the actual distributions of rents that are generated, the fairness of excluding some bona fide fishermen in the initial allocations, and the fairness of granting initial wealth to original participants (e.g., Matulich and Sever 1999). The latter two concerns are particularly acute in the context of developing countries, where fisheries are the dominant, if not the only, foundation for households’ livelihoods (United Nations Food and Agriculture Organization 2004a).

An alternative rights-based fishery management regime is territorial use rights in fisheries, or TURFs. TURFs are typically granted to the local fishing community or groups of local fishermen. These groups then collectively assume responsibility for fishery resource management, which we refer to as “comanagement.” Comanagement can be accomplished through a partnership or other power-sharing arrangement with [[[*original wasn’t clear, this is what I think you* mean]]]authorities (Jentoft 2003) or the TURF-granted community can opt to manage the resource on its own, so-called community-based management (Charles 2006). In either case, the key features of fishery comanagement are that fishermen form a group to manage the fishery in a collective manner based on mutually agreed rules and that some form of exclusive access rights—a TURF or a limited number of licenses—is granted to such a group. This regime is different from an ITQ because, within the context of rights-based management, it involves centralized and coordinated decision-making.

Fishery comanagement has recently garnered considerable interest from both fishermen and regulators and from developed and developing countries. For example, there is some momentum behind movements to establish coop-based fishery comanagement in a variety of North American fisheries based on the success of newly established cooperatives in Pacific whiting and Bering Sea pollack fisheries. In developing countries, where the enforcement capacity of authorities is weak and market infrastructures are fragile, for market-based regimes to be feasible, comanagement may be the only hope for rational management. In fact, community-based fishery comanagement has been actively promoted both by local governments and by international aid institutions (e.g., Asian Development Bank 1995).

Despite all of the interests, attention, and worldwide applications (Cunningham and Bostock 2005; Wilson et al. 2003), fishery comanagement remains poorly understood. Economists have been skeptical about the effectiveness and sustainability of comanagement regimes primarily because they involve collective action by individual fishermen. Economists argue, for example, that, even if the incumbents cooperate and manage to enhance the economic rents from the fishery, success will attract new entrants to the industry, consequently dissipating that rent. If the incumbent fishermen anticipate this happening, then cooperation might not take place at all. Comanagement might also be vulnerable to cheating. Contrary to these theoretical predictions, however, there are many successful cases of comanagement that has endured and maintained a high rate of compliance (see, for example, Cunningham and Bostock (2005), Platteau and Seki (2001), and Uchida (2004a)). This anecdotal evidence calls for more in-depth analysis of comanagement of common-pool resources.

Other disciplines such as sociology and political science, in addition to economics, have conducted many case studies on comanagement of common-pool resources. Some researchers have derived conditions that are critical for successful comanagement, such as characteristics of the resource and institutional arrangements (e.g., Agrawal 2001; Baland and Platteau 1996; Ostrom 1990; Ostrom et al. 2002; Wade 1988). Examples include maintaining small group size, cultural homogeneity, frequent communication among members, and practices of reciprocity (all user characteristics) and stationarity[[[*???*]]] and storage capability (both being resource characteristics) (Ostrom et al. 2002, p. 450). However, these studies seem to share a common assumption that fishermen will fundamentally deviate from agreed rules since it is not in their best economic interest to comply with those rules. All of the factors in the preceding list are necessary conditions for reducing the cost of monitoring and enforcement aimed at preventing fishermen from deviating from the rules. This leaves us with one pressing question: Is there a way to alter fishermen's incentives so that their individual interests are aligned with that of a group, community, or society as a whole?

Understanding the incentives and consequent behavior by fishermen is the key to analyzing fishery comanagement. If adhering to the comanagement regime by complying with its rules and thereby achieving the group's goals is in each fisherman's interest, then the burden of monitoring and enforcement can be significantly reduced. Fishermen's incentives can be altered by the "rules of the game." ITQ is one such example; in the context of comanagement, ITQ is the design of the self-imposed set of rules and the organizational structure by which the group manages the resource.

This paper analyzes the influence of the rules of the game adopted by comanagement groups on economic outcomes. For this purpose, we look to the Japanese experience with coastal fisheries management. Our primary reason for this choice is the abundant cases of fishery comanagement regimes in Japan as virtually all coastal inshore fisheries are governed by fishermen's groups. These self-governing bodies composed of local fishermen are called fishery cooperative associations (FCAs). Fishery comanagement is carried out by fishery management organizations (FMOs), which are autonomous groups of fishermen who are typically chosen by their parent FCAs (Makino and Matsuda 2005). An FMO can be simply an FCA or it can be a subgroup of FCA members or an alliance of fishermen from multiple FCAs (Uchida 2004b). We know of no study that has looked at FMOs nationwide and analyzed the relationship between their characteristics and performance using variations in their operations, management measures, and economic performance.

The advantage of studying Japanese cases to understand comanagement is that there were 1,608 FMOs in Japan in 2003 (Ministry of Agriculture, Forestry and Fisheries (MAFF) 2006). These FMOs differ in terms of types of fishing gear used, targeted species, membership size, and implemented management measures. Yet, unlike the case of a multicountry analysis, they all function under the same national fishery rules and laws and, to some extent, their cultural and social characteristics are identical. Japanese FMOs are ideal subjects for our research because, unlike a multicountry analysis of a small number of observations from each country, as is often seen in the comanagement literature (Agrawal 2001), the Japanese case offers wide variations in key fishery-related variables while other influential and difficult-to-observe disturbances are controlled.

The focus of our analysis, derived from multiple sources of anecdotal evidence, is centered on two specific measures employed by many successful FMOs: fishing effort coordination and pooling arrangements (details of these rules are explained in the next section). Our aim is to determine whether these two measures are in fact significantly correlated with higher economic returns as measured by fishery revenue. Furthermore, we examine whether having both measures in place results in better performance than comanagement regimes in which there is none or only one measure, based on the notion by Platteau and Seki (2001) that pooling arrangements are supporting mechanisms for effort coordination, thus suggesting that the two are most effective when employed together. We find that fishermen participating in FMOs with effort coordination and pooling arrangements tend to generate the greatest economic returns, and the source of the return originates mainly from coordinated marketing practices. We also find that the number of members in the group has no significant impact, contrary to a popular proposition set forth by Olson (1965) and his followers. The main message of this paper is that comanagement achieves its highest potential, in terms of generating economic returns, when fishing effort and marketing practices are well-coordinated and that pooling arrangements support the effectiveness of such coordination by altering fishermen's incentive structures.

A final note on why it is worthwhile to study Japanese fishery co-management regimes is in order, as some might argue that Japan's experience is based on its unique historical, cultural, and social characteristics and thus that its applicability in other parts of the world is limited. Firstly, through our interviews with Japanese fishermen, we came to conclude that they are just as competitive as entrepreneurs and no more cooperative-minded than fishermen elsewhere. Cohesiveness of the community surely would enhance the likelihood of cooperation and compliance, but such social characteristics can be readily observed in small coastal communities outside of Japan. The notion that Japanese fishermen are more cooperative, thus enabling comanagement to flourish, is anything but true.

Secondly, it is true that Japanese fishery comanagement and operation of the country's FMOs hinges on two unique institutions. One is the aforementioned FCAs and the other is fishing rights, a Japanese version of TURFs that is protected by law. The historical evolution of these institutions and their administrative structures is well documented in the literature (Asada et al. 1983; Makino and Matsuda 2005; Ruddle 1987; Yamamoto 1995). However, there seems to be an overemphasis on the historical background of these institutions, which has often led to a conclusion that Japanese success is due mainly to its traditional strength of cooperation. We argue that, while the two institutions themselves may be unique, the functions they perform can be thought of as universal. Fishery comanagement can be conceptually characterized by applying the framework of the theory of clubs (Buchanan 1965), which asserts that impure public goods such as fishery resources can be converted into club goods if (1) geographical and membership boundaries are defined and enforced and (2) members are better off than nonmembers. FCAs' membership control and TURF's boundaries are designed to meet the first condition, but nothing requires that these are the only method to meet this condition.[[[*vague, confusing*]]] It is the functions of FCAs and TURFs that are important, and they are generally widely applicable.[1] The second condition, in our context, is that the benefits of fishery comanagement perceived by FMO members are sufficiently high. This is an issue that has little relevance to tradition, and Japanese experience can provide hints about ways to meet, or avoid failing to meet, this condition.

2. Effort coordination and pooling arrangements: An overview

The management regime employed by FMOs can vary from simple to sophisticated. As a starting point, it must be remembered that simply having an allocation of allowable harvest assigned to a group like an FMO does not necessarily correct fishermen's incentives and behavior. One end of the spectrum is thus no different than a conventional limited-entry program in which a limited group is given unallocated rights to a total allowable catch. This configuration would likely invite race-to-fish incentives, which are well documented in the literature. A simple comanagement regime is one in which operational and output restrictions are self-imposed, leaving other fishing decisions to individual fishermen. At the other end of the spectrum is the corporate or sole-owner model in which operations of the FMO are completely coordinated to maximize total profits. Then there is a range of options in the middle that is characterized by group agreement on broad rules of behavior, leaving an opportunity for individual initiative and decision-making by participants.

