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Fishing effort coordination and revenue pooling arrangement in fishery comanagement: Evidence from Japan

Hirotsugu Uchida*

ABSTRACT

This paper analyzes the impact of fishing effort coordination and revenue pooling arrangement on overall returns from fishery comanagement. Using the survey data collected from the Japanese fishery management organizations (FMOs) in 2005, we focused on two management measures employed by FMOs: fishing effort coordination and revenue pooling arrangement. We found that FMOs with both effort coordination and pooling arrangement outperformed those with neither or only with either one. The specific activities that these FMOs are engaged in that had positive impacts on their economic performance include marketing and harvest control. Marketing in general had a significant positive effect for FMOs with both measures, but we also found that no single specific marketing activity is a silver bullet, suggesting that the specifics vary from case to case. Our analysis provides a hint of what a fishery comanagement group can do in order to be successful in their management effort.

Key words: fishery comanagement, effort coordination, pooling arrangement, Japan

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1. Introduction

Collective management in fisheries has garnered much attention in recent years as an alternative to conventional top-down regulations and completely decentralized scheme such as individual transferable quotas. While the definition of collective management or comanagement differs across the literature (Jentoft, 2003), the key feature here is that local fishermen form a group to jointly manage the common pool resource they exploit. It can take various forms, including harvester cooperatives in Alaska, sector allocations in New England (Johnston and Sutinen, 2009) and fishery cooperative communities in South Korea (MOMAF, 2007).

Collective fishery management as a scheme is anything but new. It is rather the norm in artisanal fisheries (Jentoft, 2003) and there are many examples of fishery comanagement around the world (Wilson, Nielsen and Dengbol, 2003; Cunningham and Bostock, 2005; Townsend, Shotton and Uchida, 2008). There is an abundance of literature attempting to synthesize the lessons learned from these case studies, not just in fisheries but in the context of common pool resources in general (e.g., Ostrom, 1990; Baland and Platteau, 1996; Ostrom *et al.*, 2002). Some of the key lessons listed in these literatures include the importance of well defined boundaries, homogeneous member characteristics, immobile resource, conflict resolution mechanisms and so on. What seems to be lacking in these lists, however, is what these comanagement groups can do as part of their daily fishing operations and institutional arrangements that may lead to the success of the comanagement.

Examining fishery comanagement in the coastal fisheries of Japan provides some valuable lessons. The advantage of studying Japanese fishery comanagement is their abundance and variety of cooperatives. These cooperatives function under the same national fishery rules and laws and, to certain extent, their cultural and social characteristics are identical. This enables us to utilize wide variations in key fishery-related variables while controlling for other influential and difficult-to-observe disturbances. There are several studies examining the framework, both institutional and legal, of Japanese fishery comanagement (e.g., Cancino, Uchida and Wilen, 2007). However, our focus is on the “software” of comanagement and there are two basic and important components of fishery comanagement for its success: effort coordination and pooling arrangement (Uchida, 2009).

There are several important questions about the actual relationships and interactions between effort coordination and pooling arrangements employed by the FMOs. In the literature, pooling arrangements are thought of as supporting systems that help effort coordination operations function effectively (Gaspard and Seki, 2003; Hasegawa, 1985; Baba, 1991). However, the literature on this topic is drawn from a few select cases and does not provide cross-sectional overview of how these schemes are actually employed and how they perform. Whether effort coordination and pooling arrangements bring higher economic returns in

the first place is an empirical question that may be important to sustainable fishery comanagement. Effort coordination and pooling arrangements can potentially change the way fishermen do fishing by replacing individualistic competition (race to fish) with behavior more similar to a corporate or sole owner style of operation. But making such operational and institutional changes involves long negotiations and, once implemented, a level of monitoring and enforcement effort, which all mount to significant total costs. Since fisheries are no different than any other economic activities, it is vital that implementation of these arrangements bring higher economic return for successful fishery comanagement. Some of the key questions are: Are effort coordination and pooling arrangement generally employed as a pair? Is the performance better when effort coordination and pooling arrangements perform better if they are implemented together rather than individually? If so, in what ways are such outcome achieved? The main contribution of this paper is to provide answers to these questions.

Our results show that members of FMOs with both effort coordination and pooling arrangements had higher economic performance, defined as the revenue per fishing hour, than FMOs with either one or neither of these arrangements. FMOs with only effort coordination or pooling arrangements had positive estimated impact on the economic performance but statistically insignificant compared to FMOs with neither feature, which highlights the importance of having both implemented. We also found that among various management activities that FMOs are engaged in, marketing and harvesting control had the most impact on economic performance.

This paper is organized as follows. In the next section we will briefly explain what are effort coordination and pooling arrangement and why and how they are important in fishery comanagement. The following section describes the data used for our analysis, followed by the section on empirical strategies employed. Section on estimation results will follow and the last section concludes.

2. Effort coordination and pooling arrangement

Coastal fishery management in Japan is, for the most part, carried out by the local fishermen's group known as Fishery Cooperative Association (FCA). Members of FCAs are mostly fishing households and "small" companies, as defined by the number of employees and gross tonnage of the vessels owned. The functions of FCAs are similar to other harvester cooperatives and include joint purchases of inputs (e.g., fuel, ice and boxes), administration of ex-vessel markets and provision of insurance and credit to members. FCAs are usually associated with specific coastal communities that historically have depended on fisheries resources. Each FCA typically encompasses all the fisheries within that community or communities' jurisdiction. A number of diverse fisheries?both

in terms of targeted species and gear used? may be under the auspices of any FCA.

In addition to conventional functions, FCAs play the unique role of managing fishing rights. Fishing rights are defined over a parcel of coastal water, typically in front of the community which an FCA belongs. The borders are defined often by the municipal boundaries then extending certain distance from the shore. The extent of the boundaries from the coast depends partly on the topology of ocean floor and neighboring communities. Fishing rights are granted and protected by law and restricts commercial fishing to only the permitted members of an FCA. In this sense, fishing rights is analogous to territorial use rights for fishing (TURFs) (Christy, 1982).²

Comanagement of coastal fisheries is carried out by fishery management organizations (FMOs). An FMO is defined by the Ministry of Agriculture, Forestry and Fisheries as a group of fishers who share the same fishing ground and/or operate in the same fishery and are collectively engaged in resource and/or harvest management according to mutually agreed rules. FMOs are autonomous organizations and some of Japan's FMOs have been in operation for decades. Since it was placed at the center of national fishery management policy in the early 1980s, the number of FMOs continues to rise, with 1,608 FMOs nationwide by, 2003 (MAFF, 2006). FMOs and FCAs are interrelated in number of ways: nearly 95% of FMOs are operated by a parent FCA or its affiliate organization. As such, the operation of FMOs are supported and utilizing the institutional infrastructures of FCAs and fishing rights.

FMOs and their associated FCAs and fishing rights are all institutional framework under which fishery comanagement groups operate. For FMOs to be successful, they must at minimum generate tangible benefits to the participating members that surpass not only the status quo but those of non-participants.³ The question is how to achieve such an outcome in the context of fishery comanagement. While there could be numerous activities and ways of doing business that would achieve this goal, we claim that they can be put into two very broad components: effort coordination and pooling arrangement.

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 joint ownership of vessels and fishing gear.

2 The fishing rights apply only to coastal fisheries; offshore and high-sea fisheries are typically governed by a license system that is managed by either the central or the prefectural government. Also, there are three types of fishing rights-common, demarcated and large fixed net. For the context of this paper, common fishing right is the only relevant one.

3 This is referred to as privilege condition in the club theory literature (Sandler, 1992).

Consider, for example, the fishing ground rotation. In white shrimp fishery, an FMO implemented a daily fishing ground rotation scheme (Platteau and Seki, 2001). FMO members and known fishing grounds were grouped into three, each FMO group is assigned to one fishing ground and they rotated daily when they went out fishing. If the group size is appropriately determined congestion in each fishing ground will be mitigated, if not eliminated and because there is no need to compete for better fishing grounds there is considerably low incentive to race to fish. Cost savings can come from slower steaming speed that increases fuel efficiency and less damage on fishing gear due to less congestion.

In small pink shrimp fishery fishing grounds are not rotated but assigned by the “fishing committee” that meets every day during the season (Uchida and Baba, 2008). This shrimp is a small zooplankton-like species that concentrates each evening as they rise near the surface, but the location where the clumps appear is highly variable. Rigid rotation system may be ill-suited in such condition because while one group might find near-empty ground another group might find overwhelming amount of shrimp. In fact, it often happens that some vessels with large catch radio the leader for help. The leader will then direct vessels with low catch to relocate and help haul the harvest or make additional tows nearby. Location assignment system allows such flexibility to be in place.

Effort coordination is not only applicable to the production operations; collective marketing is potentially an effective way to increase revenue and it is becoming increasingly popular among FMOs. Often seen is the development of private brand that is as simple as being explicit about the geographical origin (e.g., Maine lobster, Alaskan salmon). Others, particularly the successful ones, involve more coordinated effort in quality control and targeted marketing.

A pooling arrangement is an agreement among FMO members by which harvests, revenues and/or profits are pooled and then distributed back to members.⁴ 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. Pooling arrangement is typically characterized as a supporting mechanism for effort coordination (Platteau and Seki, 2001). This is because, in essence, effort coordination is a restriction of individual’s decisions and the differentials in harvest levels resulting from effort coordination must be addressed and adjusted (Uchida, 2009). A pooling arrangement is a method for handling this differential problem.

It is important to recognize, however, the importance of the fact that pooling arrangement 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 absence of comanagement. It also aligns the incentive of individual fishermen to that of a group; individual return is maximized

⁴ Pooling arrangements considered here do not include insurance purposes, as in risk pooling, since such fishery insurance is already offered by FCAs.

only when the group's total return is maximized. This implies, for example, that it becomes an individual's own 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. Number of case studies show that FMOs with pooling arrangements are functioning reasonably well (Hasegawa, 1985; Baba, 1991; Platteau and Seki, 2001; Gaspart and Seki, 2003; Uchida and Baba, 2008; Uchida and Watanobe, 2008). That said, the higher economic return from comanagement, particularly when that management includes a pooling arrangement, is critical in sustaining the comanagement regime.

Not all FMOs have effort coordination or pooling arrangement. According to the fishery census, about 12% of FMOs have pooling arrangement (MAFF, 2006). While the data on effort coordination per se is not included in the census, one indicative data is that approximately 50% of FMOs have joint marketing program of one form or another. These facts raise a question of what characteristics of FMOs might be influencing their decision to implement effort coordination and pooling arrangement. Using the survey data collected by the author this paper will analyze and identify those characteristics.

