Fishery co-management in Japanese coastal fisheries

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Abstract

This paper presents an empirical analysis of the Japanese coastal fishery co-management system. In particular, the paper focuses on the effectiveness of Fishery Management Organizations (FMOs), which are established by groups of fishermen and set rules and regulations that they self-enforce. The paper finds that FMOs engaged actively in marketing practices in their output markets significantly increased their member fishermen's revenue. Proceeds sharing rules, where individual proceeds are pooled and shared among the members, appeared to have marginal effects despite of several anecdotal evidence that suggests otherwise. Findings suggest that benefit gains from the output markets is substantial in successful fishery co-management.

Keywords: fishery co-management, marketing, sharing rules, Japan

1 Introduction

The concept of fishery co-management has been discussed for some time as an alternative to top-down centralized fishery management. The idea is based on the notion that local resource users have better knowledge of the resource they exploit, and thus decentralization of managerial authority to local user groups can improve the performance of resource management. In practice, however, co-management is implemented in many fisheries around the world, and in some cases for very long time (Wilson et al., 2003). The literature has yet to reach a consensus on the definition of co-management, but the key feature is that it requires individual fishermen to cooperate and act collectively for mutual benefits.

While the idea is gaining much attention and the regimes being implemented in various places, fishery co-management is yet to be well understood. Economists have been skeptical about the effectiveness and sustainability of such resource management regimes, primarily because they involve collective action of individual resource users. They argue, for example, even if the incumbents cooperate and manage to enhance the economic rents from the fishery, success attracts new entrants to the industry only to dissipate that rent. In fact, if the incumbents anticipate this happening, then cooperation might not take place at all. Co-management might also be vulnerable to cheating. Despite these theoretical objections, however, there are many successful cases of co-management, including those in fisheries. Other discipline such as sociology and anthropology have conducted case studies of co-management, and some derived conditions that need to be met for successful co-management, such as those regarding the resource system characteristics and institutional arrangements (e.g., Ostrom, 1990; Baland and Platteau, 1996).[1] But the question still remains: empirically, does fishery co-management positively impact the resource stocks and economic returns to fishermen? Do results differ depending on the self-management practices adopted by the fishery co-management regime?

The importance of better understanding of fishery co-management is that not only is it widely implemented, but it could be the only solution for many developing countries, where the government is incapable of centralized regulation and where market infrastructures are too underdeveloped to adopt market-based solutions such as tradable quotas. Perhaps for this reason, many studies on fishery co-management are those in developing countries (Wilson et al., 2003). Fishery co-management in Japan, on the other hand, is not much analyzed despite the fact that Japan has more than 1,700 fishery co-management regimes managing its coastal fisheries.[2] In addition, not only the statistical data on fishery co-management are more readily available than many developing countries, but the fact that these regimes are all under the same national laws and policies and share much of the social characteristics – which sometimes becomes a trouble in cross-country analysis – are great advantages from the empirical study's point of view.

This paper conducts empirical analysis of the Japanese coastal fisheries, many of which are managed by fishery co-management regimes. Unlike in most Western countries, coastal water in Japan were historically demarcated into parcels known as "fishing rights" areas where exclusive rights of access to these areas were granted to local Fishery Cooperative Associations (henceforth FCAs). As expected, within each area, member-fishermen of FCAs competed in open-access fashion, resulting in depletion of fish stocks and low profitability from fisheries. In response, subgroup of local fishermen formed what are now called Fishery

[1]For a review of the literature and research on common-pool resource co-management, see Agrawal (2001).

[2]Exceptions include Asada et al. (1983), Ruddle (1987), Yamamoto (1995) and Makino and Matsuda (2005), but none have empirical analysis that quantitatively evaluate the effect of collective fishery management in Japan.

Management Organizations (henceforth FMOs), often under their parent-FCAs, to collectively manage the fisheries they had exclusive rights to. The rules and activities which FMOs implement and practice vary. Of particular interest in this paper are the proceeds sharing rules adopted and marketing practices. Proceeds sharing rules are agreements that harvests, revenues or profits are pooled and then redistributed back to the members; several theoretical and empirical case studies suggest that such sharing rules could enhance the economic performance of fisheries (e.g., Schott, 2003; Platteau and Seki, 2001; Gaspart and Seki, 2003; Uchida, 2004, 2005). Marketing practices adopted by FMOs include landing the catch alive, quality control (e.g., proper icing), processing (adding value), expanding market channels and measures taken in ground transportation.

The paper focuses on the impact of FMOs and their practices on the fishery revenues of fishermen by investigating whether fishermen participating in FMOs have higher revenue than those who do not participate.[3] We find that fishermen participating in FMOs with marketing practices had significantly higher revenues. This supports the argument that the benefits of rationalizing fisheries arising from the output markets are substantial (Homans and Wilen, 2005). On the other hand, the proceeds sharing rules appear to be insignificant in this analysis. The need for further investigation is thus called for, in light of case studies that suggest otherwise, for the economic roles of sharing rules and conditions for them to succeed.