[1] For details of how FCA and TURF systems achieve these conditions, see Uchida (2004b).

From our examination of successful FMOs in Japan, it became apparent that two interesting features, which we refer to as "effort coordination" and "pooling arrangements," were often present. Effort coordination involves individual fishing operations that are coordinated with the goal of increasing the efficiency of the overall fishing effort. This includes, but is not limited to, eliminating the race-to-fish incentive and avoiding congestion at fishing grounds, which also reduces potential damage and loss of fishing gear. Typical methods employed to achieve these objectives are fishing-ground rotations and/or assignments, alternating fishing days, joint searches/assessments of fish stocks, and, in some cases, joint ownership of vessels and fishing gear. Through well-conducted effort coordination, FMOs are able to solve spatial and temporal issues of efficient allocation of fishing effort.

A pooling arrangement is an agreement among FMO members by which harvests, revenues, and/or profits are pooled and then distributed back to members.[2] The redistribution rule is either uniform (all participating fishing units receive the same amount) or weighted by indicators such as vessel size and number of crew members. In the literature, a pooling arrangement is typically characterized as a supporting mechanism for effort coordination (Baba 1991; Gaspart and Seki 2003; Hasegawa 1985; Platteau and Seki 2001; Uchida 2004a). This is because, in essence, effort coordination is a restriction of individual freedom-of-fishing decisions and the differentials in harvest levels resulting from effort coordination must be addressed and adjusted. A pooling arrangement is a method for handling this differential problem.

The key element of a pooling arrangement is that it breaks the link between the individual fishing effort applied and actual earnings received. This dampens the incentive to compete aggressively, which is favorable in light of the excessive fishing effort that is applied in the

[2] Pooling arrangements, as considered here, do not include insurance purposes, as in risk pooling, since such fishery insurance is already offered by FCAs.

absence of comanagement. It also aligns the incentive gradient of individual fishermen to that of a group: if a fisherman wishes to maximize his slice of a pie, then he must maximize the total size of that pie. This implies, for example, that it becomes an individual's personal interest to avoid flooding the market and depressing the market price, which would lead to voluntary restraining of harvests. However, a pooling arrangement is a double-edged sword: if the incentive-dampening effect goes too far, shirking problems can undermine the FMO's stability. The higher economic return from comanagement, particularly when that management includes a pooling arrangement, thus becomes critical in sustaining the comanagement regime.

Anecdotal evidence shows that there are many FMOs with pooling arrangements that are functioning reasonably well. Platteau and Seki (2001) surveyed fishermen in Toyama Bay, where there were two FMOs with pooling arrangements that operated under different FCAs but targeted the same species.[3] Uchida (2004a) studied another FMO with a pooling arrangement in Suruga Bay; in that case, fishermen from two FCAs that target the same species formed one unified FMO. This FMO has adopted a sophisticated fishing effort-coordination scheme, including harvest control to avoid market gluts and collective promotion of their products to consumers as part of its marketing activities. In both cases, the pooling arrangements function as a supporting mechanism for—and perhaps even facilitating—fine-tuned effort-coordination measures.

The number of FMOs with pooling arrangements is increasing over time. According to the tenth fishery census, 294 of 1,734 FMOs had implemented some variation of pooling arrangements (MAFF 2001). Among those, roughly half, or 144, FMOs had a uniform distribution system and 129[[[*these numbers don't add up; should they?*]]] had a weighted

[3] Platteau and Seki (2001) refer to the pooling arrangements as the "pooling system."

distribution system. The share of FMOs with pooling arrangements had risen from 11% in 1988 to 15.6% in 1993 and to 17% in 1998 (MAFF 1991, 1996, 2001).[4]

3. Empirical model and data

General model

We use revenues as a measure of economic performance for the FMOs. Ideally, one would like to use profit for such purposes since FMOs can be effective in reducing operational costs through either direct coordination or recovery of resource stock levels. The data sets we use, as we explain hereafter, provided neither profit nor cost information. Cost information is difficult to obtain in general because fishermen and their vessels are often involved in multiple fisheries simultaneously; that is, not only do seasons for multiple fisheries overlap but they can operate in multiple fisheries in a single day. With such operations, it becomes difficult to determine how much of total costs can be attributed to a specific fishery since fishermen typically do not keep records of time and other information that might be useful to determine that cost.

There are circumstances in which revenue is a suitable and plausible choice for our research purpose. A fishery-related total cost for small-scale fishers such as those considered in this paper is typically dominated by large fixed costs. In fact, in interviews with Japanese fishermen and vessel owners, they stated that variable costs such as fuel per trip are not significant compared to fixed costs such as mortgage payments for their vessels and equipment. In such a case, the vessel owners' incentive is to maximize revenue by keeping their vessels in operation as much as possible during the season to cover those fixed costs (Kirkley and Strand

[4] The share declined in the most recent (eleventh) census to 12% (MAFF 2006), but since the eleventh census redefined FMOs drastically, the relationship of this figure to the previous census is not clear.

1988). Also of note is that many of the variable costs, such as fuel, packing materials, and ice, are already discounted through joint purchases by the FMOs' parent FCAs, which is an additional justification for using revenue as a measure of economic performance.

[Figure 1 about here]

Explanatory variables of particular interest are effort coordination, pooling arrangements, and marketing activities. Marketing activities can be subdivided into two groups: one that is predominantly price-enhancement oriented and one that is oriented towards demand enhancement (Figure 1). Ex-vessel market-price-enhancing activities include quality control and self-processing to add value to products. Expansions of sales channels by means of advertisement and branding strategies, both with the aim of increasing demand, can lead to increased landing volumes and a higher market price.

Effort coordination can have both direct and indirect effects on revenue. Direct effects occur when the total landing volume is controlled to avoid market flooding, which may contribute to enhanced ex-vessel market prices. Indirect effects occur when marketing activities are conducted as part of effort coordination. Similarly, pooling arrangements may directly reduce the landing volume through mitigated race-to-fish incentives or to some extent due to shirking, or may influence revenue through reinforcement of effort coordination.

There are other variables that influence revenue levels and must be controlled. For landing volume (i.e., the harvest), the variables are the level of capital capacity such as vessel size; fishing methods and gear types; and other fishing coordination efforts such as annual fishing days and hours. The level of fish stocks will also influence the harvest level, but reliable data for that parameter were not available. On the market-price side, covariates include the species type targeted and its geographical location since place of origin is often used as part of a branding strategy. Some FMOs have been successful in branding their products.

Data sets

In our analysis, we utilized two different data sets. These data sets complement each other in the information they contain but are not compatible in the sense that they cannot be merged to create a single data set. Thus, we conducted separate analyses with each data set.

Before getting into the details of the data, explanations of terminologies used henceforth are in order. *Fishing units* are economic entities engaged in fisheries for commercial purposes. *Fishing districts* are defined as a community within the boundaries of a local municipality that operates fisheries under a common environment, such as sharing the same fishing rights area (TURF) and commonalities in other fishery-related activities. Generally speaking, there is one TURF and an FCA that administers it in each fishing district. Due to recent trends of mergers of FCAs, however, this is changing rapidly. After mergers, former FCAs often remain as branch offices and retain much of their independence in guiding fishery operations.

The first data set is the fishery census compiled by the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF). The census is conducted at five-year intervals and surveys fishing units to collect data on fishing operations, equipment, revenues, and other fishing and household characteristics. It also collects data on fishery organizations such as FMOs. It is the most comprehensive fishery data collected and made available to the public in Japan.

The main advantage of the census data is its large number of observations and its potential to form a panel data set that will enable us to control for time-invariant unobservables with fixed-effects models. However, the census data also falls short in two important areas. One is that the published census data are aggregated at the fishing-district level and so report only either sum or average values. Hence, our unit of observation is restricted to the fishing-district level. Due to confidentiality issues, data compiled at the fishing-unit level are not available from MAFF. More details about this issue and remedies for it are explained in subsequent sections. Another problem is that the census does not collect information on effort-coordination practices by FMOs. This is a huge setback as effort coordination is one of the core factors under investigation, which led us to acquire the second data set.

The second data set comes from a survey we conducted. Since there were no readily available data sets on effort coordination at the level of detail that was required, we developed a mail survey that was implemented in 2005.

The main challenge in conducting the mail survey was to identify which FMOs to include. Ideally, we wanted to send the survey to all FMOs nationwide but we quickly realized that this was not possible. The main complication is that contact information for all of Japan's FMOs does not exist, primarily because FMOs are autonomous organizations. One option was to send the survey to all of the fishery cooperatives (FCAs) since their contact information is publicly available. However, there are many cases in which there are two or more FMOs within a single fishery cooperative and we were advised that a survey sent to generic recipients (not to specific FMOs) would tend to get red-taped and receive no attention. For these reasons, it became clear that a list of specific contact information for the FMOs was needed, which led us to use the list of FMOs from a prior survey conducted in 1997.[5] As a result, 386 surveys were sent and 116 usable responses were received.