3. Data

Since there were no readily available datasets investigating effort coordination in the detail that we required, a mail survey was developed and implemented. The survey was targeted at FMO managers nationwide and was implemented in 2005 following the Dillman method (Dillman, 1978). The survey was pre-tested and then mailed out in late 2005.⁵

One of the first challenges in conducting the mail survey was to identify which FMOs to send the survey. Ideally we would want to send the survey to all FMOs nationwide, but it became apparent that this was not possible. The main complication is that there exists no single source of contact information for all of Japan's FMOs, primarily due to the fact that FMOs are typically autonomous organizations (Makino and Matsuda, 2005). An option was to send the survey to all fishery cooperatives (FCAs) for which contact information is available. However, there are many cases where two or more FMOs are formed within a single fishery cooperative and we were advised that a survey sent to a

5 Our survey was not the first one to be conducted on FMOs or on effort coordination. For example, in 1997 there was a survey conducted under the supervision of the Fishery Agency of the Japanese government. That survey was sent to regional government officers associated with FMOs located within various jurisdictions, who then answered the survey on behalf of FMOs. Our survey differs from the previous ones in two important ways: i) our survey was sent directly to FMO managers instead of government officials who oversee them and ii) questions were focused in great detail on effort coordination, pooling arrangements and other self-imposed regulations and fishing operations in general.

generic recipient (i.e., not to specific FMOs) would tend to get less or no attention. For these reasons it became clear that we needed to have a list of specific contact information of FMOs, which led us to utilize the list of FMOs from a prior survey conducted in 1997 (see footnote 4). 386 surveys were sent out and 113 usable responses were received.

We defined “effort coordination” as i) fishing grounds rotation or location assignments and/or ii) exchanging information on fishing grounds. Table 1 shows the number of FMOs in our sample identified by the combination of effort coordination and pooling arrangements employed. There are significant numbers of FMOs with either effort coordination (Type B) or pooling arrangements (Type C) alone. This suggests that these arrangements are probably not simply transitional or exceptional institutions. Having both effort coordination and pooling arrangements as a pair (Type A) is not necessarily a norm and the question becomes whether there is a significant benefit of having both. Type D is defined as FMOs without either of the two effort coordination or pooling arrangements.

Table 1. Number of surveyed FMOs by their type

Type	Effort coordination	Pooling arrangement	Count
A	x	x	38
B	x		28
C		x	18
D			29
Total			113

Notes: Count is the number of FMOs of respective types in the survey sample.

Our primary interest is determining how various combinations of effort coordination and pooling arrangement affect some economic performance measure. We focus on the revenue per unit of effort, which is defined as the revenue from the managed fisheries per member per fishing hour. The overall unconditional mean of revenue per unit of effort in our sample was 94.9 thousand yen (about \$860) with significant variance among the FMO-types ranging from 160.3 thousand yen (\$1,500) for Type A to 4.3 thousand yen (\$40) for Type D (Table 2). Note that these figures are gross revenues before subtracting any expenses such as vessel maintenance, wages for crew and usage fees for shore-side facilities. Nevertheless, from these summary statistics alone, there seems to be a good reason to believe that FMOs with effort coordination and pooling arrangements have higher revenue per unit of effort than FMOs without these arrangements. Indeed, simple *t*-tests among the means indicate that the Type A FMOs’ performance measure is statistically different from Type B and D, but not so from Type C. Type B FMOs’ revenues per fisherman day was statistically significant only from Type D, while that was not the case between Type C and Type D. This is weakly suggestive of the notion that effort coordination and pooling arrangements are more productive when implemented together. However, we would need to control for other factors affecting the revenue level to be more confident in this claim.

Table 2. Descriptive statistics of survey sample data

Variables	FMO Type			
	A	B	C	D
Average membership size	49.8	48.1	28.4	73.7
Average members age	55.6	59.6	59.7	59.4
Average years of experience	31.6	34.2	32.6	30.5
Average number of vessels registered	35.4	39.7	26.2	84.7
Average number of vessels in operation	15.4	19.9	21.9	29.1
Average vessel tonnage	9.2	3.7	3.8	6.1
Average per member revenue	9,833	5,337	5,388	3,027
Average number of fishing days per year	66.0	118.9	92.6	120.2
Average fishing hours per day	5.3	5.0	4.6	10.6
Revenue per fishing effort	102.1	10.4	12.6	3.7
Fishing ground within TURF (% of “yes”)	87.8	85.2	80.0	85.7
Solely owned TURF (% of “yes”)	66.7	43.5	62.5	58.8
Type of managed targeted species: pelagic	0.0	6.9	8.3	12.5
Groundfish	14.0	20.7	8.3	4.2
Crustacean	23.2	31.0	25.0	12.5
Sedentary	62.8	41.4	58.3	70.8

Notes: Monetary unit is in thousand Japanese yen.

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. Table 2 seem to suggest that FMOs with pooling arrangements (Type A and C) tend to fish fewer days than 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, in comparison with behavior under individualistic competition. On the other hand, members of Type B FMOs are not under the environment of individualistic competition, but their numbers of fishing days are the same level as Type D FMOs. A possible explanation for this result is the “fairness adjustments” in response to effort coordination. With effort coordination such adjustments must be made, such as by providing equal chances of fishing at any given fishing ground to a vessel in a season (as observed in walleye pollack fishery in northern Japan; see Uchida and Watanobe, 2008 for details). This equity constraint may translate to maintaining a certain minimum days of fishing per year since it is easier to make such adjustments with more fishing days

Fishing hours per fishing day are not much different across FMO-types except Type D, which on average exhibits much longer fishing hours per day. This suggests that fishing effort may be more concentrated, presumably around the most profitable times, in Type A and perhaps Type C FMOs.

If Type A FMOs are earning higher revenue per unit of effort, one might expect that, *ceteris paribus*, i) membership size of these FMOs are smaller than other types (e.g., Agrawal, 2001) and ii) FMOs would successfully attract younger generation (i.e., successors)

to the fishery. Regarding the first point, Type A through Type C FMOs have smaller membership sizes 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 average years of experience as a fisherman. Thus, the two hypotheses above are not supported by our sample.

According to the literature such as Ostrom *et al.* (2002), self governance has better chance of success if the managed resource is sedentary. Our survey sample shows the consistent trend, where the majority of FMOs of all types manage sedentary species. Furthermore, it is interesting that none of the Type A FMOs manage pelagic fish species, which is considered to be the least suitable for resource self governance. The high share of crustacean species could be the effect of their higher value in general; species such as spiny lobster and many types of crabs tend to fetch higher price in the market. High valued species could provide an extra incentive to manage well so as to sustain the fishery.

4. Empirical model

We are interested in whether there are any systematic differences between the revenue per unit of effort (*rpue*) and the FMO-types. Our objective is to determine how much we can attribute this variation to the difference in management regimes.

Simply establishing a TURF-based fishery cooperative does not eliminate the incentive to race to fish (Uchida, 2004). New entries will be limited but, if nothing else is done, the race among the incumbents will prevail, leading to a waste of capital, low profitability and overall depletion of the resource and economic rents. The simple establishment of an FMO will not be much different either, unless other actions are taken by FMO members. With an FMO, the authority of fishery management devolves from the officials to the local fishermen. This decentralization may improve the level of compliance, but since underlying incentives to race for fish are unaffected without additional measures, the impact of such a regime shift on economic outcomes is likely to be limited.

We hypothesized that FMOs with effort coordination and/or pooling arrangements (Type A, B, or C) will have higher revenue per unit of effort than those without such arrangements implemented (Type D). Successful fishery comanagement requires that a restricted group be granted rights to the resource. This is what establishment of the TURF provides. But successful comanagement also requires that the restricted group that has been granted rights can successfully overcome internal organization costs and collectively exercise policies that manage the resource sustainably and profitably. Effort coordination is an active management measure that may be used to fulfill this requirement. Pooling arrangements, in contrast, can be thought of as passive measures in the sense that they do not require fishermen to continuously decide on terms of operation. However, pooling arrangements

alter the incentive structures in such a way that, if implemented appropriately, individual incentives are aligned with that of a group as a whole. This is because maximizing the total benefit of a group, i.e., the whole “pie”, will also maximize one’s individual dividend under the pooling arrangement.

We would also expect that FMOs with *both* effort coordination and pooling arrangements (Type A) to exhibit higher revenues per unit of effort than those with only either one (Type B or C). Effort coordination deals with the allocation of inputs of harvesting operation, while pooling arrangements deal with the allocation of outputs among the FMO members. Intuitively, coordinating and pooling complement each other and we would expect FMOs with both to be more efficient and effective.

The following simple regression was conducted to check quantitatively whether the FMO-types matter at all. The model is

$$\ln rpue_i = \alpha + \beta_1 Type_A_i + \beta_2 Type_B_i + \beta_3 Type_C_i + \varepsilon_i,$$

where Type_A through Type_C are as defined in Table 1 and ε_i is the error term. The subscript i denotes an FMO. Note that the Type D FMO variable is excluded from the estimation. The result from heteroskedasticity-robust OLS shows that Type A and Type B FMOs have significantly higher revenue per unit of effort than Type D FMOs (Table 3). Thus, it seems suggestive at this junction that FMO-types do have influence over the revenue per unit of effort; the next step is to control for other covariates that affect revenue per unit of effort.

Other influential factors that may impact revenues per unit of effort need to be controlled for. These include targeted species-type, product-type (which product markets the harvest is allocated to) and the vessel size. In addition, membership size of an FMO might also be an influencing factor. Literature on commons and collective action often claim that smaller groups have better chances for successful collective action, in terms of sustainability and performance (Agrawal, 2001). Therefore, smaller FMOs might have higher revenue per unit of effort, *ceteris paribus*. Lastly, there could be a learning effect.

Table 3. Heteroskedasticity-robust OLS with only FMO-type variables

Variable	Coefficient
Type A	1.813 (4.70)***
Type B	0.711 (1.97)*
Type C	0.781 (1.34)
Constant	-1.324 (5.17)***
Adjusted R ²	0.165

Notes: Absolute t-values in parentheses. Number of observations in this regression is 72.

*** significant at 1%, ** 5% and * 10%.

The hypothesis is that the longer an FMO endures, the better it is in management performance. This is a plausible hypothesis given anecdotal evidence of actual cases where FMOs often modify and fine-tune their management practices over time (Uchida, 2004).

4.1 Targeted species-types

It is common knowledge that certain harvested species command higher prices than other species in general. In Japan, for example, spiny lobsters and certain species of crabs (e.g., snow crabs) are generally considered high-end or luxury foods and thus are traded at higher prices. Thus, we would need to control for FMOs' main targeted species.