The paper is organized as follows. Section 2 gives a brief background on Japanese coastal fisheries and the definition of the terminologies used throughout this paper. Section 3 describes the data used and reports the main empirical analysis results. Conclusions are given in section 4.

[3]Ideally we would want to have data on profits rather than revenues, but the data set used, namely 10th Fishery Census, only had revenues data. Also, the state of resource stock levels was not included in the analysis because such data were not available in the census and no other comparable data set was found.

2 Background

The definition of the terminologies used throughout this paper describing the Japanese coastal fisheries and management are as follows:

- **Fishing rights** area: a parcel of coastal water demarcated for exclusive commercial use. It is analogous to the territorial use rights in fisheries (TURFs). Fishing rights are granted to FCAs and not to the individual member-fishermen. Thus, only the members of FCAs are allowed to commercially fish in these areas. The boundaries of each area roughly correspond to that of local municipality and extend outwards to the sea, but how far they extend out varies. Some have only 1km or less while others extend more than 5km out into the sea coast, depending on the ocean topography, such as the existence and the size of continental shelf, and the types of fisheries operated within the coastal water. Figure 1 shows an example of how fishing rights areas are defined.

- **Fishery Cooperative Association** (FCA): a collective body of individual fishing units (individuals and small-scale companies). Its functions are similar to that of any other industrial cooperative, plus the distinctive function of administering the fishing rights granted to the Association. There are approximately 1,600 FCAs nationwide (Zengyoren, 2005).

- **Fishery Management Organization** (FMO): a group of fishermen, usually within an FCA who share the same fishing grounds or operate the same fishery, collectively performing the tasks of resource and/or harvest management. Some FMOs are formed across neighboring FCAs and span across multiple fishing rights areas, but mostly they operate within their own fishing rights area. There are often multiple FMOs in a fishing district, usually corresponding to multiple fisheries operated in that district. There were 1,734 FMOs nationwide in 1998 (MAFF, 2001).[4]

[4] For historical background of fishing rights, FCAs and FMOs, see Yamamoto (1995) and Makino and Matsuda (2005).

- **Fishing districts**: defined by the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF), it is a community, within the boundaries of a local municipality, operating fisheries under a common environment, such as sharing the same fishing rights area and commonalities in other fishery-related activities. Generally speaking there is one fishing rights area, and an FCA that administers it, per fishing district (see Figure 2). Due to recent trends of merges of FCAs, however, this is changing rapidly. After mergers, former FCAs often remain as branch offices and retain much of their independence in fishery operations. Fishing district is also a geographical unit for which the data in the Fishery Census, a nationwide survey conducted every five years by MAFF, are reported.

- **Proceeds sharing rule**: mutually agreed conventions whereby proceeds, such as harvests, revenues or profits, are pooled and redistributed back to the members in a certain way. Proceeds may be shared uniformly or weighted by some index such as the vessel size or the level of individual catch.

- **Fishing units**: economic entities engaged in fisheries for commercial purpose. There are six categories of fishing units defined in the Fishery Census: individuals (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.

The Japanese government has implemented FMO-based co-management of its coastal fisheries as national policy since the early 1980s, but many FMOs have much longer history. Therefore, it was not the case that the government imposed the co-management regimes on its fisheries, but rather it codified the *de facto* regimes that were already in place. The census began recording data on FMOs in 1988 (8th Fishery Census). At that time there were 1,339 FMOs and the number has been increasing steadily; in 1993 there were 1,524 FMOs and in the latest census (1998) there were 1,734 FMOs.

FCAs and FMOs are not necessarily the same entity, but are closely related. Among 1,734 FMOs in 1998, nearly 95% of them were operated by an FCA or its subdivisions.[5] Clearly, FMOs utilize the functions of FCAs such as the administration of fishing rights and controlled membership (Uchida and Wilen, 2004).

The nature of self-regulation varies among the FMOs. Some FMOs simply self-impose a fishing season to avoid fishing during the spawning period. At the other extreme, some FMOs utilize sophisticated fishing effort coordination schemes where representatives of member fishermen meet every day during the fishing season to decide the details of that day's fishing operations. The primary objectives differ as well; some focus on cost savings through effort reduction while others focus on harvest control to avoid market glut.

Another feature which some FMOs have implemented is a system which we refer to as "proceeds sharing rule." According to MAFF (2001), 294 or roughly 17% of FMOs have some kind of sharing rules implemented. Among these, 144 (49%) FMOs have uniform distribution of proceeds and 129 (44%) FMOs have weighted distributions. The share of FMOs with sharing rules is also increasing over time, rising from 11% in 1988 to 15.6% in 1993, and to 17% in 1998.