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[5] The 1997 survey, conducted by the Japanese government, was sent to regional government officers associated with FMOs located within their jurisdictions, who then answered the survey on behalf of the FMOs. Our survey differs from the previous one in two important ways: (1) our survey was sent directly to FMO managers instead of to the government officials who oversee them, and (2) our questions were focused in great detail on effort coordination, pooling arrangements, and other self-imposed regulations and on fishing operations in general.

The advantage of survey data lies in the details provided regarding not only effort coordination but also pooling arrangements, other self-imposed regulations, and marketing activities. The disadvantage is the relatively small number of observations provided. In this case, after eliminating responses that were only partially complete, we had 67 data points for use in the subsequent regression.

In sum, we could not combine and merge the two data sets since the census collected data at the fishing-district level and the survey collected data at the FMO level. We instead exploited the advantages that each data set possesses—which correspond to the disadvantages of the other—to investigate the impact of effort coordination, pooling arrangements, and marketing activities on fishery revenue.

4. Census data results on pooling arrangements

Data issues and remedies

The unit of observation in the census is fishing district and the fact that the census data are aggregated at the fishing-district level poses some problems. There are six categories of fishing units defined in the fishery census: individuals (typically fishing households), corporations, FCAs, production cooperative associations (PCAs), joint operations (two or more individuals jointly operating (JO)), and others (government agencies and research institutions). Individual fishing units include only those who own and operate the business; hired fishermen are excluded.

Table 1 clearly shows that levels of average revenue differ substantially between individuals and other types of operations. Furthermore, the distribution of the fishing unit types is not symmetric between FMO participants and nonparticipants (henceforth “FMO units” and “non-FMO units” respectively); in other words, a majority of nonindividual fishing units do not participate in FMOs. These observations imply that one must control for the fishing unit type to examine the impact of FMOs on average revenue. However, since average revenue and other variables are aggregated into a single data point per fishing district, the ability to control for fishing unit type is imperfect. The remedy is to focus on districts that have only individual fishing units. In that way, the individual fishing units are overwhelmingly dominant among both FMO units and non-FMO units.

[Table 1 about here]

Our primary interest in evaluating the census data is whether (1) fishery comanagement by FMOs brings higher revenues to member fishermen and, if so, (2) the degree to which such returns differ between FMOs that do and do not have pooling arrangements and marketing activities. Ideally, one would want data on each fishing unit with information on whether that unit is an FMO or a non-FMO unit. The census, however, provides only the mean of all fishing units in a district and the mean conditional on FMO units. In other words, for some variable x, each fishing district i has data of the form $N^{-1}\sum_{j} x_j$ and $N^{-1}\sum_{j\in FMO} x_j$ where the subscript j denotes the fishing unit. With these data, we computed average values for non-FMO units. The dependent variable, which is average fishery revenue, was computed in this manner. In what follows, we separated the data for each variable into FMO units and non-FMO units within each district so that we could estimate the impact of FMOs using the dummy variable method.

The variables for fishing capital recorded in the census include the average number of boats or vessels owned, vessel tonnage, and vessel engine horsepower. Boats and vessels are divided into three categories: “nonpowered boats” have no engines attached; “externally powered boats" are defined as those with external engines attached to otherwise nonpowered boats; and "vessels" are those with integrated engines. Tonnage and engine horsepower are reported for the vessel category only. The number of boats and vessels is reported per fishing unit whereas the averages for tonnage and horsepower are defined per vessel per unit to incorporate the fact that one unit might own two or more vessels and one vessel might be jointly owned by two or more units.

The census provides data on the total number of FMOs that use pooling arrangements in a fishing district and a breakdown list for uniform, weighted, and other forms of distribution rules. The problem is that if, for example, there are three FMOs in a fishing district and only two have pooling arrangements, then the average revenue of the FMO units in the district is a composite of two FMOs with pooling arrangements and one FMO without them. Since there is no way to decompose the single observation of average revenue, we constructed the share of FMOs with pooling arrangements for each distribution rule (s) in each fishing district, $POOL_{i,s}$. Let $S(k,s)=1$ if an FMO k has pooling arrangement s and $S(k,s)=0$ otherwise. Then the share $POOL_{i,s}$ is

$$POOL_{i,s} = \frac{\sum_k S(k,s)}{K_i} = \frac{\text{Number of FMOs with pooling arrangement } s}{\text{Total number of FMOs in fishing district } i}.$$

Note that one unit can at most implement one type of pooling arrangement but some FMOs have none. Thus, the shares do not necessarily sum to one. The share of FMOs with any pooling arrangement is

$$POOL_i = \sum_s POOL_{i,s}.$$

The census records marketing activities by FMOs. Subcategories of marketing activities as defined in the census are (a) keeping the catch alive ("live"), (b) quality control ("quality"), (c) “processing” (dressing, etc.), (d) expanding sales channels (“sales”), and (e) transportation improvement (“transportation”). Activities (a) and (b) are grouped together as “onboard” activities while the rest are grouped as “on-land” activities. The fishery census reports the number of FMOs engaged in any of these marketing activities. If an FMO is engaged in two or more marketing activities, it is recorded in one[[[*seems to be word missing here*]]] of those activities. The marketing variables are constructed as the share of FMOs engaged in a certain marketing practice (m) over the total number of FMOs in that fishing district. Let $M(k,m)=1$ if an FMO k has engaged in marketing practice m and $M(k,m)=0$ otherwise. Then the share $MKT_{i,m}$ is calculated as[[[*below, “marketing activities” perhaps should be marketing activity”- singular used just above*]]]

$$MKT_{i,m} = \frac{\sum_k M(k,m)}{K_i} = \frac{\text{Number of FMOs engaged in marketing activities } m}{\text{Total number of FMOs in fishing district } i}.$$

Since one FMO can engage in multiple marketing activities, the shares could sum to more than one. Also, we define the share of FMOs in a district with any marketing activities as

$$MKT_i = \frac{\sum_k M(k)}{K_i},$$

where $M(k)=1$ if FMO k is engaged in at least one marketing practice and $M(k)=0$ otherwise.

Descriptive statistics of census data

A panel data set was formed from the ninth and tenth fishery censuses, which were conducted in 1993 and 1998[[[*I think it’s obvious so no need to state*]]]. Although the first census was conducted in the late 1940s, data on FMOs have been collected only since 1988. A closer examination revealed that some details of the census data have changed over the years. The 1988 census is incompatible with the two that followed it (1993 and 1998) and the results from the 2003 census are not available yet.

The unconditional mean of fishery revenue for FMO units was higher than that of non-FMO units for both 1993 and 1998. But while FMO units' average revenue decreased over this period by approximately $400, average revenue for non-FMO units increased by nearly $2,000. This may be due in part to the increase in vessel tonnage and engine horsepower that occurred during that period: non-FMO units on average shifted toward larger vessels with more powerful engines while FMO units changed little. Another possibility is the decline in fishing days. Although fishing days declined for both FMO units and non-FMO units, the magnitude was much larger for FMO units (-7.5 days) than for non-FMO units (-3.3 days).

[Table 2 about here]

Fishing capacity remained mostly unchanged for FMO units. The number of boats and vessels increased only slightly and vessel engine power decreased. The same pattern can be seen in non-FMO units for number of boats and vessels, but, as previously mentioned, tonnage and engine power increased by fair margins. Since the number of vessels did not increase as much, this indicates that non-FMO units switched to larger vessels, a typical pattern under the free competition associated with TURFs. Another interesting result is the stark difference in the levels of vessel tonnage and engine power between FMO and non-FMO units. These figures are calculated on a per-vessel per-unit basis to incorporate the fact that one vessel might be jointly owned by two or more units. Thus, this result suggests that some FMOs have shifted to joint ownership of vessels, and possibly of other fishing gear, to rationalize their inputs.

Pooling arrangements were implemented by 17.6% and 20.8% of FMOs in the sample in 1993 and 1998, respectively. There were more FMOs with weighted distributions than with uniform distributions in both years. Under weighted distribution schemes, weights are based on factors such as landing volume to mitigate the incentive to shirk, a downside of pooling arrangements. The net effect of the two opposing incentives is an empirical question. Other weighting schemes include consideration of vessel tonnage, which is intended to compensate for the cost differential due to vessel investment. This scheme does not distort the (short-run) incentive structure for a fisherman. However, it is not commonly seen because vessels in the same fishery vary little in size (tonnage and engine horsepower); thanks to the race-to-fish incentive, all vessels are typically the maximum size allowed by the regulations imposed by the central or local government.

Nearly half of the FMOs in the sample engaged in marketing activities, with onboard activities being more popular than on-land ones. This is intuitive given that these are probably what the fishermen are best at pursuing. The lack of popularity of landing the catch alive ("live") probably derives from the fact that it involves a significant upfront investment for things such as building fish tanks in vessels and purchasing devices that control water temperature.