One needs to be cautious in including the species-type variables into the model. If the case was such that high-value species are caught dominantly by Type A FMOs and low-value species are caught dominantly by Type D FMOs, or vice versa, then including both FMO-type and species-type variables will cause serious multicollinearity problems. To see if this problem exists in our sample, we counted the number of FMOs by targeted species and by FMO-types. There were total of 66 species targeted in our sample, with most of them having only three or fewer FMOs involved. Our focus is the "popular" targeted species and thus we separated species with seven or more FMOs involved. Also, since abalone and turban shell were often harvested as a pair of targeted species, these two were treated as one species entry. The results showed that there are no systematic correlations between FMO-type and species-type variables and hence we include the species-type variables into the model.

4.2 Product-types

The revenue level can potentially be influenced by the market-types to which harvested fish are sold. Fish designated to fresh markets generally fetch higher prices than those going to frozen or processed markets. Freshness is of particular importance for Japanese consumers as there is substantial demand for raw consumption of fish. Whether that translates into higher revenue, however, is an empirical question. Nonetheless, implementing rigorous quality control measures so as to allocate their harvest to raw and fresh consumption is a popular practice that FMOs engage in. This is in line with the claim that benefit of rationalized fishery management coming from output markets in terms of increased price is substantial and critical in sustaining the regime (Homans and Wilen, 2005; Herrmann, 1996).

We will denote the different markets which harvest is designated to as "product-type." First we divided the product-type into two categories: domestic consumption, including both final and intermediate and exports.⁶ Domestic consumption was further sub-categorized into raw, fresh, processed and feed. The first two are for final consumption.

It is not uncommon that a single species is allocated to multiple markets. For this reason, the survey asked the respondents to give the share of each product-type. Overall, the majority of harvests go to either raw or fresh markets, with average of 27.7% going to the raw market and 56.9% to the fresh market.

4.3 Gear-types

Another factor that might affect the revenue level is the harvest method employed, particularly within a single species-type. Controlling for gear-type is clearly necessary if there are multiple gear-types employed for the same targeted species and that there is a reason to believe that might have an impact on revenue level. We examined the top two gear-types used to harvest the popular targeted species.⁷ Results showed that the issue of multiple gear-types in a single species is quite limited. With an exception of turban shell, all other species are harvested by single gear-types across different FMOs. As for turban shell, since it is often combined with the abalone fishery, diving can be considered as the dominant harvesting method for the two species. From these results, we conclude that including both species-type and gear-types variables will likely to cause multicollinearity problems, thus gear-type variables were excluded from the estimation models.

4.4 Other variables

There are other variables that can potentially be included in the model. An obvious one is the average tonnage of vessels. This is the average tonnage of vessels owned by FMO members and it is intended to be a proxy for crew member size. Intuitively, larger crew sizes bring higher revenues for an FMO member, who is typically a vessel owner and skipper, per fishing hour. Since we do not have the crew size variable, we include the average tonnage of vessels based on the assumption that typically larger vessels have more crew members on board.

A few more variables are considered primarily in response to the possible issue of endogeneity. Specifically, we are concerned about any omitted variables that not only affect the level of per member revenue but also the likelihood of a group choosing a particular FMO type.⁸ One of such variable is the FMO's membership size. As Ostrom (1990)

6 According to the fisheries white paper, during the 2004 fiscal year the domestic fishery production was 1,604 billion yen, of which 148 billion yen or 9.2% was exported (Fishery Agency, 2005).

7 First we tried to count the top three gear-types, but turned out that there was no third popular gear-type in our sample.

8 We do not have a selection bias issue here; we have observations on revenue for all four types of FMOs and we know exactly which revenue data belongs to which FMO-type. Also, since our sample is confined within FMOs we cannot address the question of what factors determine the establishment of FMOs.

and others have pointed out, smaller groups have better chance of implementing collective action and perhaps more sophisticated forms of collective action than larger groups, *ceteris paribus*. This suggests that group size affects the choice of FMO types; smaller groups tend toward being Type A.

In addition to membership size, we considered the FMOs' established year index variable. This variable range from 1 to 11, each corresponding to an interval of five years where 1 is the oldest (established on year 1935 and prior) and 11 is the most recent (established year, 2001 and after).⁸ The question is whether any learning effect is present or not. Also, it is often the case that FMOs modify and in many cases fine-tune their management schemes and rules over time. We would expect that such modifications take place in aim to increase the return from the fishery, because making such changes incur cost.

4.5 Model specification

All of the aforementioned covariates were considered to be included in our empirical model. It was revealed, however, that inclusion of both species-type and product-type variables exhibited a typical sign of multicollinearity: high adjusted R^2 , a significant F-test and non-significant t-tests of coefficients. We thus conclude that species-type and product-type variables should not be included together in our estimation model. Upon comparing the models with species-type and product-type variables, it was determined to retain the species-type variables in our empirical model.

We also considered specifications such as double-log (replacing tonnage, membership size and years variables with the logarithm of respective variables) and inclusion of squared terms for tonnage, membership size and years variables. Furthermore, interaction terms of FMO types and tonnage, membership size and years variables were considered to examine whether the effects of these variables differ across FMO types. The goodness of fit of these models were compared based on the F-values and adjusted R^2 . In conclusion, our basic empirical model is

$$\ln rpue_i = \alpha + \sum_j \beta_j type_{ij} + \sum_k \beta_k species_{ik} + \nu_1 tonnage_i + \nu_2 membership_i + \nu_3 years_i + \sum_j \gamma_j (type_{ij} \times tonnage_i) + \sum_j \delta_j (type_{ij} \times membership_i) + \sum_j \eta_j (type_{ij} \times years_i) + \varepsilon_i \quad (1)$$

where subscript i denotes an FMO, $j = \{A, B, C\}$ and k is a vector of species-type as listed in Table 4. Regression diagnostics were performed to detect any influential outliers in our sample but none among the 67 observations was found; details are explained in the appendix.

5. Regression results

5.1 FMO types

The coefficient estimate of the Type A FMO variable is 1.19 and it is statistically significant at 1% level (Table 4). Since only the dependent variable is in a natural log form, the interpretation of coefficients is the percentage change in revenue per unit of effort in response to a unit change in explanatory variables. Thus, it is estimated that a member of Type A FMOs earn approximately 118% more revenue per unit of effort than

Table 4. Heteroskedastic-robust OLS model with RPUE as dependent variable

Variables		Estimated Coefficient
FMO type ^a	Type A	1.189 (2.247)***
	Type B	0.425 (0.456)
	Type C	1.961 (1.703)*
Species type ^b	Spiny lobster	0.097 (0.143)
	Abalone and turban shell	-0.315 (0.767)
	Scallop	1.756 (5.927)***
	Asari-clam	-0.412 (0.534)
	Other migratory fish	-0.479 (1.441)
	Other non-migratory fish	2.250 (3.937)***
	Other sedentary species	1.927 (4.428)***
FMO membership size		-0.00002 (0.003)
Average vessel tonnage		0.155 (2.506)**
Years since FMO establishment		0.0203 (0.212)
Type A x membership size		-0.003 (0.331)
Type A x tonnage		-0.166 (2.684)***
Type A x years		-0.071 (0.563)
Type B x membership size		0.028 (2.600)**
Type B x tonnage		-0.018 (0.206)
Type B x years		-0.285 (1.959)*
Type C x membership size		0.017 (1.511)
Type C x tonnage		-0.998 (7.473)***
Type C x years		-0.003 (0.020)
Constant		-1.797 (3.554)***
Adjusted R ²		0.549
Number of observations		67

Notes: ^a, Type D FMO is set as the base FMO-type.

^b, Surf clam is set as the base species-type.

Absolute t-values in parenthesis. Significance levels are indicated by *** significant at 1%, ** 5% and * 10%.

the Type D FMO members. This is within the plausible range based on the result from the descriptive statistics (Table 2). The model also estimates that Type A FMO members earn significantly, in a statistical sense, higher revenue per unit of effort than Type B FMO member at 5% significance level. 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.

The results show that Type A and Type C FMO members earn significantly higher revenue per unit of effort compared to Type D FMO members, with much stronger significance for Type A FMOs. This suggests that (1) combining effort coordination and pooling arrangement has super-additive impact on revenue per unit of effort, while (2) effort coordination or pooling arrangement alone has no or only marginal impacts on the revenue per unit of effort.

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 not fully supported since Type B was statistically insignificant. Our second hypothesis that FMOs with both measures perform better than those only with only either one was almost fully supported, as the coefficient for Type A was estimated to be highly significantly different from Type D. We say “almost” because (1) Type C was also statistically significant, albeit at only 10% level and (2) the t-test among the coefficients of three FMO types revealed that none were statistically superior over the other, although Type A was almost significantly different from Type B with the p-value of 0.112.

The result that there is no significant difference in revenues per unit of effort between Type A and Type C FMOs raises an interesting question as to how exactly Type C FMOs operate. If the revenue is pooled but without established central decision-making mechanisms (such as committees), how does each individual fisherman in Type C FMOs operate? For example, do they operate the same way spatially (i.e., in choosing fishing grounds) but simply less intensively? An interview with one Type C FMO manager provides hints about answers to these questions. This particular FMO harvests surf clams and the purpose of employing the pooling arrangement was to mitigate the members’ incentive to race to fish. On each fishing day, revenue is shared only among the members who participate in fishing; those who stay on shore are excluded. This eliminates the incentive to free-ride by staying on shore. Also, in this fishery there are several fishing grounds that are distant from their port, but nonetheless need to be cultivated. With the pooling arrangement in place, no individuals have the incentives to fish in these grounds since fishing costs are not shared. There are no explicit rules as to how to take turns to harvest these fishing grounds, but there is an implicit rule-of-thumb that if you operate in nearby fishing grounds for three days you would go to more distant grounds for a day. If a member is caught not following this implicit rule, based on peer monitoring, this member will be

penalized in the form of reduced share of pooled revenue. In essence, this Type C FMO has implicit effort coordination in place. We have no method to verify if this is the norm for any of the surveyed Type C FMOs. If it is, however, then the distinction between Type A and Type C becomes vague and this would explain why we do not detect significant differences in revenue levels between these two FMO types.

A few observations on the interaction terms are worth mentioning. For Type A FMOs it turns out that none of the three attribute variables—membership size, tonnage and years since establishment—matters for the members' revenue per unit of effort. Note that the coefficients for average tonnage (0.155) and that interacted with Type A (-0.166), both statistically significant, cancel out. Similar outcome is observed for tonnage variable interacted with Type C (-0.998). An interesting result is that the membership size was positive and significant for Type B FMOs. Given that the magnitude of fishing inefficiency increases with membership size (Cheung, 1970; Gordon, 1954), this in retrospect implies that effort coordination has the greatest impact on FMOs with larger membership size.