The traditional view of sharing rules is that they could encourage fishermen to shirk and result in too little collective fishing effort since each fisherman no longer individually gains by out competing the others. Schott (2003) argues that such shirking is beneficial since it curtails excessive fishing effort that leads to overexploitation. Uchida (2005) claimed that sharing rules could induce collusive behavior among the fishermen noncooperatively and generate benefits by exploiting market power they have in local markets.[6] However, an empirical question still remains of whether FMOs with sharing rules could endure and

[5] It is not surprising, therefore, that many researchers have concluded that successful fishery co-management in Japan rests on the strength of its tradition of FCAs (e.g., Hanna (2003)). We believe this is somewhat misleading, as it conveys an impression that such management schemes cannot be implemented in other places. Uchida and Wilen (2004) argue the importance of FCAs and fishing rights using the conceptual framework of the theory of clubs, focusing on the *functions* of these institutions that are more generally applicable.

[6] Many fisheries potentially have certain degree of local market power since the product is very perishable and often costly to transport. Raw product markets are thus likely to be local or regional in scope.

succeed, and overcome shirking or other non-productive behavior. The increasing number of FMOs implementing sharing rules seems to suggest that at least many fishermen have perception that they are beneficial.

Anecdotal evidence shows there are FMOs with sharing rules that are working reasonably well. Platteau and Seki (2001) surveyed fishermen in Toyama Bay where there were two FMOs with sharing rules under different FCAs but targeting the same species.[7] Uchida (2004) studied another FMO with a sharing rule in Suruga Bay; in this case fishermen from two FCAs targeting the same species formed one unified FMO. This FMO has adopted a very sophisticated fishing effort coordination scheme, including the harvest control to avoid market glut. In both cases the sharing rules are functioning as a supporting – perhaps even facilitating – mechanism for fine-tuned fishing effort coordination among the member fishermen.

3 Empirical analysis

3.1 Data

The data are from the 10th Fishery Census conducted in 1998 by the Ministry of Agriculture, Forestry and Fisheries (MAFF). The survey was conducted with fishing units as the basic unit of observation. However, the published census data are aggregated to the fishing district level, reporting only either the sum or the average values. The fishing unit-level data are not available from MAFF due to the duty of confidentiality on their part. Thus, our unit of observation is at the fishing district level.

The first problem faced with the census data is that not all data are available by each unit-category, but rather summed up in a district. This raises a concern if one is to compare the average revenues of FMO-participating and non-participating units (henceforth referred as "FMO units" and "non-FMO units", respectively). If the characteristics, such as average revenues, of each category differ significantly from each other then such difference will cause

[7] Platteau and Seki (2001) refers the sharing rules as the"pooling system."

a bias in our estimation since we cannot control for it. For example, the average revenue for FMO units, inclusive of all six unit-categories, was \$95.7K and that of non-FMO units was \$143.9K. Does this imply that FMO units are earning less revenue than non-FMO units? If corporations tend to earn far more revenue than individual fishing units and there are more corporations as non-FMO units than as FMO units, then such comparison of average revenues is biased and misleading. Indeed, Table 1 clearly shows that this is the case. The difference is most vivid between the individual units and the rest.

To bypass this problem, the analysis will focus only on the individual fishing units. The justification for this is that the individual fishing units are overwhelmingly dominant in both FMO and non-FMO units. In practice, we took the fishing districts that have FMO units and/or non-FMO units consisting only of individual fishing units. Note that, because the observations are at a fishing district level, some fishing districts might have only either FMO units or non-FMO units data while other fishing districts might have both.

The second issue is the treatment of influential observations, particularly if they are due to the measurement errors. The major concern is that whether a fishing unit is individual or corporation (or any other) depends on how the units are registered, not on how they are actually operating. If a unit is substantially a corporation but registered as an individual, then the sample would be contaminated.

While it was not possible to check each observation (i.e., fishing districts) one by one, such mismatches are likely to reveal themselves as outliers, or influential observation. To identify influential observations, the regression diagnostic described in Belsley et al. (1980) was conducted. Two fishing districts were suspected of containing units that are substantially corporations but registered as individuals. These two districts were thus deleted from the sample.

3.2 Estimation

The primary interest is whether FMO units have higher revenues than non-FMO units after controlling for other factors that affect the revenue level. One set of covariates are those which are indicative of capital levels. Intuitively, the higher the level of capital the higher the revenues, *ceteris paribus*. This set includes the number of non-powered boats, powered boats and vessels owned by a unit, vessel tonnage and vessel engine horsepower. Non-powered boats are those with no engines attached; they constitute about 2% of all boats and vessels owned and operated by the fishing units. They are used mainly in small-scale near-shore fishery collecting shellfish and seaweed.[8] Powered boats are defined as those with external engines attached to otherwise non-powered boats, and vessels are those with integrated engines. Tonnage and engine horsepower are those of vessels only.[9] The averages for the tonnage and horsepower are defined as 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 (Table 2, second row).

Another set of covariates are those of fisheries that units are operating. It is reasonable to assume that different fisheries yield, on average, different levels of revenue and thus require control. The census records the number of units participating in each fishery categorized by the gear-type, such as bottom trawl, gill net, etc. One could also control by the targeted species, but the census does not provide such data. Furthermore, quite a few species are caught by different gear across the regions; for example, clams are caught by diving and bottom trawl. For the same targeted species, namely the clams in this case, revenues may differ significantly between the two methods of harvesting. Therefore, controlling by the gear-type would be appropriate.