In sum, key FMO-related activities for which data are available, namely pooling arrangements and marketing activities, were employed by the majority of the FMOs in 1998. As these institutional arrangements and activities are costly to set up and maintain, we would expect that there must be a significant economic return for such investment.

Model specification

The base model is a semilog function:

$$\ln \overline{R}_{it} = \alpha T + \mathbf{POOL}_{it}^{'}\beta_1 + \mathbf{MKT}_{it}^{'}\beta_2 + \mathbf{CAP}_{it}^{'}\beta_3 + \beta_4 DAYS_{it} + \beta_5 UNITS_{it} + \beta_6 (UNITS_{it} \times FMO_{it}) + \beta_7 CPI_{it} + \mathbf{Z}_i^{'}\gamma + \varepsilon_{it}, t = 1, 2, \quad (1)$$

where $\mathbf{CAP}_{it}$ is a vector of fishing capital variables and $\mathbf{POOL}_{it}$ and $\mathbf{MKT}_{it}$ are pooling and marketing shares that we previously defined. Since vessel tonnage and engine power is highly correlated, only the tonnage variable is included in the estimation model. $\overline{R}_{it}$ is average revenue per fishing unit in a district. $DAYS_{it}$ is the average number of fishing days, which includes days that a fisherman was engaged in any fishery-related activities, whether offshore or onshore. Onshore activities include not only maintenance of fishing gear but also various marketing activities. $T = 1, 2$ is the time-trend variable and $\mathbf{Z}_i$ is a vector of time-invariant fishing-district-specific variables, including gear type, targeted species, and other unobservables. $CPI_{i \in r, t}$ is consumer price index (CPI) data reported from Bank of Japan with base year 2000, which we included to capture the general trend of price changes over the analyzed periods. The data set contains the CPI for ten regions in Japan and is denoted by subscript r. This captures region-specific trends, something that is more desirable than using the nationwide average. Lastly, ε_{it} is the error term.

In addition to the preceding variables, we included the number of units as a covariate ($UNITS_{it}$). The general impact of the number of units on fishery revenue per unit is ambiguous. Large numbers of units in a fishery may, on one hand, intensify competition, which could lead to a downward spiral of large landing volumes, market flooding, lowered prices and revenues, and increased subsequent harvests to make up for the decline. On the other hand, large numbers of vessels may facilitate joint production in the fishery and increase per-unit revenue. Then there is the FMO-specific impact of the number of units; *ceteris paribus*, the smaller the membership's size, the better the chance of success in comanagement (Agrawal 2001; Olson 1965). To incorporate this effect, the interaction term of $UNITS_{it}$ and the FMO indicator variable (FMO_{it}) were included.

We took the first-difference transformation of the base model (1) to control for the fixed effects:

$$\Delta \ln \overline{R}_i = \alpha + \Delta \mathbf{POOL}_i{}'\beta_1 + \Delta \mathbf{MKT}_i{}'\beta_2 + \Delta \mathbf{CAP}_i{}'\beta_3 + \beta_4 \Delta DAYS_i + \beta_5 \Delta UNITS_i + \beta_6 \Delta (UNITS_i \times FMO_i) + \beta_7 \Delta CPI_i + \Delta\varepsilon_{it},$$

where Δ denotes the first difference between 1998 ($t = 2$) and 1993 ($t = 1$). We chose the first-difference model over the alternative fixed-effects models because the former also controls for potential serial correlation of the error term while the latter does not.[6] The estimates of coefficients, on the other hand, are identical for the two methods (Cameron and Trivedi 2005).

Note that this transformation was done separately for each FMO and non-FMO unit's data set. That is, for any given fishing district i there will be at most two observations: one for FMO units and another for non-FMO units. The focus is to capture whether changes in average revenue differ between FMO units and non-FMO units by adding an FMO dummy variable, FMO_i. The estimation model thus becomes

$$\Delta \ln \overline{R}_i = \alpha + \Delta \mathbf{POOL}_i{}'\beta_1 + \Delta \mathbf{MKT}_i{}'\beta_2 + \Delta \mathbf{CAP}_i{}'\beta_3 + \beta_4 \Delta DAYS_i + \beta_5 \Delta UNITS_i + \beta_6 \Delta (UNITS_i \times FMO_i) + \beta_7 \Delta CPI_i + \beta_8 FMO_i + \Delta\varepsilon_{it}, \quad (2)$$

where $FMO_i = 1$ for an observation of an FMO unit in district i and $FMO_i = 0$ otherwise.

An important consequence of this method is that observations in which FMO/non-FMO units disappeared or newly emerged between the two periods are not included in the sample. This may seem odd since such observations are commonly used in the literature to assess the treatment effects, which in our context is the formation (or dissolution) of FMOs. The justification for this approach is that the number of such observations (i.e., fishing districts) is very small.

Regression results

The results from heteroskedastic-robust ordinary least squares (OLS) regressions are presented in Table 3. Models 1 through 4 differ by specification of $\Delta POOL_i$ and ΔMKT_i; all other covariates included in the regressions are identical. There are 459 observations, of which 126 are FMO units. All models rejected the null hypothesis for an overall F test at the 1% significance level. Adjusted R^2s were all in the neighborhood of 0.26–0.27.

The FMO dummy variable was estimated to have no statistical significance in explaining the change in average fishery revenue, although the signs were all positive. Since the panel has only two periods, the estimation results for within-fixed-effect, first-difference, and pooled OLS models are all identical (Cameron and Trivedi 2005). This implies that the FMO dummy variable is statistically insignificant with respect to not only the change in revenue but also the revenue level after controlling for covariates. This suggests that the mere existence of an FMO has only a marginal impact, if any, on fishery revenue per unit in a fishing district.

[Table 3 about here]

Contrary to our prior expectations, the marketing variables showed no statistical significance in all model specifications. The estimated signs of onboard activities were positive and on-land activities were negative (model 2 and model 4). Considering that fishermen are likely to have more expertise in onboard activities relative to on-land activities, this is an intuitive result. Models with subcategories of onboard and on-land marketing activities were also estimated (model 2 and 4), but none had statistical significance.

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[6] Note that this is only true for a two-period panel.

It might be the case that not all marketing activities pursued by FMOs were effective and that fact is affecting the preceding results. There are no specific measurements of marketing effectiveness, but it is a plausible hypothesis that FMOs with pooling arrangements are more effective when marketing is included. For example, freed fishing effort that results from curtailed fishing under a pooling arrangement could be diverted to marketing efforts. Since, with the pooling arrangement, individual shares increase as total revenue increases, FMO units will have stronger incentives to make marketing activities effective.

[Table 4 about here]

To test this hypothesis, we ran additional regressions based on model 1 and model 2 with a new variable, $\Delta POOL_i \times \Delta MKT_i$ (Table 4). The overall marketing effect of FMOs with pooling arrangements is now positive with a *t*-value of 1.19 (model 1a). In model 2a, the onboard marketing variable has a much higher *t*-value and the on-land marketing variable now has a positive estimated sign. Although none were statistically significant at the 10% level or higher, these changes suggest that marketing activities are more effective when proffered by some kind of collective action mechanism such as a pooling arrangement.

The estimated coefficients for pooling arrangements were positive and statistically significant at the 10% level. Such was not the case when estimated with subdivided variables defined by the distribution rules, but the results suggest that weighted distribution rules have more influence than uniform distribution rules. As aforementioned, weighted distribution rules distort incentives in the opposite direction that pooling arrangements do. The primary motivation for implementing this rule is often focused mainly on what can be referred to as "fairness restoration." With pooling arrangements, fishermen with greater skills are disproportionately taxed and are thus typically dissatisfied with the new rule. The possibility of these high-line[[*??*]]] fishermen leaving or blocking the agreement could seriously undermine the FMO itself. For this reason, some FMOs implement a landing-volume-based weighted distribution rule to award or to compensate those with a reputation for large catches. This explains the relative significance of the weighted distribution rule over the uniform rule. However, it is conceivable that finding the "right" weights that optimally balance incentives to shirk and to race to fish is difficult, which could be the cause of the statistically insignificant results.

The question remains as to whether the pooling arrangement per se, by altering incentives for fishermen, is positively influencing revenue or not. The results could instead be capturing the effect of effort coordination through pooling arrangements, since the two are often implemented together (Platteau and Seki 2001). One cannot verify or test this hypothesis with the census data because the data do not include information on effort coordination. A direct assessment of effort coordination on fishery revenues is investigated in the next section using the survey data.

5. Survey results on effort coordination and pooling arrangements

This section examines the impact of FMOs that employ effort coordination and pooling arrangements on fishery revenues. In particular, several important, unanswered questions remain about the actual relationships and interactions between effort coordination and pooling arrangements employed by FMOs. In the literature, pooling arrangements are thought of as support systems that help effort-coordination operations function effectively (Baba 1991; Hasegawa 1985; Platteau and Seki 2001). However, the literature on this topic is drawn from a few select cases and does not provide a cross-sectional overview of how these measures actually are employed and perform. Are effort coordination and pooling arrangements generally employed as a pair? Are the cases where only one measure is employed exceptions? Do effort coordination and pooling arrangements perform better if they are implemented together rather than individually?