5.2 Other self-imposed regulations

Next we asked whether the combination of effort coordination and pooling arrangement is solely responsible for higher revenue per unit of effort. There are many other types of self-imposed regulations and measures that FMOs can employ and they indeed do so (Table 5). We categorized these self-imposed regulations as follows.

1. Marketing: quality control measures such as proper icing and careful release from nets, development of new value-added products and branding.
 2. Harvest control: setting TAC and/or individual quota, control daily landing volume to avoid market glut and fish size and age restrictions.
 3. Operation regulations: restrictions on fishing hours and days, seasonal closure, setting no-fishing zones and restrictions on fishing method, fishing gear and number of crew on a vessel.
 4. Vessel regulations: restrictions on number of vessels, tonnage and engine power.
- Note that some of above regulations are also imposed by the local or central government but in the survey we explicitly asked for self-imposed regulations, including those are more stringent than existing government regulations.⁹

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 6). Results show that none has a statistically significant impact. The estimated positive sign for the marketing variable is intuitive, as such activities are typically aimed to bring higher revenue. The negative sign for the harvest control variable is plausible if the market price did not respond enough to reduced landing volume to supplement the loss.

Table 5. Number of FMOs by 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 that the Type A FMO variable remained statistically significant even after the addition of self-imposed regulation covariates. Thus, the next question is whether the combinations of Type A FMOs and self-imposed regulations have significant impacts on revenue per unit of effort. To do so, we introduced the interaction terms of Type A and regulation variables. The model is

$$\begin{aligned} \ln r_{pue_i} = & \alpha + \sum_j \beta_j type_{ij} + \sum_k \gamma_k species_{ik} + \nu_1 tonnage_i + \nu_2 membersize_i + \nu_3 years_i \\ & \sum_j \gamma_j (type_{ij} \times tonnage_i) + \sum_j \delta_j (type_{ij} \times membersize_i) + \sum_j \eta_j (type_{ij} \times years_i) \\ & \sum_l \kappa_l (TypeA_i \times regulations_{il}) + \varepsilon_i \end{aligned} \quad (2)$$

where $regulations_{il}$ denotes regulation l 's dummy variables, which equals 1 if implemented by an FMO i .

The estimation results of equation (2) are shown as Model 1 in Table 6. Results show that marketing employed by Type A FMOs has positive and statistically significant impacts on revenue per unit of effort. This suggests that marketing practices is likely to be effective in increasing the revenue if they are conducted under the effort coordination supported by the pooling arrangement. On the other hand, we find that harvest controls have negative and significant impacts. Harvest control often involves curtailing the harvest volume, which could then lead to the reduction of total revenue.

In the next estimation model, both marketing and harvest control were divided into their subcategories to investigate which of these subcategories were most influential (Model 2 in Table 6). Marketing variables includes quality control, new product development and branding. Harvest control variables includes total catch limit (or TAC), individual catch limit (or IQ), supply/landing volume control and size/age restrictions. Each of these subcategories was interacted with Type A FMO dummy variable.

There are several interesting results from Model 2. Firstly, none of the marketing sub-categories were significant. A plausible explanation could be that the success of marketing depends heavily on the product-type and market conditions on case-by-case basis, thus no specific marketing activities can be a silver bullet. The result with the aggregated marketing variable in Model 1, in return, implies that Type A FMOs are engaged in different

but most effective marketing activities given their market environment.

Table 6. Heteroskedasticity-robust OLS with interaction terms of Type A FMOs and other self-imposed regulations

Variables		Estimated Coefficient	
		Model 1	Model 2
FMO type ^a	Type A	2.059 (2.591)***	1.697 (1.847)*
	Type B	0.561 (0.599)	-0.363 (0.333)
	Type C	1.609 (1.396)	1.718 (1.100)
Species type ^b	Spiny lobster	0.141 (0.193)	0.459 (0.649)
	Abalone and turban shell	0.223 (0.501)	-0.581 (1.096)
	Scallop	1.954 (5.833)***	1.275 (2.250)**
	Asari-clam	0.161 (0.232)	-0.076 (0.089)
	Other migratory fish	-0.248 (0.620)	-0.649 (1.575)
	Other non-migratory fish	2.307 (3.535)***	1.575 (2.643)**
	Other sedentary species	2.063 (3.801)***	1.531 (2.274)**
FMO membership size		-0.003 (0.319)	-0.0001 (0.011)
Average vessel tonnage		0.184 (3.030)***	0.148 (2.220)**
Years since FMO establishment		-0.017 (0.170)	-0.002 (0.016)
Type A x membership size		-0.003 (0.385)	-0.001 (0.128)
Type A x tonnage		-0.200 (3.266)***	-0.156 (2.314)**
Type A x years		-0.054 (0.424)	0.041 (0.257)
Type B x membership size		0.030 (2.780)	0.024 (2.189)**
Type B x tonnage		-0.032 (0.384)	0.012 (0.136)
Type B x years		-0.272 (1.937)*	-0.162 (0.917)
Type C x membership size		0.017 (1.607)	0.017 (1.295)
Type C x tonnage		-0.966 (7.614)***	-0.965 (5.822)***
Type C x years		0.037 (0.262)	0.029 (0.150)
Type A x marketing		1.224 (2.104)**	
Type A x harvest control		-1.082 (2.179)**	
Type A x operation regulations		-0.199 (0.392)	
Type A x vessel regulations		0.448 (1.064)	
Type A x quality control			-0.666 (1.240)
Type A x new product development			0.964 (1.364)
Type A x branding products			-0.605 (1.167)
Type A x TAC			0.640 (1.153)
Type A x individual quota			1.365 (2.011)*
Type A x supply control			-0.508 (0.763)
Type A x size/age control			-0.811 (1.659)
Operation regulations			0.762 (1.296)
Vessel regulations			-0.064 (0.158)
Constant		-1.995 (3.372)***	-2.109 (2.067)**
Adjusted R ²		0.559	0.565
Number of observations		67	67

Notes: ^a, Type D FMO is set as the base FMO-type.

^b, Surf clam is set as the base species-type.

Absolute *t*-values in parenthesis. Significance levels are indicated by *** significant at 1%, ** 5%, and * 10%.

Secondly, results on harvest control subcategory variables show that individual quota (IQs) system has positive and significant impact on revenue per unit of effort. If the race to fish incentive prevailed prior to IQ being implemented, then with the IQ system the landing volume might have decreased, mitigating the flooding of the market and fetched higher price, leading to higher revenue per unit of effort. However, here we are examining the impact of these self-imposed regulations within the context of Type A FMOs, who has both effort coordination and pooling arrangements. Therefore, the incentive to race to fish is likely to be less intense, so this scenario is probably unlikely.

Alternative explanation is that IQs could be functioning as a “benchmark” 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 his fishing trip with a harvest volume far below his quota to an extent that it is beyond a reasonable daily fluctuations, that could be used as an indicator that he might have been shirking out in the sea. IQs can be used to replace physical peer monitoring among the members, which can be useful in fisheries where vessels are operating in a dispersed manner.

6. Conclusions

Using the survey data collected directly from a sample of FMO managers across Japan, we investigated whether FMOs with fishing effort coordination and pooling arrangements perform better than those without these management arrangements. Theoretically, effort coordination will convert the fishing operation from individualistic competition under the limited access environment to more sole owner-like operation. Pooling arrangements alter the incentives such that individual incentives are aligned with the group incentive, thereby further enhancing the possibility of sound and sustainable collective fishery management. However, whether and how that translates to higher economic returns, such as increased revenue, is an empirical question.

We estimate that a member of Type A FMOs (both effort coordination and pooling arrangement) earn significantly higher revenue per unit of effort than a member of Type D FMOs (none of the two implemented). Furthermore, in Model 1 Type C FMO (only pooling arrangement) members also earn higher revenues per unit of effort than Type D FMO members; such was not true for Type B FMO members (only with effort coordination). Although this might seem to suggest that pooling arrangements have larger influences on revenue than effort coordination, Type B and Type C were not significantly different from each other and Type C became insignificant in subsequent estimation models. Thus, our hypothesis that FMOs with either effort coordination or pooling arrangement perform better

than those without the two arrangements was not fully supported. However, the data supports our second hypothesis that FMOs with both perform better than those with only either one.

As a policy implication, does our result indicate that effort coordination and pooling arrangement are the essential ingredients, particularly so when put together, for successful fishery comanagement? We believe that is the case to a certain extent, but there are other conditions that are essential. In particular, effort coordination and pooling arrangements are still frameworks to act within their institutions and the question remains as to what actions do FMO members take with coordinated effort supported by pooling arrangements.

One answer this study suggests is that active-and well-coordinated?marketing activities enhance revenues in Type A FMOs. There are several ways to do this depending on the market conditions which the industries/communities face. If the fish they catch is well known by consumers (e.g., salmon) then an effective marketing strategy could be to pursue stringent quality control with the aim of differentiating locally caught fish in the market from those caught elsewhere. On the other hand, if the product itself is not well known in designated markets (e.g., Chilean sea bass a few years back) then promotion marketing can be effective. Taking this one step further, one might be able to create a new market by introducing new products. If these activities are sought in fisheries that are dominated by small-scale fishers, as was the case in most of the Japanese coastal fisheries, then they need to be carried out collectively to be effective. Thus, effort coordination and pooling arrangements become essential and complementary institutional frameworks.

Note that the dependent variable of our model was revenue per unit of effort, which was defined as revenue per FMO member per fishing hour. This means that even if the revenue per unit of effort is high, one's total (or annual) revenue level can still be low, or not enough to support a livelihood throughout the entire year. Effort coordination, particularly rotating fishing grounds and days, could mean that your turn to go out fishing comes only once in a while. Pooling arrangements will discourage one to go fishing under uncomfortable conditions, such as in bad weather. All of these result in fewer fishing days. Indeed, according to Table 2, the number of fishing days per year was much smaller for Type A, followed by Type C FMOs.

The possibility of fisheries being lucrative but unable to bring enough total revenues to support the livelihood of fishermen means that income from outside the managed fisheries can be critical for successful and sustainable fishery comanagement. This point was raised by many FMO managers and local researchers we interviewed. Such outside income sources include fisheries other than the managed ones, farming and non-primal industries sector jobs such as construction work.

This is not, of course, necessarily always the case. Like the case of the Pacific halibut fishery, 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 not be

of significant importance. The conclusion of this paper is thus that effort coordination and pooling arrangements may not be the most important, but certainly may be one of the important factors for successful fishery comanagement.