Additional explanation on the fishery gear-type dummy variables is necessary, for they are not necessarily dichotomous dummy variables due to the way Fishery Census data are made available. There are two issues. The first issue is that most fishing districts have two or

[8] Personal communication with Dr. Baba.

[9] The correlation between the vessel tonnage and engine horsepower in the sample was 0.58, and thus both variables were included in subsequent regressions.

more gear-types operated within their boundaries. However, there is only single observation for average revenue in a fishing district, i.e., ideal data of average revenue for each gear-type per fishing district are not available. Thus, gear-type dummy variables are calculated as shares based on the number of operating units in each gear-type, which serves as weights. The second issue is that a single unit often operates two or more gear-types in a district. To accommodate this fact in calculating the shares, such units were counted twice or more according to the total number of fisheries they contained. The denominator is the grand total of units, that is, including double or more counting of a unit. In doing so, we are acting as if each unit is operating only one gear-type in calculating the shares. Shares add up to one by this method, so one fishery variable was dropped from the regressions (Table 2, third row).

Two additional sets of covariates were included regarding the FMO units, namely the sharing rules and marketing practices. The census provides the number of FMOs within a fishing district that implemented proceeds sharing rules with uniform, weighted or other forms of distributional rules. The variables were constructed such that each is a share of total number of FMOs in that fishing district. Note that one unit can at most implement one type of sharing rule but not all FMOs have it, thus the shares do not necessarily sum up to one (Table 2, fourth row).

Marketing practices, as defined in the census, include (a) keeping the catch live, (b) quality control, (c) processing (dressing, etc.), (d) expanding sales channel and (e) transportation improvement. Due to high consumption of raw fish (*sashimi*) in Japan, keeping the catch alive and well in a fish tank on a vessel is an important value-added.[10] Quality control includes carefully releasing the catch from a net or a hook, and proper icing while in transport. Processing is another form of adding value to their catch, such as dressing the fish. Fishery Census reports the number of FMOs engaged in any of the above marketing

[10]Simply keeping the catch alive is not good enough. If the fish become weak during the time kept in a tank then, in terms of the quality of flesh, they might be worse than those being immediately frozen or killed and iced. It takes a great deal of care, such as maintaining the water temperature at optimum, to keep the catch alive and well until the vessel reaches the landing port.

practices. If an FMO is engaged in two or more marketing practices, that FMO is recorded in all of them. To incorporate such facts, marketing variables are calculated as the share of FMOs engaged in a certain marketing practice over the total number of FMOs in that fishing district. Note that, with this calculation method, the shares could sum up to more than one (Table 2, last row).

Table 4 shows the descriptive statistics of the dependent and independent variables in the sample. The average revenue for FMO units was higher than that of non-FMO units but the unconditional difference was statistically insignificant. While the average number of vessels owned was similar, the tonnage and engine horsepower were larger for FMO units. This could be an indication that FMOs were established in fisheries where overcapitalization and resulting low profitability were prominent, perhaps with the aim to reversing that situation.

The difference in mean-shares between the FMO and non-FMO units was statistically significant in 10 out of 11 fishery gear-types. Diving, which mostly targets shellfish and seaweed, is dominantly operated under the command of FMOs. This is consistent with the notion that resource co-management suites immobile resources better. The same reasoning might partially apply for small-scale bottom trawl, since it mainly harvests sedentary or demersal species that tend to be less mobile (though the difference is statistically insignificant). Also, tangible benefits from coordinated fishing effort as part of fishery co-management might be realized in fisheries prone to congestion and gear-damage as a consequence. This could be the explanation for the higher share of FMO units in small-scale bottom trawl and gill net fisheries. On the other hand, the higher share of non-FMO units in aquaculture is intuitive since the ownership over the resource is best defined.

The basic estimation model is

$$R_i = \mathbf{Capital}_i\boldsymbol{\beta}_1 + \mathbf{Fishery}_i\boldsymbol{\beta}_2 + \delta_1 FMO_i + \delta_2 FMOsize_i + \epsilon_i, \tag{1}$$

where R_i is the average revenue of fishing units in fishing district i, $\mathbf{Capital}_i$ and $\mathbf{Fishery}_i$ are vectors of capital and fishery gear-types variables explained above, respectively. FMO_i is a dichotomous dummy variable for whether an observation is of FMO units (=1) or non-FMO units (=0), and $FMOsize_i$ is the average number of units per FMO in a fishing district. Our interest is the estimated coefficient for δ_1. Model (1), however, assumes that the coefficients β_1 and β_2 are homogeneous for both FMO and non-FMO units, which might not be true for some variables. To check for this possibility, average revenue was regressed on covariates in the Model (1) and all covariates interacted with FMO dummy variable; thus while the slope of non-FMO units is β that of FMO units is $\beta + \delta_1$. The result showed that for three covariates – average vessel tonnage, share of other trawl fishery and that of aquaculture – we failed to reject the null hypothesis that the slopes are homogeneous at the significance level of 10% or higher. This result was incorporated in our subsequent regressions.