The effort-coordination variable is defined as (a) fishing-grounds rotations or assignments, (b) exchanges of information about fishing grounds, and (c) joint ownership of fishing vessels and gear. Table 5 shows the number of FMOs in our sample in each category of combinations of effort coordination and pooling arrangements employed. There are significant numbers of FMOs that use only effort coordination (Type B) or only pooling arrangements (Type C). This suggests that these arrangements probably are not simply transitional or exceptional institutions. Having both effort coordination and pooling arrangements as a pair (Type A) is not necessarily the norm so the question becomes whether there is a significant benefit to having both. Type D is defined as FMOs that employ neither.

[Table 5 about here]

Descriptive statistics of survey data

As a way of measuring the economic performance of an FMO, we focus on revenue per unit of effort (henceforth RPUE), which is defined as the revenue from a managed fishery per member per fishing hour. The unconditional means of RPUE ranged from 102.1 thousand yen (about $928) for Type A FMOs to 3.7 thousand yen ($34) for Type D FMOs (Table 6). These estimates are considerably higher than the revenue per unit derived from the census data. An important difference is that, in the census data, the average revenue for the FMO units was a composite of all of the fisheries that a unit works—that is, the average could include both FMO-managed and nonmanaged fisheries. Also, the RPUE for Type A FMOs, which seems extremely high, is comparable to that for units in the small pink shrimp fishery, a well-known FMO-managed fishery documented in Uchida (2004a). Note that these are gross revenues before subtracting any expenses for vessels, crews, shore-side facilities, etc.

From the descriptive statistics alone, there seems to be good reason to believe that FMOs with effort coordination and pooling arrangements enjoy greater revenue per unit of effort than FMOs without these arrangements. Indeed, simple t-tests among the means indicate that the Type A FMOs' RPUE is statistically different from the values for Types B and D but not for Type C. Type B FMOs' RPUE was statistically significantly different only from the value for Type D, which was not the case between Type C and Type D. This weakly suggests that effort coordination and pooling arrangements are more effective when implemented together.

[Table 6 about here]

One of the distinctive differences among FMO types is the number of fishing days per year. Most notably, Type A FMO members spend far less time fishing than Type B or Type D FMO members do. Table 6 seems to suggest that members of FMOs with pooling arrangements (Types A and C) tend to fish fewer days than fishers of the other two types. This is intuitive since under the pooling arrangement there is less incentive to go out fishing in bad weather, for example, relative to behavior under individualistic competition. Type B FMOs show a number of fishing days that is similar to Type D FMOs. A possible explanation for this result is that, for Type B, "fairness adjustments" in response to effort coordination must be made by providing equal chances of fishing at any given fishing ground to a vessel in a season (the pooling arrangement removes the need for this adjustment for Type A FMOs). Depending on the size of the membership of an FMO, this equity constraint may translate to maintaining a certain minimum number of days of fishing per year, and the more the number of days, the easier to make that adjustment. Fishing hours per fishing day are not much different across FMO types except for Type D, which, on average, exhibits much longer hours per day. This suggests that fishing effort may be more concentrated, presumably around the most profitable times.

If Type A FMOs are earning higher revenue per unit of effort, one might expect that, *ceteris paribus*, (1) the size of the membership of these FMOs would be smaller than for other types (e.g., Agrawal 2001) and (2) FMOs would successfully attract younger generations (i.e., successors) to the fishery. Regarding the first point, FMOs of Type A through Type C have fewer members than Type D, but Type A is certainly not the smallest. The average age of FMO members is lower for Type A but not significantly so, and the same is true for the average number of years as a fisher. Thus, the preceding two hypotheses do not seem to be supported by this sample.

Fishing vessels and gear are still largely owned by individuals rather than by the FMOs as institutions. For Type A FMOs, for instance, it might seem natural to bring inputs such as vessels and gear under joint ownership, just as is done for revenues (i.e., pooling arrangements), to fully rationalize the operation and maximize profit. Table 6 shows that such a trend, if it exists at all, is still in progress. Interviews with managers of some of the most progressive FMOs confessed the difficulty of persuading members to spare their own vessels in the interest of increasing group profit through joint ownership of fewer (and possibly larger) vessels.

Model specification

The dependent variable is average revenue per unit of effort of an FMO i ($rpue_i$). The first set of covariates is composed of the dummy variables for Type A through Type C FMOs; the Type D dummy is excluded to avoid multicollinearity.

It is common knowledge that certain harvested species generally command higher prices than other species. For example, spiny lobsters and certain species of crab (e.g., snow crab) are generally considered to be high-end or luxury foods and thus are traded at higher prices. Thus, one must control for the FMOs' main targeted species. On the other hand, caution is required in including species-type variables in the model. If there is a strong correlation between the FMO type and species types, including both variables will cause serious multicollinearity problems. To see if this problem existed in our sample, we counted the number of FMOs by targeted species and by FMO type (Table 7). There were 66 species targeted in our sample and, for most of them, three or fewer FMOs were involved. We separated "popular" targeted species, which we defined as species for which seven or more FMOs considered them to be main targets. Also, since abalone and turban shell were often harvested as a pair of targeted species, they were treated together as one entry. Other species that were targeted by only a few FMOs were categorized by their mobility characteristics—migratory fish, local (nonmigratory) fish, and sedentary species. The results show no systematic correlation between variables for FMO type and for species type and hence we included the species-type variables in the model.

[Table 7 about here]

Revenue level can potentially be influenced by the markets to which harvested fish are allocated. Fish designated to fresh markets generally fetch higher prices than those going to frozen or processed markets. Freshness is particularly important for Japanese consumers as there is substantial demand for consumption of raw fish. Whether that translates into higher revenue, however, is a different issue. In reality, FMOs often implement rigorous quality control measures when they allocate their harvests to raw and fresh consumption. This is in line with the claim that the benefit of rationalized fishery management from output markets in terms of increased price is substantial and critical in sustaining the regime (Herrmann 1996; Homans and Wilen 2005).

Upon further examination, however, it became apparent that species-type and product-type variables caused multicollinearity problems when both were included in a regression. It turned out that, of the two variables, species type had more explanatory power.[7] This led us to drop the product-type variables from our estimation model.

Harvest method can also influence revenues, particularly if there are multiple gear types that can be used for a single species. For example, revenue from a clam fishery clearly will be different when one FMO harvests by diving and the other by dredging. However, in our sample the issue of multiple gear types in a single species is limited; with the exception of turban shell, all of the species in our study are harvested using a single type of gear (Table 8). As for turban shell, since it is often coexists with the abalone fishery, diving can be considered the dominant harvesting method for the two species. We concluded that including both species-type and gear-type variables would likely cause a multicollinearity problem and thus gear-type variables were excluded from the regression models.

[7] This was done by comparing the results from the regressions $\ln rpue_i = \alpha + \mathbf{type}_i'\beta_1 + \mathbf{X}_i'\beta_2 + \varepsilon_i$, where **X** was substituted by species-type and product-type variables.

[Table 8 about here]

Other variables can potentially be included in the model. One is the average tonnage of the vessels owned by FMO members. The intuition is that larger vessels can have more crew members onboard and/or can be equipped with more powerful gear, all leading to a higher RPUE.

A few more variables were considered, primarily in response to the issue of potential endogeneity. Specifically, the main concern involved omitted variables that affect not only the level of per-member revenue but also the likelihood of a group choosing a particular type of FMO.[8] One such variable is the size of the FMO's membership. As Ostrom et al. (2002) and others have pointed out, smaller groups have a better chance of implementing collective action and perhaps of developing more sophisticated forms of collective action than larger groups, *ceteris paribus*. This suggests that group size affects the choice of type of FMO; for example, smaller groups tend toward choosing Type A.

In addition to membership size, we considered the FMOs' established year index variable. This variable ranged from 1 to 11, each corresponding to an interval of five years where 1 is the oldest (established on or prior to 1935) and 11 is the most recent (established on or after 2001).[9] This variable is intended to capture any learning effects that might exist. Also, it is often the case that FMOs modify, and in many cases fine-tune, their management schemes and rules over time.

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[8] There is **no** selection bias issue here; there are observations on revenue for all four types of FMOs and which revenue data belongs to which FMO type is exactly known. Since the sample is confined to FMOs, one cannot address the question of what factors determine establishment of FMOs.

[9] The survey was constructed such that respondents were asked to check the interval into which establishment of their FMO fell. This particular format was employed based on experience from past surveys and results from pretests with local FMO managers, all of which indicated that FMO managers typically did not know the exact year the FMO had been established (particularly if it was in the distant past) but comfortably knew *around when* it was established. This format choice was one of the strategies we employed to enhance the response rate by easing the burden on the respondents.

One expects that such modifications take place in efforts to increase the return from the fishery since making such changes incurs costs.