Acknowledgement

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Appendix: Regression diagnostics

One of the issues with mail survey is that the researcher does not have a full control on how the respondents respond to the questions, as opposed to face-to-face interviews. We made every effort to make important aspects of our questions explicit and comprehensible with wording and layout of the survey itself. Nonetheless, we still need to pay attention to possible measurement error of the data. As such, we devoted much time cleaning and checking the data for apparent inconsistencies. Beyond that there is little we can do without resorting to ad hoc methods, which is inappropriate. However, one would want to avoid the situation where small numbers of erroneous but undetected data outliers dominate the model estimates and predictions. For this reason we conducted a set of regression diagnostics to detect influential observations and outliers. The strategy we pursued was to look for such observations and then take closer looks at the data points to determine whether they are legitimately occurring outliers or erroneous data.

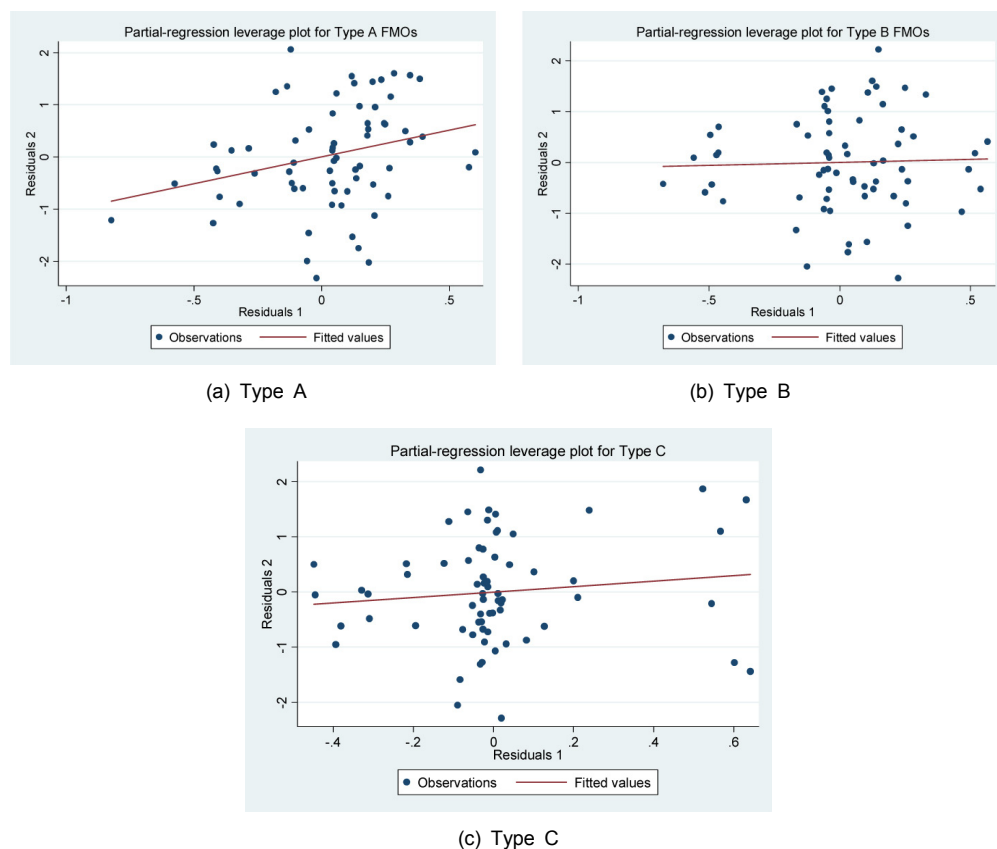


Figure 1. Partial regression leverage plots for variables Type A, B and Type C

Following Belsley, Kuh and Welsch (1980), we conducted diagnostics on two main issues: i) influential observations on estimated coefficients (the slope of fitted curve) and ii) normality assumption of the error term. For the first diagnostic, since the variables of our primary interest are FMO-types (A, B and C) we examined if there are any observations influencing disproportionately the estimated coefficients of these variables.

Partial regression leverage plots, which visually show the influential observations, are presented in Figure 1. The slope of fitted line represents the estimated coefficient for the respective variables. In panel b there are no apparent observations suspected of disproportionately influencing the slope of the fitted line. In panel a, an observation to the far left is suspected of pulling down the fitted line on that end, thus creating a significant and positive slope. In panel c, a data point at upper right-hand corner could be pooling up the fitted line on that end, thus creating a significant and positive slope. However, DFBETA statistics, which gives numerical values of an observation's influence on estimated coefficients, indicates that these particular observations were below the threshold level (i.e., the null hypothesis that this observation is not influential was not rejected). In fact, there was no incident where DFBETA statistics were above the threshold, thus none of the 67 observations in our model was statistically influential. The possibility of the existence of multivariate outliers were also tested and rejected.

The results from partial regression leverage plots and other statistics such as DFBETA suggest that there is no influential outlier in the regression sample, but clearly this does not imply that the data is error-free. However, with 67 observations-not large but certainly not small in statistical sense-we can assume that any bias will on average cancel out.

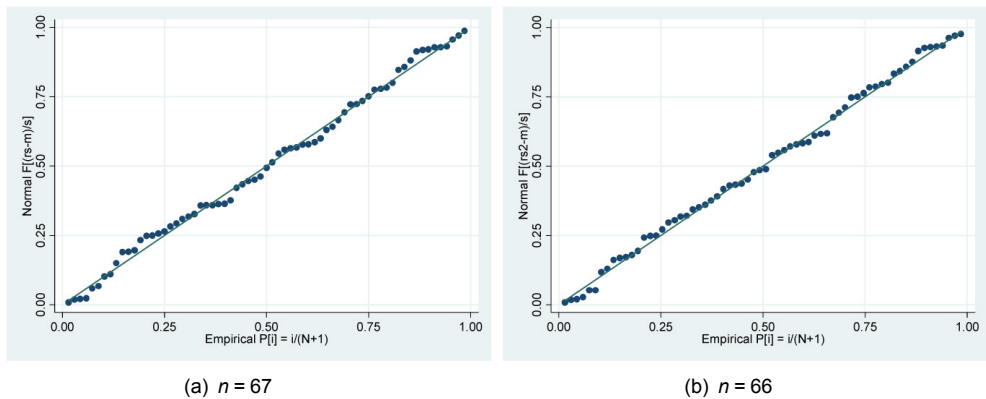


Figure 2. Normal probability plot

Normality assumptions of the error term in the model and thus the regression residuals, are critical in making inference of the regression results. A moderate departure from normality can impair estimation efficiency and the meaningfulness of standard hypoth-

esis tests. A commonly used method to detect such departures from normality is the normal probability plot, where observed cumulative probabilities of occurrence of the standardized residuals are plotted against the expected normal cumulative probabilities of occurrence. If the regression residuals are truly distributed normally, then the result will be the 45-degree line. Thus, departure from this line will indicate that normality assumption is violated.

Panel (a) in Figure 2 is the normal probability plot of our model using its full sample ($n = 67$). Plots are remarkably coincident with the 45-degree line. RSTUDENT statistics, based on the studentized regression residuals, indicate that there is one observation that is above the threshold level of normality assumption. Panel 2b is the normal probability plot after deleting this observation ($n = 66$). As expected, plots are closer to the 45-degree line indicating an enhanced validity of normality assumption.

Now that we have identified the observation that is adversely influencing the normality assumption, the question is whether we should delete it from our regression sample. Deleting observations is certainly a drastic measure and potentially can cause different bias and other issues and therefore one would want to avoid that decision whenever possible. The key is whether the outcomes regarding the variables of our interest are sensible to this single observation. For example, if the signs of estimated coefficients alternate or the significance levels fluctuate then we would have a problem. It turns out, however, that such was not the case. Qualitative results from regressions with and without this observation were identical. We thus decided to retain this observation because i) the departure from normality assumption is not severe (Figure 2) and ii) adverse consequence of even smaller sample size could be more substantial than the benefit of deleting one observation.

In sum, we concluded that our empirical model with its full 67 observations can be used confidently in making inference on estimation results.

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Global maritime transport and logistics: Recent developments and implications for Asian container ports

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ABSTRACT

Globalisation and transport revolution, logistics integration and the consequent expansion of port area and hinterland in the maritime industry have redefined the functional role of ports in global logistics and supply chains and have generated a new pattern of freight distribution. The rapidly increasing world trade in the last decade has brought about a new round of port (especially, container port) development and caused the restructuring of the world port network as well as more intensive inter-and intra-port competition. This phenomenon again requires a new approach towards port development and related planning. This paper aims at, in a holistic way, providing an overview of the recent developments in maritime transport and logistics in the global scale and discussing strategic implications for the container port industry in the Asian context.

Key words: global logistics and supply chain, container ports, strategic implications, Asia.

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1. Introduction

The role and importance of ports for international, national and local economies are well recognised and established in the literature. It has been viewed that an effective and efficient port raises the productivity of prime production factors, such as labour and capital and profitability of the producing units thereby permitting higher levels of output, income and employment (Walter, 1975). A port was (and still is) regarded as the springboard for economic development of the hinterland. On this basis much of the research and developmental emphasis has been on the ability of ports to carry out their functions of accommodating ships and other modes of transport effectively and efficiently. Contemporary developments in global transportation, logistics and supply chain, however, dictate that the emphasis should be placed on the ability of ports to fulfil a new role in the logistics and supply chain era in the context of integrated global supply chain systems.

Globalisation and transport revolution, logistics integration and the consequent expansion of port area and hinterland in the maritime industry have redefined the functional role of ports in global logistics and supply chains and have generated a new pattern of freight distribution. The rapidly increasing world trade in the last decade has brought about a new round of port (especially, container port) development and caused the restructuring of the world port network as well as more intensive inter- and intra-port competition. This phenomenon again requires a new approach towards port development and related planning. In addition, there have been dramatic changes in the mode of world trade and cargo transportation, characterised by the prevalence of business-to-business and integrated supply chains. In the port industry, these changes have been embodied by the increasing demand for value-added logistics services and the integration of various transportation modes such as inter-or multi-modal transport systems.

As a consequence, the business stability and sustainability of the industry is largely subject to how well it adapts to such ever-changing environment. Therefore, the high quality of logistics services and the effective and efficient integration of transport systems offered by a port have become an important issue. The world major ports have already regarded the trend as the key area to support their long-term vision. The trend does inevitably create a new dimension of competition. Bearing these developments in mind, this paper aims at, in a holistic manner, providing an overview of the recent developments in maritime transport and logistics in the global scale and discussing strategic implications for Asian container port industry.

2. Environmental forces for changes

As a starter, it would be useful to have a close look at what forces are pushing forwards the industry both within the sector and outside. These currently and likely influencing factors would be identified as illustrated in Figure 1.