The results of heteroskedastic-robust OLS estimation of Model (1) are presented in the second column of Table 3.[11] The estimated coefficient for the FMO dummy variable shows that on average an FMO unit earns about $13,300 more revenue compared to a comparable non-FMO unit. This account for about 27% of average revenue for an FMO unit (c.f. Table 4). Most of the capital level-related variables have intuitive results; their signs are positive and statistically significant. For gear-type variables, note that one variable, namely the share of "other fisheries", was dropped to avoid singularity. The gear-types used in fisheries included in this category are those require large capital such as high-sea tuna trawl and offshore bonito hook-and-line, typically operated by corporations and joint-units. But, as Table 4 shows, about 0.4% and 7% of individual FMO and non-FMO units, respectively, are engaged in one of the fisheries included in this category. Since these fisheries typically earn higher revenues (not necessarily the profits), this explains why many estimated coefficients for gear-type variables are negative.

The third column of Table 3 shows results of an extended version of Model (1), that includes proceeds sharing rules and marketing enhancement dummy variables (Model (2)). These two variables are interaction terms with the FMO dummy variable. Results show that sharing rules had marginal impacts, which contradicts our hypothesis. Several other speci-

[11] Test for heteroskedasticity rejected the null hypothesis (homoskedasticity) at 1% significance level.

fications were tried, such as including the average number of years since the establishment of FMOs in a fishing district. The justification for that specification was that if there is a learning process involved in FMO operation and its effectiveness is assumed to improve over time, then this variable could pick up some of the learning curve heterogeneity in FMOs. Another specification tried was to interact with the FMO member size variable. None of them, however, were effective. These results do not disprove the notion that proceeds sharing rules mitigate rent dissipation incentives but rather suggest for more detailed investigation. For example, education level of member fishermen and various attributes regarding the leader of an FMO, all of which were unavailable in the census, might be a much more important factor in determining the performance of FMOs with proceeds sharing rules.

The results of marketing variables indicate some interesting stories. The introduction of marketing variable captured the statistical significance of the single FMO dummy variable; note that the coefficient estimates and their statistical significance of other variables remained mostly unchanged. This result is suggestive of the notion that the impacts on the output market conditions, such as price, is a prominent factor in the generation of economic benefits from local fishery co-management institutions in Japan. Indeed, as Table 3 shows, FMOs engaged in some kind of marketing practices had significant increases in their average revenues while FMOs without marketing practices did not. Since our dependent variable is the revenue and not the profit, we cannot conclude anything more about the impact of marketing relative to that of input cost savings. However, considering the fact that the effect of cost savings input changes are likely to be gradual whereas increased exvessel price changes are immediate, it is plausible that marketing effects might be the strongest results of coastal fishery co-management in Japan.

As aforementioned, there are five subcategories of marketing as defined in the census. Given that the marketing as a whole has a prominent impact on the performance of FMOs, a natural question to ask is: which types of marketing had the most impact? Model (3) in Table 5 shows the results (Model (2) corresponding to that in Table 3). Interestingly, none of the marketing subcategories were significant individually in statistical sense. In addition, FMO dummy variable is significant once again, but at lesser degree compared to model (1). Sub-grouping the marketing practices, such as "onboard" practices ((a) and (b)) and "onshore" practices ((c), (d) and (e)) as defined in the census, did not alter these outcomes. One possible explanation for these outcomes is that combinations of marketing practices are necessary to be effective, and that effective combinations differ by fishing districts.

With an exception of transportation, all have positive signs that are consistent with our intuition. Among those the quality control (item (b)) has the highest magnitude and statistical significance. This is consistent with the comments expressed by fishermen and FMO leaders during the author's field trip to Japan, that quality control practices are least costly and most doable for fishermen. Keeping the catch alive and well while cruising back to the landing port requires additional costs of capital investment, such as onboard built-in fish tanks and water temperature controlling devices. Onshore marketing practices – items (c) through (e) – are not exactly fishermen's expertise.[12] In contrast, quality control such as releasing the catch from the net or hooks carefully (minimizing cosmetic damage), apply proper icing and to avoid catching lesser-value individuals[13] are readily doable and something they could have been doing if they were not under the pressure to "race for fish", which is what FMOs primarily aim to mitigate.

4 Conclusion

This paper investigates empirically the effectiveness of fishery co-management, by means of Japanese FMOs, in enhancing the fishermen's revenue. We find that, at least for the individual fishing units, those who participate in FMOs have, on average, higher revenues than their non-participating counterparts after controlling for capital levels and fishery-types. Furthermore, the analysis shows that much of that economic benefit of FMOs originates

[12]Recall that FCAs are collective bodies of fishermen, and the chairmen are often senior fishermen. It is very rare that an FCA hires an outsider as a manager or marketing officer.