Lastly, we added regional dummy variables to account for any prefecture-specific fixed effects. There is a trend in market prices for certain species of fish that have been landed in particular parts of the country to be priced higher than the same species of fish landed elsewhere. For example, fish caught in northern waters are often regarded as being of better quality and so can fetch a premium price. In other cases, FMOs successfully differentiate their products (i.e., branding) and receive higher market prices. The regional dummy variable is intended to control for such influences on revenues.

Considering all of the preceding points, our estimation model is a semilog function:

$$\begin{aligned} \ln rpue_i = \alpha + \mathbf{type}_i'\beta_1 + \mathbf{species}_i'\beta_2 \\ + \beta_3 TON_i + \beta_4 MEMSIZE_i + \beta_5 YEAR_i + \beta_6 REGION_i + \varepsilon_i, \end{aligned} \tag{3}$$

where $\mathbf{type}_i$ is a vector of FMO-type dummy variables; $\mathbf{species}_i$ is a vector of the main targeted species-type dummy variables; TON_i is the average tonnage of vessels owned per FMO member; $MEMSIZE_i$ is the size of the membership of an FMO; $YEAR_i$ is the number of years since establishment of the FMO; $REGION_i$ is the regional dummy variable; and ε_i is the error term.

Regression results

One issue associated with mail surveys is that the researcher does not have full control on how respondents will answer the questions. Every effort was made to make important aspects of our questions explicit and comprehensible, both with wording and with layout of the survey, but one still must pay attention to possible measurement errors in the data. As such, much time was devoted to cleaning and checking the data for apparent inconsistencies. Little more can be done without resorting to ad hoc methods. However, we wanted to avoid the situation where small numbers of erroneous but undetected outliers dominate the model estimates and predictions. For this reason, we conducted a set of regression diagnostics based on Belsley et al. (1980) to detect influential observations and outliers. No outlier was detected in our estimation sample.

[Table 9 about here]

The coefficient estimate of the Type A FMO variable is 0.886 and is statistically significant at the 5% level. This estimate implies that members of Type A FMOs earn approximately 88.6% more[[[*more than what, lacks a closing comparison*]]] revenue per unit of effort. This is within the plausible range based on the results from the descriptive statistics in Table 6. The model estimates that Type A FMO members earn significantly higher RPUE than Type B FMO members. Such was not the case, however, between Type A and Type C. In addition, estimated coefficients of Type B and Type C were not significantly different from each other.

These results suggest the following regarding the relationships among effort coordination, pooling arrangements, and RPUE: (1) neither effort coordination nor pooling arrangements *alone* has a significant impact on the level of RPUE; (2) there is no superiority of effort coordination over pooling arrangements or vice versa; and (3) combining effort coordination and pooling arrangements has the most impact on RPUE.

We hypothesized that FMOs with either effort coordination or pooling arrangements perform better than those without either of the two schemes. This is partly supported by the fact that estimated coefficients for Type B and Type C were positive, but it is not fully supported since both were statistically insignificant. The second hypothesis—that FMOs with both perform better than those with only one—was almost fully supported, as the coefficient only for Type A was estimated to be significantly different from Type D. We say “almost” because the difference between Type A and Type B was significant but the difference between Type A and Type C was not.

Next we analyze whether the combination of effort coordination and pooling arrangements is solely responsible for higher RPUE. Many other types of self-imposed regulations and measures can be employed by FMOs (see Table 10). We divide the self-imposed rules into four categories. The first, marketing measures, includes quality control measures (proper icing, careful handling, etc.), development of new value-added products, and branding. Another is harvest control, which can involve setting a total-catch limit and/or an individual quota, controlling the daily landing volume to avoid market gluts, and restricting the size and/or age of the fish caught. Operational regulations cover restrictions on fishing hours and days, closures during the season, setting of no-fishing zones, and restrictions on fishing methods, fishing gear, and/or the number of crew members on a vessel. Finally, vessel regulations restrict the number of vessels, their tonnage, and their engine power. Some of these regulations are also imposed by the local or central government but in the survey we explicitly asked for self-imposed regulations, including those that are more stringent than existing government regulations. The primary reason for constructing our survey in such a way is that virtually all coastal fisheries in Japan have some sort of government regulations and they typically include operational restrictions and vessel regulations. Therefore, there would not have been much variation had the survey simply asked whether the fishery had regulations imposed. This led us to focus our attention on the existence of self-imposed and typically more stringent regulations that do vary across FMOs.

[Table 10 about here]

We first estimated whether these four categories of self-imposed regulations have any impact of their own on revenue per unit of effort (Model 1 in Table 10). The results show that none has a statistically significant impact. The estimated positive sign for the marketing variable is intuitive since such activities are typically aimed at increasing revenue. The negative sign for the harvest control variable is plausible if the market price did not respond enough to supplement reduced landing volumes.

Note that the Type A FMO variable remained statistically significant even after the addition of self-imposed regulation covariates. Thus, the next question is whether combinations of Type A FMOs *and* self-imposed regulations have significant impacts on revenue per unit of effort. To answer that question, we added interaction terms for Type A and regulation variables to the estimation model (3).[10]

[Table 11 about here]

First we estimated the model with the four regulation categories—marketing, harvest control, operation regulation, and vessel regulation—interacting with the Type A dummy variable (model 2 in Table 10). Each category has multiple subcategories, so these dummy variables were constructed such that if one or more of the subcategories was employed then the dummy variable would equal 1; otherwise it would equal 0. The results show that marketing employed by Type A FMOs has a positive and almost statistically significant (p -value = 0.101) impact on the RPUE.

[10] Interaction terms for Type B and Type C variables were also estimated but neither had statistically significant impacts.

This suggests that marketing practices can be effective in increasing revenue if they are conducted through effort coordination supported by a pooling arrangement, which is consistent with our intuition and in line with the result we found from census analysis.

Next we focused on both marketing and harvest-control regulations by dividing them into their subcategories to investigate which subcategories are most influential. Marketing variables include quality control, new product development, and branding. Harvest-control variables include total catch limits (TACs), individual catch limits (IQs), supply/landing volume controls, and size/age restrictions. Each subcategory was interacted with the Type A FMO dummy variable (Model 3 in Table 10).

Several results are interesting. First, none of the marketing subcategories was significant. A plausible explanation is that the success of marketing depends heavily on the product type and on market conditions on a case-by-case basis so no single marketing activity can be a silver bullet. The result from the aggregated marketing variable in model 2, in return, implies that Type A FMOs select the most effective form of marketing activity based on market conditions.

Secondly, the results from the harvest-control subcategory variables show that individual catch limits (IQs) have a positive effect and that size and age control have a negative impact on RPUE and that both are statistically significant. Size and age restrictions either reduce harvest volumes or prolong fishing time as operators try to compensate for the volume loss.[11] Thus, RPUE typically decreases in such cases.

Interestingly, all FMOs with IQs in the sample also had size and age controls (but not vice versa). The fact that the IQ subcategory was estimated to have a positive and significant impact

[11] Harvested volume could increase since now each fish that is harvested is larger (due to minimum size restrictions) even though the harvested number decreased. Although this is possible in principle, it is an unlikely case because the current condition is often such that stock depletion is accompanied by shrinking in the size of harvested fish; that is, the fish that are large enough to compensate for the loss of volume are long gone.

on RPUE suggests the strength of IQs. Two possible scenarios come to mind. One is that, with only size and age restrictions, fishermen are driven by the incentive to race and hence spend too much time fishing, ultimately to the extent that the RPUE declines. Such excessive fishing is mitigated by capping harvest volumes and allocating the share of that total harvest to fishermen via IQs, thus enhancing RPUE. However, recall that we are examining the impact of these self-imposed regulations within the context of Type A FMOs that have both effort coordination and pooling arrangements. The incentive to race to fish is likely to be less intense in this case so this scenario is unlikely. Another potential scenario is that IQs function as a “benchmark” by which to detect shirking members. Because of the presence of the pooling arrangement, FMO members are, in principle, prone to shirking. If a member returns from a fishing trip with a below-quota harvest volume that is beyond reasonable daily fluctuations, such incidents can be used as an indicator of shirking. IQs can be used to replace physical peer monitoring among members, which can be useful in fisheries in which vessels operate in a dispersed manner.

On a final note, the significance level for the Type A FMO’s dummy variable decreased with the introduction of interaction terms of Type A and self-imposed regulation variables. This result suggests that, in practice, effort coordination and pooling arrangements alone are not enough—members must engage in revenue-enhancing activities.

6. Conclusion

This paper analyzes the economic performance of fishery comanagement regimes as measured by fishery revenue by using the case of FMOs in Japanese coastal fisheries. Our focus is on the rules of the game that alter the incentive structure for individual fisherman and the outcomes that have resulted. Upon examination of rules and management measures adopted by successful FMOs, we selected three features: effort coordination, pooling arrangements, and marketing activities. Conceptually, each feature has the potential to bring higher revenue, even more so when implemented together. However, high transaction costs involved in implementing these measures and making them work give rise to an empirical question about whether their potential benefits have been realized in practice. The objective of this paper is to answer that question using publicly available fishery census data and survey data collected by the authors.