On the *external* side, these include-increasing international trade volume, ever more globalised manufacturing and production sites, logistics and supply chain being even more complicated in order to reflect and accommodate the changes on the demand side, transport networks being greatly multi-faceted and other matters such as information communication and technology.

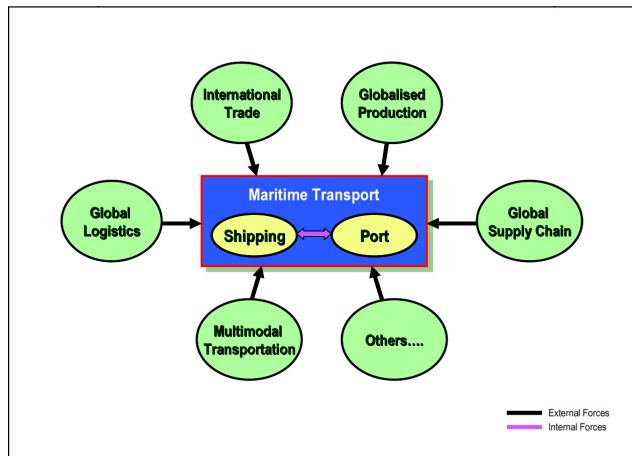


Figure 1. External and internal forces for changes

2.1 External factors

Almost all the external factors are stemmed from the currently ongoing globalisation as vividly described in a recent book by Friedman (2004). Trends derived from the globalisation include offshored production, outsourced businesses activities and/or functions (e.g., business-process-outsourcing), widely fragmented manufacturing settings over the world. These developments create a challenging task for a logistics and supply chain manager to cope with-that is, how to effectively and efficiently co-ordinate the scattered sites and settings over the globe.

In more detailed terms, global logistics and supply chain activities are equally outsourced to tackle the same trend in the manufacturing industry in a form of leanness and agility (Paixao and Marlows, 2003) and via third-party and fourth-party logistics providers (Coyle, Bardi and Langley, 2003). At the same time, they are required to be more

integrated and better operated, which could be feasible thanks to information communication and technology (Song and Panayides, 2008).

The fourth-party logistics providers (4PLs) as a potentially major player in the whole logistics sector in future expand their scope of businesses where shipping companies and port operators become merely sub-sector components. Whether or not the maritime sector establishes a successful linkage with other units under the logistics integrator would be the key point for its future competitiveness. This possible situation is illustrated in Figure 2.

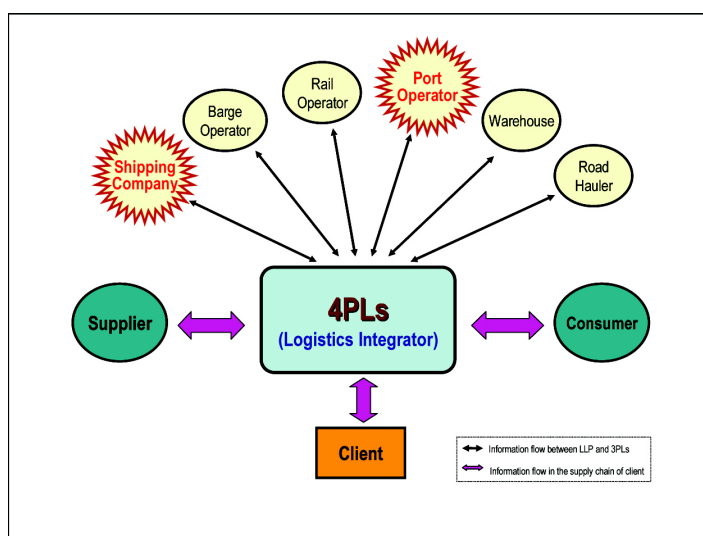


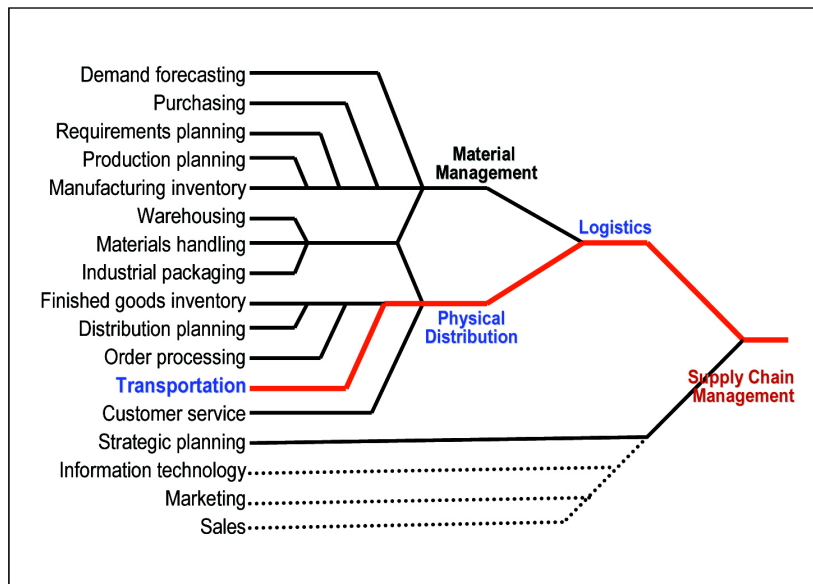
Figure 2. The 4PL as a logistics integrator

2.2 Internal factors

Before turning to internal factors, it would be suggested that maritime transport be examined as just a node of the whole supply chain systems. Figure 3 shows that transportation including maritime branch has evolved from a segmented component in the early stage of development to an element of the bigger and integrated supply chain systems. This development provides an insight into a fact that maritime transport including shipping and ports should be considered within the comprehensive picture of the whole chain on the global scale.

In respect of the *internal* factors in maritime transport, the sub-sectors-shipping and ports-evoke their own direction so as to hold a sort of internal hegemony. Shipping lines are keen to launching an ever bigger vessel-the biggest container ship currently in operation is 12,000 TEUs-to get an operational benefit from scale economies. It is, furthermore, estimated that an 18,000 TEUs vessel could be built from an engineering per-

spective, although its economic feasibility is still in doubt (Cullinane and Khan, 1999). Another effort made by (container) shipping lines is to penetrate into terminal operations in a form of dedicated terminals. APM, Hanjin, Evergreen and COSCO are just a few examples in this list. Finally, strategic alliances or other similar types of consortia become nowadays an industry norm (Song, 2003). All these developments being taken place in the shipping sector allow shipping companies to hold the greater bargaining power against its counterpart port operators.

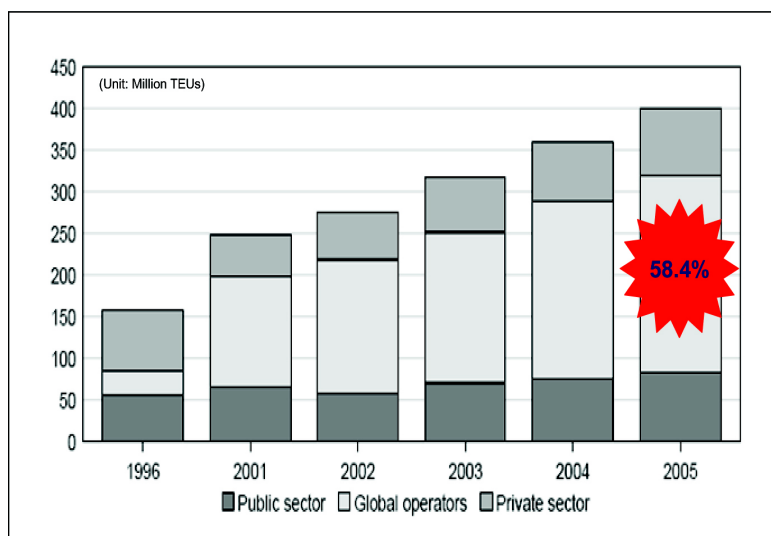


Source : Drawn from David (2004)

Figure 3. The evolution of logistics and supply chain

Responding to the trend and development on shipping, the port industry makes a number of efforts to sustain and obtain relative competitive edge. Their efforts include becoming more price competitive through internal arrangements, improving service quality with customers, expanding service range from the conventional boundaries, dealing effectively with shipping lines and globalising their business management and operations.

The world major players in terminal operations account for approximately 60 percent of the whole market, which is such a remarkable phenomenon that no other industry has the similar pattern. The top 5 operators (i.e. HPH, PSA, APM, DP World and Eurogate) take more than half of the market volume. Should top 10 operators be included, the portion becomes even bigger: a trend that the 20/80 business rule is no longer applicable to this industrial sector. It seems that the bigger takes almost all as indicated in Figure 4.



Source : Drewry Shipping Consultants (2006)

Figure 4. Market shares by global port operators

Table 1 shows terminals being managed and operated by these global operators. HPH and PSA puts their focus on Asia and Europe, while Eurogate, SSA and APM on European and American sides. However, DP World covers all the main continents in the world.

Table 1. Terminals operated by global terminal operators

TOCs	Europe	North America	Asia
HPH	Felixstowe, Rotterdam, Thames port, Harwich		Hong Kong, Shanghai, Yantian, Juizhou, Nanhai, Shantou, Jiangmen, Gaolan, Xiamen, Ningbo
PSA	Antwerp, Zeebrugge, Genoa, Venice, Shines		Singapore, Dalian, Nantong, Fuzhou, Tiancang
Eurogate	Bremen, Hamburg, La Spezia, Giaio Tauro, Lisbon		
SSA		Los Angeles, Log Beach, New Orleans, Oakland, Portland, Seattle	
P&O Ports (DP World)	Antwerp, Southampton, Tilbury, Cagliari	Baltimore, York, Portland, Norfolk, Miami, Gulfport, New Orleans, Lake Charles, Houston, Galveston, Freeport	Shekou, Qingdao
APM	Rotterdam, Bremen, Giaio Tauro, Algeciras, Aarhus	Tacoma, Oakland, Los Angeles, New York, Baltimore, Portsmouth, Charleston, Jacksonville, Port Everglades, Miami, New Orleans, Houston	Shekou, Qingdao

Source : Slack and Fremount (2005, p.120).

Given the discussion thus far, we could see that which side of the maritime transport-shipping or ports-would command or manoeuvre the subset market factors and forces under global logistics and supply chain systems.

Shipping sector seems to have an initiative or leading force while port sector endeavours to catch up with. Slack (1993) pointed out this odd situation of ports as a prawn in global transportation game. It can be claimed that shipping plays proactively while port does reactively, as implied in Figure 5.