[13]For example, in the small pink shrimp fishery in Suruga Bay, where the price of shrimp increases with bigger size, fishermen would first haul a basket into the clump they found to check for the size. If the shrimp is big enough they would haul the trawl net; otherwise they would continue searching for another clump with bigger shrimp size.

from various marketing practices, onboard quality control in particular, that enhance the value of catch in output markets. The impact of marketing practices on revenue found in this analysis is intuitive, as markets tend to respond quickly to changes in raw product quality. This implies that, though economic rents could eventually emerge from cost savings, appropriating the quick gains from output markets could be the key for sustaining the FMO regime, and fishery co-management in general.

The results found regarding the proceeds sharing rules were somewhat surprising. One plausible explanation is the notion of "fairness" in the context of sharing rules. One of the toughest negotiations when implementing the sharing rules is how to redistribute the pooled proceeds. Uniform distribution might be favored from equity point of view but not necessarily considered fair, especially if fishermen were heterogeneous in skills and capital levels. Case studies of Platteau and Seki (2001) and Uchida (2004) were the ones that were successful in overcoming such obstacles, but perhaps they were among the rare cases. On the other hand, if an FMO pursuing marketing practices aims for higher exvessel prices and revenues but without sharing rules then the distribution of bigger "pie" will be in proportion to fishermen's individual skills, for example, which is likely to be perceived as fair. Perhaps this is why we found a strong significance for marketing practices but very weak or no significance of sharing rules on the fishermen's revenue.

The results of this analysis suggest several policy implications for a successful fishery co-management. Firstly, mere establishment of demarcated areas covered by the fishing rights and collective body of fishermen, whether it is an FCA or an FMO, are not good enough. Among the things which an FCA/FMO can do, it is suggested that marketing practices are high payoff activities for generating returns from fishery co-management. The types of marketing practices that are most effective depend on the pattern of consumption demand (such as high raw consumption, as in Japan, or mostly for processed foods), among other things. Secondly, the fact that marketing had significant impact on revenue increase suggests that benefits arising from the output markets are substantial and important in fishery co-management. Policies aimed at developing market infrastructure, such as the wholesale fish markets, and means of transporting the fish (i.e., linking the markets) could benefit the fishery co-management.

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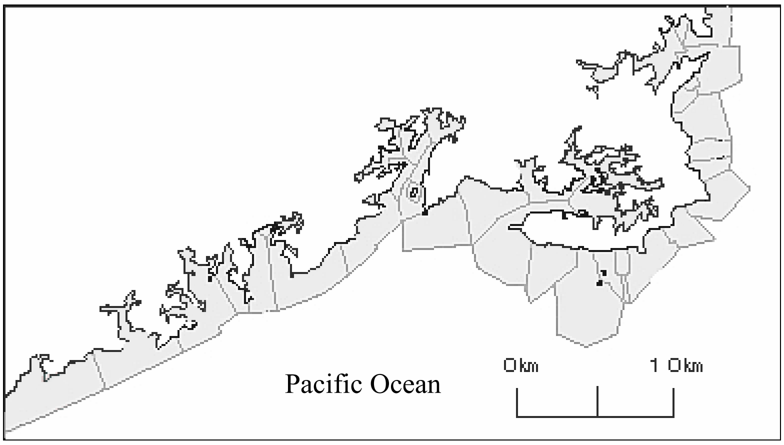