First, using data from the fishery census, we tested whether fishermen associated with FMOs that have pooling arrangements earn greater revenue than fishermen in FMOs that lack such arrangements and non-FMO fishermen. Our analysis showed that FMOs that have pooling arrangements earn significantly higher revenue. The question remains whether it is the pooling arrangements per se or the effort coordination or both that generates these results since pooling arrangements are often implemented to support sophisticated methods of effort coordination to fetch higher prices and hence greater revenues.

The statistical insignificance of the marketing activity variables on fishery revenue is somewhat surprising, particularly since markets tend to respond quickly. One explanation for such a result is that engaging in marketing is different from using marketing effectively. Perhaps marketing activities must be coordinated and pursued in a collective manner for them to be effective. Since pooling arrangements create an incentive for such collective action, we examined whether FMOs that have pooling arrangements and engaged in marketing activities had an impact on fishery revenue. The results were not statistically significant, but the direction of the changes in the results suggests that our hypothesis is a plausible one.

Following our analysis of the census, we focused our attention on the combination of pooling arrangements and effort coordination using data from our survey. We estimate that a member of a Type A FMO (which employs both effort coordination and a pooling arrangement) earns approximately 88.6% more revenue per unit of effort than a member of a Type D FMO (neither regime is used). Members of Type A FMOs earn significantly higher revenue per unit of effort (RPUE) than do Type B FMO (effort coordination only) members. Although this might seem to suggest that pooling arrangements have a larger influence on revenue than effort coordination, Type B and Type C (pooling arrangements only) were not significantly different from each other, *and* neither was significantly different from Type D. Thus, our hypothesis that FMOs with either effort coordination or pooling arrangements perform better than those without the two measures was not fully supported, although the estimated coefficients had the expected positive signs. Our second hypothesis that FMOs with both measures in place perform better than those with only one was almost fully supported. The results regarding marketing activities were similar to those for the census results: the marketing variable by itself showed no significance, but when conditioned on Type A FMOs, its significance level was enhanced. This suggests that marketing activities per se cannot automatically bring in higher revenue. To be effective, they must be delivered in a collective manner and adoption of effort coordination and pooling arrangements enhances the chance of successful collective action.

There are some caveats to our analysis. Most importantly, neither the census data nor our survey data provide information on costs related to fishing operation, so any effects of pooling arrangements and effort coordination on cost savings are not captured. As discussed earlier, pooling arrangements may reduce the race to fish by introducing an incentive to “shirk.” But if this simply reduces input costs, it would not reveal its impact in the current regression. On the other hand, pooling arrangements and effort coordination may actually be adopted to help sustain intertemporal effort-smoothing in order to maximize revenue, in which case it would show a statistical effect. Another important factor not considered in our analysis is the effect of comanagement on resource stock levels and its feedback impacts on harvest costs.

There are, nonetheless, several policy implications for successful fishery comanagement that can be drawn from our results. Establishment of demarcated areas covered by fishing rights and governed by collective bodies of fishermen, whether they are FCAs or FMOs, is a necessary but not sufficient condition for success. Among things in which an FCA/FMO can get involved, marketing activities have a good chance of generating higher returns from fishery comanagement if the marketing efforts are effective. The effectiveness of marketing depends on whether it is done in a collective manner, and for this reason, implementing pooling arrangements, effort coordination, or any other policy to enhance the chance of collective action should be considered. The fact that marketing has positive impacts on revenue suggests that benefits arising from output markets can be substantial and important in fishery comanagement. Policies aimed at developing market infrastructure, such as wholesale fish markets and means of transporting the fish (i.e., linking the markets), may benefit fishery comanagement.

This paper shows that fishery comanagement that employs effort coordination and pooling arrangements can bring higher revenue to participating fishermen, but there is one catch that must be addressed in relation to policy implications. For example, note that in our survey data analysis the dependent variable in the estimation models was RPUE. This means that even if the RPUE is high, one's total (or annual) revenue level can still be low, or not enough to support the family through an entire year. Effort coordination, such as rotating fishing grounds and days in particular, can mean that one's turn to fish comes only a few times a month. Pooling arrangements discourage fishing in uncomfortable conditions such as bad weather. All of these factors result in fewer fishing days to such an extent that annual earnings are too low.

The possibility of fisheries being lucrative per unit of effort but unable to bring in enough total revenue to support the annual livelihoods of fishermen requires the existence of income from outside the managed fisheries for successful and sustainable fishery comanagement. This point was raised by many FMO managers and local research authors who we interviewed. Such outside income sources include fisheries other than managed ones and nonfishing jobs such as farming and construction work. Interestingly, this is in direct contradiction with the notion that outside options undermine the sustainability of comanagement regimes (e.g., Ostrom et al. 2002, p. 450).

The trade-off between lucrative fishery and a supporting yearly livelihood is not, of course, necessarily always the case. Like the case of the Pacific halibut fishery (Casey et al. 1995), a fishery management policy that reduces the race to fish and redirects more effort to quality control can achieve both a more lucrative fishery and a prolonged fishing season. In such a case, the availability of outside income sources might be of no significance. The take-home message of this paper is, therefore, that effort coordination and pooling arrangements may not be *the* most important element but certainly they may be *one of the* important factors for successful fishery comanagement.

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Figures

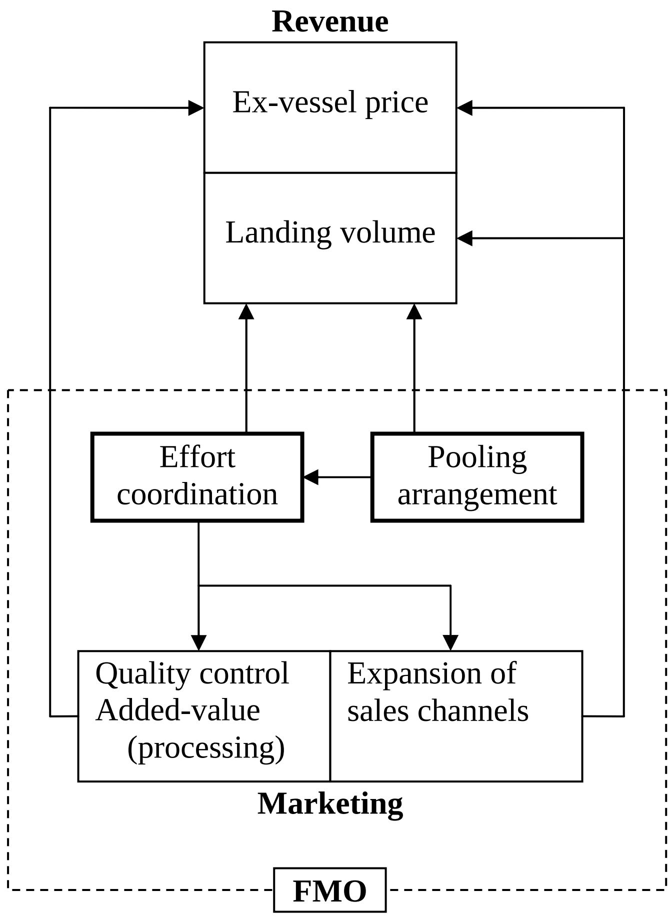

Figure 1: Relationships of key variables with ex-vessel price and landing volume

Tables

Table 1: Fishery revenues and number of fishing units by their unit-types in 1998

	Individuals	Corporations	FCA	PCA[a]	JO[b]	Others[c]
Fishery revenue ($K)	64.8	2,410	1,560	2,220	335.2	570.5
Number of FMO units	58,195	715	56	40	1,169	4
(% of within total)	(96.7%)	(1.2%)	(0.1%)	(0.1%)	(1.9%)	(0.0%)
Number of non-FMO units	84,999	2,348	233	119	2,591	117
(% of within total)	(94.0%)	(2.6%)	(0.3%)	(0.1%)	(2.9%)	(0.1%)

From 10th Fishery Census (MAFF, 2001).

[a] PCA is a processors cooperative association.

[b] JO, or joint operation, is where two or more individual fishing units are operating together as a joint venture.

[c] Others include entities such as fishery research stations.

Table 2: Descriptive statistics (mean values) of panel data

	FMOs		Non-FMOs	
Variable	1993	1998	1993	1998
Average fishery revenue (yen)	5,252,090	5,205,887	4,624,336	4,826,802
($1=110yen)	($47,746)	($47,326)	($42,039)	($43,880)
Average number of units per district	60.0	53.5	45.6	38.5
Average number of fishing day per unit	193.1	185.6	177.9	174.6
Rowing boats per unit	0.039	0.024	0.091	0.064
Externally-powered boats per unit	0.773	0.797	0.556	0.576
Vessels per unit	0.628	0.639	0.766	0.798
Tonnage per vessel per unit	0.159	0.159	3.228	3.490
Engine horsepower per vessel per unit	2.522	2.287	41.48	47.31
Share of FMOs with pooling arrangements	0.176	0.208		
Pooling (uniform)	0.056	0.059		
Pooling (weighted)	0.095	0.129		
Share of FMOs with marketing	0.427	0.491		
Onboard activities	0.345	0.425		
Live	0.134	0.171		
Quality control	0.267	0.301		
On-land activities	0.179	0.298		
Processing	0.028	0.063		
Sales	0.131	0.215		
Transportation	0.067	0.090		

Note: Districts with only individual units are included in the sample.