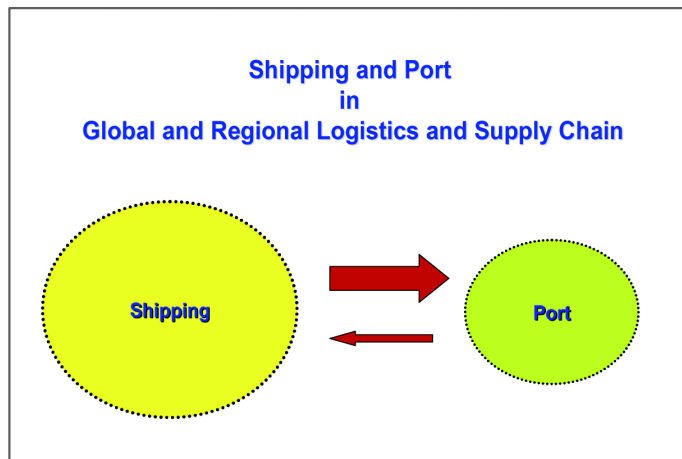


Figure 5. Hegemony between shipping and port

3. Possible strategic options from port operators

Traditionally port authorities played the role of facilitator, focusing on the provision of superstructure and infrastructure for ship operations, loading/unloading, temporary storage and intra-port operations. On this basis the bulk of research in the area has been on the efficiency and performance of seaports and container terminals (e.g. Cullinane, Song and Gray, 2002).

Today's ports play a rather different role as a member of a supply chain. In this role, the port is considered as part of a cluster of organisations in which different logistics and transport operators are involved in bringing value to the final consumers. In order to be successful, such channels need to achieve a higher degree of coordination and cooperation (DeSouza, Beresford and Pettit, 2003). The determination of the parameters that encompass the extent of integration of ports/terminals in global supply chains has, therefore, become of great importance for ports (Song and Panayides, 2008).

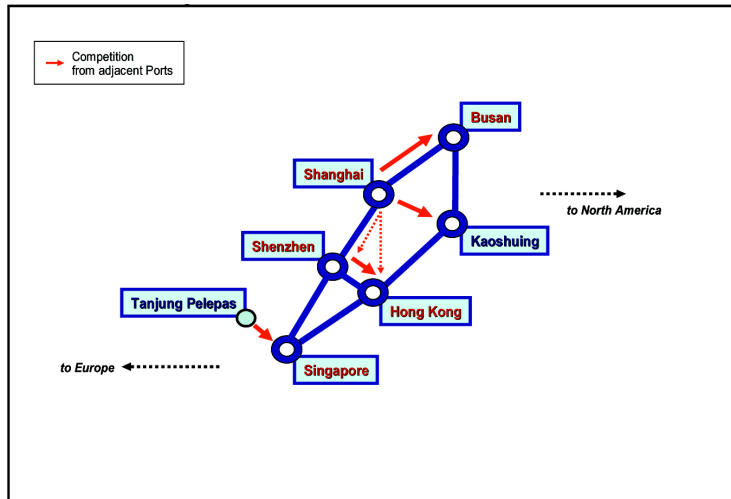
The recognition that ports are increasingly integrated in supply chains is well illus-

trated in the papers by Paixao and Marlow (2003), Marlow and Paixao (2003) and Bichou and Gray (2004). Paixao and Marlow (2003) and Marlow and Paixao (2003) introduce the logistics concepts of 'lean' and 'agile' operations as key factors in the measurement of port performance. It is therefore, implied that port performance depends to a large extent on logistics measures of cost and responsiveness. Bichou and Gray (2004) indicate that adopting a logistics approach to the measurement of port performance is beneficial to port efficiency because it directs port strategy towards relevant value-added logistics activities.

Furthermore, port operators need to gain 'knowledge' being required to respond to the changing business environments such as market-specific knowledge: organised and structured information about the market (Li and Calantone, 1998), or firm-specific knowledge: experience and expertise, essential know-how of organisations and organisational memory about practices or procedures (Bresman, Birkinshaw and Nobel, 1999). Knowledge management has argued that inter-organisational cooperation provides easy access to new knowledge that cannot be internally generated. Such an inter-organisational cooperation includes a number of forms of strategic alliances, joint ventures and social networks. However, as the former two forms limits the inter-organisational cooperation phenomena into dyadic rather than multiple relationships, Lee and Song (2007) show a way that port operators could get and accumulate knowledge-bases in the setting of multiple network relationships among operators. The effectiveness of knowledge acquisition may vary with the conditions of competition among the operators. If operators do not compete with each other to internally maximise their own benefits, they could not make the best possible decision to assess their relative strengths and weaknesses, estimate valuable information for their own requirements, choose appropriate knowledge and even use shared knowledge (Tsai, 2002).

Alliances and integrations among large shipping lines have facilitated the hub and spoke system among ports, which reflects another feature of port operators' network locally and regionally. As ports are facing increased levels of competition on an inter-regional basis regardless of extended hinterlands and even long-distance, the accessibility to large inland transport networks also has become an important strategic consideration.

As far as Asian ports are concerned, there exists a variety of efforts made by individual ports in the capacity of port authority and public, private or hybrid ownership forms of terminal operators having strong supports from local, regional and even central governments. The goal for which they are heading is to be a regional hub port with the wider coverage of immediate or even a bit remote hinterland.



Source : Updated from Song (2003)

Figure 6. Asian container port network

Figure 6 shows the latest status of competition among main regional ports. Apart from intra-port competition, the inter-port competition as highlighted in Figure 6 seems getting only severe in recent years. Shanghai becomes a major threat to all the surrounding ports especially, ports of Busan and Kaohsiung. Hong Kong and Singapore are interesting facing the similar fate-the competition from their adjacent Shenzhen and Tanjung Pelepas ports. However, their responsive approaches to this challenges look different-Hong Kong gears more on a co-operative way, while Singapore on a competitive manner. Kaohsiung and Busan have made a number of measures to stay in the league table, but their future looks not much brighter than expected.

4. Concluding remarks

This paper attempts to holistically view maritime transport as a subset of global logistics and supply chains. Its analysis is mainly descriptive rather than analytical in nature. However, the paper could suggest at least a few implications to be kept in mind for terminal operators, port management and authorities in making a strategic direction and development. These are: i) Maritime transport is subject to international trade and logistics chains, ii) Maritime business is therefore to be planned, managed and operated according to the changing pattern in international trade and logistics, iii) Larger and fewer players hold the ever-stronger market power. The rule of games is changed, iv) New and adoptable strategies are to continually be developed and implemented to remain competitive and sustainable, v) Successful integration into global supply chains is the key to their future businesses.

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Estimating technical efficiency of the coastal purse seines fishery using a stochastic frontier analysis

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ABSTRACT

This study analyzes the technical efficiency of the coastal purse seine fishery in Korea, using the stochastic frontier analysis (SFA). A Cobb-Douglas production function with inefficiency represented by a half-normal distribution was set up; and the output variable was the total production value and the input variables were physical production factors directly related to fishing activities of vessels, i.e. the numbers of tons, fishing days and crew size.

The average technical efficiency of the sample vessels, estimated by SFA, was 60%, which meant there was a relatively high degree of inefficient production in the vessels. The technical efficiencies for each vessel were observed to spread evenly over a wide range between 14% and 100%. In addition, there was statistically significant difference in the technical efficiencies by vessel size: the technical efficiency was highest in the vessels of 5 tons and more, followed by those of less than 3 tons and those of 3-5 tons.

Key words: technical efficiency, stochastic frontier analysis, coastal purse seine fishery, productivity

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1. Introduction

Technical efficiency is an important index to decide whether a specific firm is productive or profitable since it is to measure production efficiency derived from input and out factors of the firm. Comparison of efficiencies of firms enables each firm to examine and improve its management and to set up management strategies. In addition, technical efficiencies can be used to figure out the productivity level of firms of a single industry and to compare it with that of other nations, so that they would be critical data for formulating policies for industrial development. In particular, analysis of technical efficiencies is useful for assessing effects of policy regulations and/or systems and new technology development and application on firms.

Analysis of technical efficiencies has been applied for various industrial sectors such as banking, manufacturing and tourism businesses (Park, 2008; Kim *et al.*, 2007; Okeahalam, 2006). For the fishing industry, such as longline fishery of Hawaii (Sharma and Leung, 1999) and scallop fishery of the mid-Atlantic (Kirkley *et al.*, 1995), technical efficiencies were estimated. As the issue of fishing capacity management came to the fore across the world in the 2000s, methods to analyze technical efficiencies, as a way to measure a fishing capacity, have been domestically and internationally researched (FAO, 2004; Kim, 2006; Kirkley *et al.*, 2001).

As a method to estimate technical efficiencies, Data Envelopment Analysis (DEA), a non-parametric technique and Stochastic Frontier Analysis (SFA), a parametric technique, have been generally applied. DEA has the advantages that it does not require weights for input and output factors and can include a number of output factors in efficiency estimation. But it has shortcomings that measurement errors are included as a factor of inefficiency so that the degree of inefficiency can be exaggerated and that it is hard to statistically estimate and select input variables. On the other hand, SFA has some advantages that it is possible to verify statistically input variables, which, as a feature of parametric techniques, is difficult in DEA methods and that errors of measurement can be divided and estimated as random error and inefficiency.

The purpose of this study is to analyze technical efficiency of a coastal purse seine fishery in Korea, using the SFA. Considering the situation that recent changes in the domestic and international fisheries require the Korean government to set up various policies to stabilize, strengthen and restructure the coastal fisheries, the study is expected to present basic data and methodology for framing and implementing such policies. Chapter 2 introduces the SFA technique and data used for analysis; Chapter 3 shows results of the analysis; and the study ends in Chapter 4 with summary and conclusion.

2. Analytical method and data

2.1 Stochastic frontier analysis (SFA)

The stochastic frontier production function for cross-sectional data is defined as:

$$y_i = f(x_i; \beta) + v_i - u_i \quad (1)$$

where, y_i denotes the production of the i -th sample firm ($i = 1, 2, \dots, n$); x_i is a $(1 \times k)$ vector of functions of input quantities used by the i -th firm; β is a $(k \times 1)$ vector of parameters to be estimated; the v_i s are assumed to be independently and identically distributed $N(0, \sigma_v^2)$ random errors, independent of the u_i s are non-negative random variables, associated with technical inefficiency in production, which are assumed to be independently and identically distributed and truncations (at zero) of the normal distribution with mean, 0 and variance, σ_u^2 [$u_i \sim N^+(0, \sigma_u^2)$].

Assuming the half-normal distribution of the error term, where $\epsilon_i = v_i - u_i$, it satisfies the following conditions; (i) $v_i \sim iidN(0, \sigma_v^2)$ and it is called the symmetric error component; (ii) $u_i \sim iidN^+(0, \sigma_u^2)$, i.e. non-negative half-normal distribution and it is called the one-sided error component; and (iii) u_i and v_i are distributed independently of each other and of the regressors.