Figure 1: Example of fishing rights in Shima, Mie prefecture in western Japan

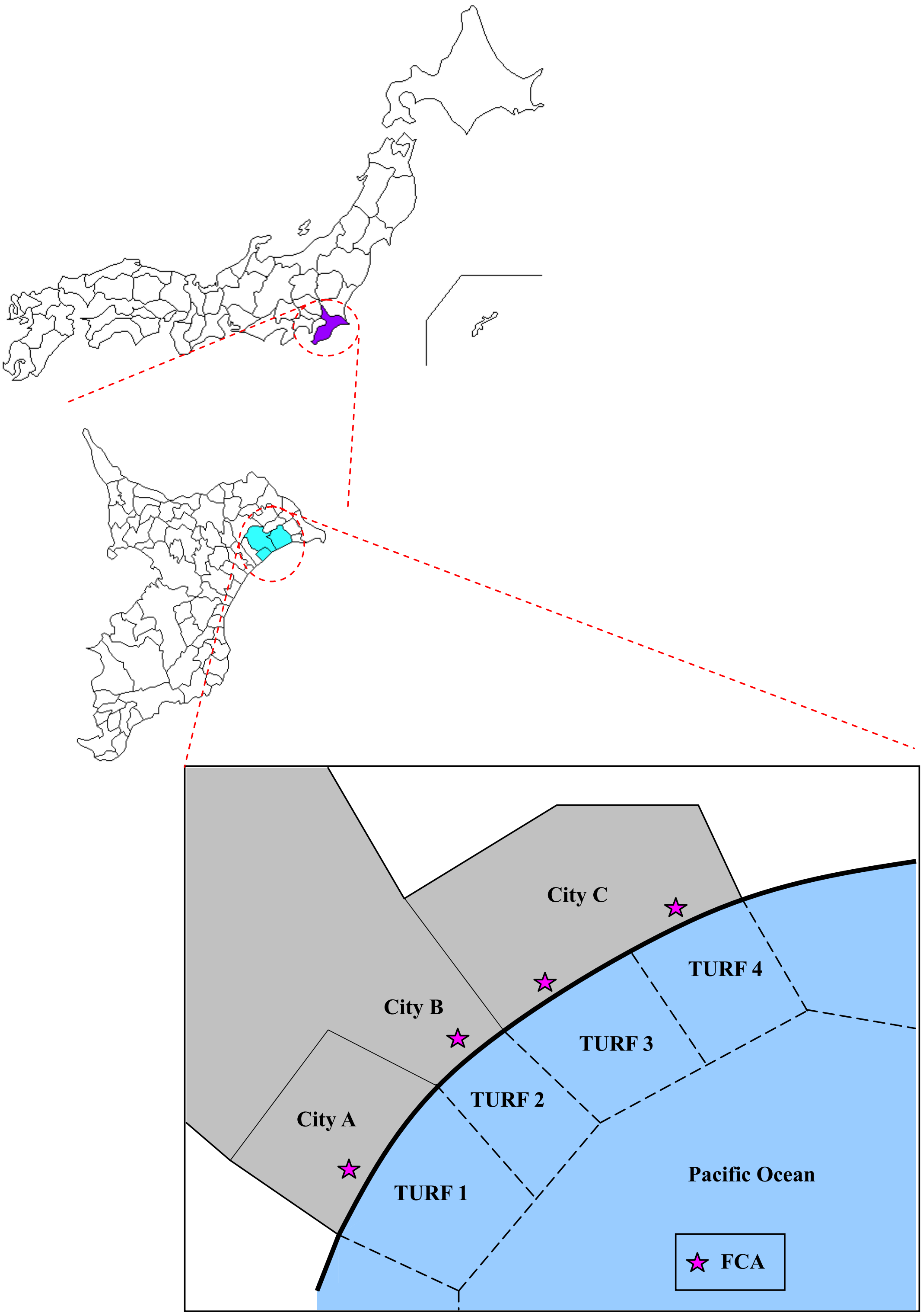

Figure 2: This diagram shows typical cases of how fishing districts are defined. Fishing rights areas are referred as TURFs. For cities A and B, each is defined as separate fishing district. City C has two fishing districts likely to be defined; one associated with TURF 3 and the other with TURF 4.

Table 1: Average by unit-category: Full sample (FMO and non-FMO units combined)

	Individuals	Corporations	FCA	PCA	JO	Others
Number of boats (no engine)	0.05	0.16	0.44	0.42	0.14	0.03
Number of powered boats	0.65	0.89	0.91	0.77	0.66	0.30
Number of vessels	0.80	2.77	2.20	3.23	1.49	0.98
Vessel tonnage[a]	5.8	19.4	7.3	8.4	5.4	230.9
Vessel horsepower[a]	73.9	75.3	42.6	38.5	54.5	787.5
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%)

[a] Average vessel tonnage and horsepower is calculated as per vessel per unit.

Table 2: Ideal data versus what the census has and what we did with them. Subscripts i and j denote fishing districts and fishing units, respectively. Subscript k denotes FMOs in a fishing district.

Variable	Ideal	Available	Data used as...
Dependent variable[a]	Revenue of each unit R_{ij}	Average revenue $\bar{R}_i = \frac{1}{n_i}\sum_{j=1}^{n_i} R_{ij}$	As-is $\bar{R}_i$
Capital variables[b]	Capital levels of each unit C_{ij}	Aggregated over units in a district $\hat{C}_i = \sum_{j=1}^{n_i} C_{ij}$	Average values $\bar{C}_i = \frac{1}{n_i}\hat{C}_i \cdots$ Number of boats/vessels $\bar{C}_i = \frac{1}{n_i v_i}\hat{C}_i \cdots$ Tonnage/horsepower
Fishery-gear variables[c]	Gear-type(s) of each unit $G_{ij,g} = (0, 1)$	Number of units by gear-type $\hat{G}_{i,g} = \sum_{j=1}^{n_i} G_{ij,g}$ $\sum_g \hat{G}_{i,g} \geq n_i$	Share of each gear-type $\sigma_{i,g} = \frac{1}{\sum_g \hat{G}_{i,g}}\hat{G}_{i,g}$ $\sum_g \sigma_{i,g} = 1$
Sharing rules variables[d]	For each FMO, by sharing rules $S_{ik,s} = (0, 1)$	Number of FMOs by sharing rules $\hat{S}_{i,s} = \sum_{k=1}^{K_i} S_{ik,s}$ $\sum_s \hat{S}_{i,s} \leq K_i$	Share of each sharing rules $\sigma_{i,s} = \frac{1}{K_i}\hat{S}_{i,s}$ $\sum_s \sigma_{i,s} \leq 1$
Marketing variables[e]	For each FMO, by practices $M_{ik,m} = (0, 1)$	Number of FMOs by practice $\hat{M}_{i,m} = \sum_{k=1}^{K_i} M_{ik,m}$ $\sum_m \hat{M}_{i,m} \geq K_i$	Share of each practice $\sigma_{i,m} = \frac{1}{K_i}\hat{M}_{i,m}$ $\sum_m \sigma_{i,m} \geq 1$

[a] R denotes revenue and n_i is the number of fishing units in district i.