Table 3: Heteroskedastic-robust OLS on first-difference panel data

Variables	Model 1	Model 2	Model 3	Model 4
FMO dummy	0.012	0.018	0.007	0.013
	(0.18)	(0.26)	(0.10)	(0.19)
Number of units	0.004	0.004	0.004	0.004
	(1.63)	(1.62)	(1.64)	(1.63)
Number of units	−0.002	−0.002	−0.002	−0.002
× FMO dummy	(0.79)	(0.81)	(0.86)	(0.87)
Number of rowing	0.170	0.168	0.170	0.169
boats per unit	(1.09)	(1.08)	(1.10)	(1.09)
Number of external-powered	0.177	0.167	0.183	0.173
boats per unit	(1.32)	(1.24)	(1.36)	(1.29)
Number of vessels	0.703	0.696	0.698	0.693
per unit	(3.70)***	(3.64)***	(3.67)***	(3.63)***
Tonnage per vessel	0.056	0.056	0.056	0.056
per unit	(2.34)**	(2.34)**	(2.34)**	(2.34)**
Fishing days per unit	0.006	0.006	0.006	0.006
per season	(5.38)***	(5.57)***	(5.41)***	(5.59)***
Food consumption CPI,	0.009	0.005	0.009	0.005
base year (2000)	(0.27)	(0.14)	(0.27)	(0.15)
Pooling arrangements	0.237	0.230		
(all distribution)	(1.70)*	(1.71)*		
Uniform distribution			0.084	0.094
			(0.75)	(0.85)
Weighted distribution			0.401	0.369
			(1.35)	(1.20)
Marketing	−0.017		−0.015	
(onboard and on-land)	(0.21)		(0.20)	
Onboard		0.145		0.129
		(1.10)		(0.94)
On-land		−0.118		−0.109
		(1.19)		(1.16)
Constant	−0.062	−0.049	−0.061	−0.050
	(0.59)	(0.46)	(0.59)	(0.47)
Observations	459	459	459	459
Adjusted R^2	0.266	0.267	0.266	0.266

Absolute value of robust t statistics are in parentheses.
Significance levels are denoted by * (10%), ** (5%), and *** (1%).

Table 4: Heteroskedastic-robust OLS with marketing and pooling interaction terms

Variables[a]	Model 1a	Model 2b
FMO dummy	0.014	0.022
	(0.21)	(0.32)
Pooling arrangements	0.235	0.196
(all distribution)	(1.77)*	(1.70)*
Marketing	−0.021	
(onboard and on-land)	(0.26)	
Onboard		0.140
		(1.06)
On-land		−0.090
		(1.02)
Marketing×Pooling	0.328	
	(1.19)	
Onboard×Pooling		0.349
		(1.33)
On-land×Pooling		0.199
		(0.69)
Constant	−0.059	−0.048
	(0.57)	(0.45)
Observations	459	459
Adjusted R^2	0.268	0.268

Absolute value of robust *t* statistics are in parentheses.
Significance levels are denoted by * (10%), ** (5%), and *** (1%).

[a] Although not shown, other covariates are also included in the regressions.

Table 5: Number of FMOs by their type

Type name	Effort coordination	Pooling arrangement	Count
A	x	x	44
B	x		32
C		x	12
D			28
Total			116

Table 6: Descriptive statistics of survey sample data

Variable averages	A	B	C	D
Membership size	49.8	48.1	28.4	73.7
Member age	55.6	59.6	59.7	59.4
Years of experience	31.6	34.2	32.6	30.5
Number of vessels registered	35.4	39.7	26.2	84.7
Number of vessels operating	15.4	19.9	21.9	29.1
Vessel tonnage	9.2	3.7	3.8	6.1
Per member revenue[a]	9,833	5,337	5,388	3,027
Fishing days in a year	66.0	118.9	92.6	120.2
Fishing hours per day	5.3	5.0	4.6	10.6
Revenue per member per fishing hour[a]	102.1	10.4	12.6	3.7
Fishing ground within TURF (No=0, Yes=1)	87.8%	85.2%	80.0%	85.7%
TURF solely owned (No=0, Yes=1)	66.7%	43.5%	62.5%	58.8%
Vessel: individually owned	88.2%	99.3%	97.8%	100.0%
jointly owned	3.8%	0.7%	2.2%	0.0%
owned by an FMO	9.3%	0.0%	0.0%	0.0%
Gear: individually owned	75.0%	96.1%	100.0%	100.0%
jointly owned	7.0%	0.0%	0.0%	0.0%
owned by an FMO	18.0%	3.9%	0.0%	0.0%

[a] Monetary unit is thousand Japanese yen (1 US$ is approximately 110 yen).

Table 7: Number of FMOs by main targeted species

Species	FMO-type				
	Type A	Type B	Type C	Type D	Total
spiny lobster	8	9	1	1	19
abalone/turban shell	2	5	6	11	24
surf clam	12	2	0	0	14
scallop	7	2	0	1	10
asari clam	2	2	1	2	7
migratory fish[a]	0	2	1	3	6
local fish[b]	6	6	1	1	14
sedentary[c]	7	4	2	9	22

[a] Migratory fish species include squid, mackerel, bonito, and yellowtail.
[b] Local fish species include flat fish, pollack, red snapper, and sandfish.
[c] Sedentary species include sea urchin, sea cucumber, shellfish other than above, and seaweed.

Table 8: Number of FMOs by targeted species and gear-type

Species	Gear-type 1	Count	Gear-type 2	Count
spiny lobster	gill net	19		
abalone	diving	17		
surf clam	small bottom trawl	14		
scallop	small bottom trawl	8	aquaculture	1
asari clam	diving	6		
turban shell	diving	3	gill net	3

Table 9: Heteroskedastic-robust OLS estimation results

Variables[a]		Coef.	
FMO-type	Type A	0.886	(2.18)**
	Type B	−0.050	(0.12)
	Type C	0.616	(1.00)
Species-type	spiny lobster	−0.345	(0.44)
	abalone[b]	−1.241	(2.11)**
	surf clam	−1.358	(2.55)**
	scallop	0.281	(0.49)
	asari clam	−1.998	(2.07)**
	migratory fish	−0.454	(0.73)
	local fish	1.218	(1.82)*
FMO member size		−0.000	(0.11)
Vessel tonnage		−0.011	(2.59)**
Years since FMO establishment		−0.019	(0.32)
Region dummy		−0.024	(2.00)**
Constant		0.343	(0.69)
Adjusted R^2		0.467	
Number of observations		67	

Absolute value of t statistics are in parentheses.
Significance levels are indicated by ** (5%) and * (10%).

[a] Following variables were excluded to avoid perfect multicollinearity: Type D, sedentary species, and fresh product-type.
[b] Abalone *and* turban shell.

Table 10: Number of FMOs by types of self-imposed regulations

Regulations	Type A	Type B	Type C	Type D	Total
Marketing	27	10	4	5	46
Harvest control	25	13	6	8	52
Operation regulations	31	18	6	8	63
Vessel regulations	18	4	2	2	26

Note: Counted within the Model 4 sample of $n = 67$.

Table 11: Heteroskedastic-robust OLS with interaction terms of Type A and other self-imposed regulations

Variables[a]		Model 1		Model 2		Model 3	
FMO-type	Type A	0.927	(2.12)**	1.290	(2.84)***	0.823	(1.41)
	Type B	0.050	(0.11)	0.053	(0.11)	−0.383	(0.76)
	Type C	0.600	(0.94)	0.572	(0.91)	0.496	(0.73)
Marketing		0.244	(0.52)				
Harvest control		−0.041	(0.07)				
Operation regulations		−0.336	(0.69)				
Vessel regulations		0.079	(0.22)				
Interaction terms: generic	Type A× Marketing			0.703	(1.11)		
	Type A× Harvest control			−0.823	(1.48)		
	Type A× Operation regulations			−0.528	(1.22)	0.268	(0.45)
	Type A× Vessel regulations			0.614	(1.69)*	0.141	(0.23)
Interaction terms: marketing	Type A× quality control					−0.799	(1.48)
	Type A× new product development					0.862	(1.20)
	Type A× branding products					−0.590	(1.16)
Interaction terms: harvest control	Type A× TAC					0.536	(1.03)
	Type A× individual quota					1.164	(1.85)*
	Type A× supply control					−0.318	(0.50)
	Type A× size/age control					−0.663	(1.48)
Observations		67		67		66	
Adjusted R^2		0.429		0.469		0.477	

Absolute value robust t-statistics are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

[a] Although not shown, species types, vessel tonnage, FMO member size, years since FMO was established, and regional dummy were included in all regression models presented here. The results were qualitatively identical to those shown in Table 9.