[b] C denotes capital level such as number of vessels owned and tonnage. v_i is the total number of vessels in district i.

[c] Subscript g denotes each gear-type. G is a dichotomous variable; 1 if engaged and 0 otherwise.

[d] Subscript s denotes each sharing rules. S is a dichotomous variable; 1 if implemented and 0 otherwise. K_i is the number of FMOs in district i.

[e] Subscript m denotes each marketing practice. M is a dichotomous variable; 1 if engaged and 0 otherwise.

Table 3: Heteroskedastic-robust OLS estimation

Variables	Dependent variable: Average revenue[a]			
	Model (1)		Model (2)	
FMO dummy	13.3	(2.92)**	8.1	(1.59)
FMO member size	0.05	(1.50)	0.05	(1.41)
Marketings			10.0	(2.60)**
Sharing rules			-0.7	(−0.17)
Non-powered boats	17.5	(2.46)*	17.8	(2.51)*
Powered boats	16.8	(5.50)**	16.7	(5.56)**
Vessels	49.1	(9.01)**	49.2	(9.05)**
Vessel tonnage	0.04	(0.74)	0.04	(0.80)
Tonnage × FMO dummy	0.3	(2.39)*	0.3	(2.55)*
Vessel engine (hp)	0.0	(0.36)	0.0	(0.11)
Small bottom trawl	-18.3	(−0.98)	-19.2	(−1.03)
Other bottom trawl	1,740.4	(7.05)**	1,727.2	(6.99)**
Other bottom trawl × FMO dummy	-1,757.0	(−7.45)**	-1,741.3	(−7.39)**
Gill net	-42.6	(−2.32)*	-42.8	(−2.32)*
Hook and line	-34.8	(−1.62)	-34.4	(−1.60)
Long line	-30.0	(−1.24)	-32.6	(−1.31)
Trawl net	-20.3	(−0.50)	-19.7	(−0.48)
Diving	-39.9	(−2.10)*	-38.8	(−2.04)*
Set net	-21.2	(−0.66)	-25.1	(−0.79)
Other capture fisheries	-21.5	(−1.14)	-21.5	(−1.14)
Aquaculture	31.6	(1.37)	31.6	(1.37)
Aquaculture × FMO dummy	127.6	(1.93)	125.5	(1.91)
Constant	11.3	(0.61)	11.4	(0.61)
Observations		738		738
Adjusted R^2		0.39		0.39

Note: *t* statistics in parentheses. * significant at 5%; ** significant at 1%.

[a] Units are in 1,000 U.S. dollars.

Table 4: Descriptive statistics of variables: Averages per fishing district

	Variables[a]	FMO units	Non-FMO units
Revenue[b]		49.7	47.1
Capital	Non-powered boats**	0.03	0.06
	Powered boats**	0.67	0.56
	Vessels	0.80	0.83
	Vessel tonnage	9.16	8.80
	Vessel engine (hp)*	150	107
Fishery	Small bottom trawl	0.10	0.07
	Other bottom trawl*	0.007	0.00
	Gill net**	0.25	0.16
	Hook and line**	0.03	0.19
	Long line**	0.02	0.03
	Trawl net**	0.004	0.01
	Diving**	0.38	0.10
	Set net**	0.01	0.03
	Other capture fisheries**	0.17	0.10
	Aquaculture**	0.01	0.23
	Other fisheries**	0.003	0.07
Sharing rules	Total	0.17	–
	Uniform	0.07	–
	Weighted	0.09	–
	Other	0.01	–
Marketing	Total	0.51	–
	Freshness	0.19	–
	Quality control	0.31	–
	Processing	0.07	–
	Salea channel	0.22	–
	Transportation	0.09	–
Number of observations		534	571[c]

[a] Difference in means: * significant at 5%; ** significant at 1%.
[b] The unit is ten thousand US dollars ($1=105 yen).
[c] Number of observations for non-FMO units varied 227–571 depending on the variables.

Table 5: Regressions with marketing variables

Variables		Model (2)		Model (3)	
FMO Dummy		8.1	(1.59)	10.6	(2.17)*
FMO Member size		0.05	(1.41)	0.05	(1.35)
Marketing	Total	10.0	(2.60)**		
	(a) Live catch			4.5	(0.87)
	(b) Quality			5.1	(1.13)
	(c) Processing			0.03	(0.00)
	(d) Sales Channel			4.1	(0.68)
	(e) Transportation			-6.2	(−0.94)
Observations		738		738	
Adjusted R^2		0.39		0.39	

Note: Capital and fishery variables are suppressed but included in estimation models. t statistics in parentheses. * significant at 5%; ** significant at 1%.