The density function of $u \geq 0$ and the density function of v are described as follows, respectively.

$$f(u) = \frac{1}{\sigma_u \sqrt{2\pi}} \cdot \exp\left(-\frac{u^2}{2\sigma_u^2}\right) \text{ and } f(v) = \frac{1}{\sigma_v \sqrt{2\pi}} \cdot \exp\left(-\frac{v^2}{2\sigma_v^2}\right) \quad (2)$$

Given the independence assumption, the joint density function of u and v is as follows.

$$f(u, v) = \frac{2}{2\pi\sigma_u\sigma_v} \cdot \exp\left(-\frac{u^2}{2\sigma_u^2} - \frac{v^2}{2\sigma_v^2}\right) \quad (3)$$

Since $\epsilon = v - u$, the marginal density function of ϵ is obtained as follows.

$$\begin{aligned} f(\epsilon) &= \int_0^\infty f(u, \epsilon) du = \frac{2}{\sqrt{2\pi}\sigma} \cdot \left(1 - \Phi\left(\frac{\epsilon\lambda}{\sigma}\right)\right) \cdot \exp\left(-\frac{\epsilon^2}{2\sigma^2}\right) \\ &= \frac{2}{\sigma} \cdot \phi\left(\frac{\epsilon}{\sigma}\right) \cdot \Phi\left(-\frac{\epsilon\lambda}{\sigma}\right) \end{aligned} \quad (4)$$

where, $\sigma = (\sigma_u^2 + \sigma_v^2)^{1/2}$, $\lambda = \sigma_u/\sigma_v$ and $\Phi(\cdot)$ and $\phi(\cdot)$ are the standard normal cumulative distribution and density functions.

The marginal density function $f(\epsilon)$ is asymmetrically distributed. Its respective mean and variance are as follows.

$$E(\epsilon) = -E(u) = -\sigma_u \sqrt{\frac{2}{\pi}} \quad \text{and} \quad V(\epsilon) = \frac{\pi-2}{\pi} \sigma_u^2 + \sigma_v^2 \quad (5)$$

Using equation (4), the log likelihood function for a sample of I firms is as follows.

$$\ln L = \text{constant} - I \ln \sigma + \sum_i \ln \Phi\left(-\frac{\epsilon_i \lambda}{\sigma}\right) - \frac{1}{2\sigma^2} \sum_i \epsilon_i^2 \quad (6)$$

The log likelihood function in equation (6) can be maximized with respect to the parameters to obtain maximum likelihood estimates of all parameters. These estimates are consistent as I approaches to infinity. In addition, the conditional distribution of u_i , given ϵ_i , is as follows.

$$f(u | \epsilon) = \frac{f(u, \epsilon)}{f(\epsilon)} = \frac{1}{\sqrt{2\pi}\sigma_*} \cdot \exp\left(-\frac{(u - \mu_*)^2}{2\sigma_*^2}\right) \Bigg/ \left(1 - \Phi\left(-\frac{\mu_*}{\sigma_*}\right)\right) \quad (7)$$

where $\mu_* = -\epsilon\sigma_u^2/\sigma^2$ and $\sigma_*^2 = \sigma_u^2\sigma_v^2/\sigma^2$. Since $f(u | \epsilon)$ is distributed as $N^+(\mu_*, \sigma_*^2)$, either the mean or the mode of this distribution can serve as a point estimator for u_i , which is defined respectively as follows.

$$E(u_i | \epsilon_i) = \mu_{*i} + \sigma_* \left(\frac{\phi(-\mu_{*i}/\sigma_*)}{1 - \Phi(-\mu_{*i}/\sigma_*)} \right) = \sigma_* \left(\frac{\phi(\epsilon_i \lambda / \sigma)}{1 - \Phi(\epsilon_i \lambda / \sigma)} - \left(\frac{\epsilon_i \lambda}{\sigma} \right) \right)$$

$$\text{and } M(u_i | \epsilon_i) = \begin{cases} -\epsilon_i \left(\frac{\sigma_u^2}{\sigma^2} \right) & \text{if } \epsilon_i \leq 0 \\ 0 & \text{otherwise} \end{cases} \quad (8)$$

Once point estimates of u_i are obtained, estimates of the technical efficiency of i -th firm (TE_i) can be obtained from the equation (9).

$$TE_i = \exp(-u_i) \quad (9)$$

In order to see how technical inefficiency influenced the production variances of the samples during the period, $\lambda = \sigma_u^2/\sigma_v^2$ is introduced. That is, when λ approaches to 0 (because of either $\sigma_v^2 \rightarrow \infty$ or $\sigma_u^2 \rightarrow 0$), the symmetric error component dominates the one-sided error in the determination of ϵ . On the other hand, as λ approaches infinity,

the one-sided error component dominates the symmetric error component in determining ϵ . It means that a large value of λ indicates a large portion of the production variance is attributed to the technical inefficiency error (σ_u^2) and vice versa (Kumbhakar and Lovell, 2000). The frontier production for i -th firm is computed as its actual production divided by its technical efficiency estimate.

2.2 Data

The coastal purse seine fishery is a sector of the fishing industry where non-power vessels or power vessels not exceeding 8 tons catch marine animals with purse seines or ring nets. The yearly production of the domestic coastal purse seine fishery was 130 tons in 1990 and increased continually to about 2,400 tons in 1998 and after that, showed a remarkable surge as nearly 8,000 tons in 2004. It reached the highest point of 16,000 tons (valued at 17.63 billion won) in 2008 thanks to the increase in production of anchovies and herrings.

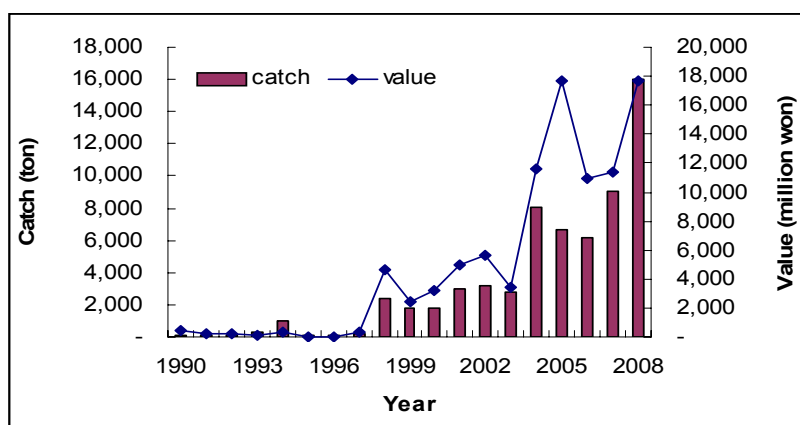


Figure 1. Changes in catch and values of coastal purse seine fishery (1990~2008)

In the average catches for the last 3 years (2006~2008) of coastal purse seine fishery, the fish produced in the largest amount was anchovies (59.8%), followed by herrings (24.0%), saurels (6.0%), gizzard shads (3.6%) and sauries (1.4%). And the fish with the highest monetary value in production was anchovies (61.2%), followed by gizzard shads (11.3%), herrings (9.6%) and saurels (3.7%).

For this study, the data of 275 fishing business units (vessels) of coastal purse seine fishery which had been collected as the samples for the 2005 fishing industry survey were used. The data of production value, instead of landings due to the data unavailability, were used as an output variable in analyzing technical efficiencies by SFA. Those business

units of coastal purse seine fishery had caught various fishes such as anchovy, herring and saurel, but the production values per fish were summed up and the full amount of values was used as an output variable. And the three input variables used in the analysis were physical production factors in direct relations with fishing activities of vessels, i.e. the numbers of tons, fishing days and employed people. Table 1 shows descriptive statistics of the used variables.

Table 1. Summary statistics for variables used in the efficiency analysis

Variable	Mean	Standard deviation	Minimum	Maximum
Production value (10 thousand won)	3,620.3	4,115.6	75	15,000
Trip days (day)	168.5	62.6	30	305
Tonnage (ton)	4.0	2.8	0.08	8.0
Employed people (number)	3.6	2.9	1	15

The average production value of the sample vessels for coastal purse seine fishery, which were figured out by summing up the production values of each fish, was nearly 36.20 million won and the deviation among the productions per vessel was found out to be quite large according to the numbers of fishing days and the scales of vessels. As for the input variables, the mean of the fishing days of the vessels was 169 days in a year, the mean tons of the vessels were 4 tons and the mean number of the people working in the vessels was surveyed to be 3.6.

3. Results

The form of production functions used in applying the SFA technique to coastal purse seine fishery was the Cobb-Douglas production function as shown in the following equation 10.

$$\ln sale_i = \alpha_0 + \alpha_1 \ln trip_i + \alpha_2 \ln ton_i + \alpha_3 \ln emp_i + v_i - u_i \quad (10)$$

In the function, i is the i -th vessel of the sample vessels; $sale$ is the output variable, a production value; and as the input variables, $trip$ is the number of fishing days, ton is the number of tons and emp is the number of employed working people; and v and u are the non-negative variables associated with the random error term and inefficiency

as said above.

The production function in the equation 10 according to the SFA method is estimated by Maximum Likelihood Estimation (MLE) and the variance is $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\lambda = \sigma_u / \sigma_v$. Table 2 shows the result of assuming the production function in the equation 10 by SFA.

Table 2. Parameter estimates of stochastic production frontier

Variables	Parameter	Coefficient	Standard-error
<i>Constant</i>	α_0	6.155***	0.834
<i>Intrip</i>	α_1	0.306**	0.147
<i>Inton</i>	α_2	0.361***	0.079
<i>Inemp</i>	α_3	0.398***	0.103
σ^2		1.962***	0.111
λ		1.401***	0.368
σ_u [$H_0: \sigma_u=0$]		4.550***	
Log(likelihood)		-405.912***	

Notes: **statistically significant at the 0.05 level. ***statistically significant at the 0.01 level.

As a result of analysis, the coefficients of parameters for all the variables were estimated to be statistically significant within the level of 5%; the sum (σ^2) of the error variances of the production function was found out to be statistically significant and of the error variances, the weight (λ) for the part described by technical inefficiency was analyzed to be statistically significant as 1.401. Therefore, the part of technical inefficiency in the error term of the assumed production function is important as to determine the degree and range of production of a vessel for coastal purse seine fishery.

In the log-log Cobb-Douglas production function, the coefficients of parameters mean the output elasticity of an input variable. The output elasticities of all the input variables were figured out to be positive numbers: the elasticity was highest (0.398) for the number of working people, followed by the number of tons (0.361) and the number of fishing days (0.306). The value of the returns to scale of the coastal purse seine fishery, for which the output elasticities of all the input variables were summed up, was 1.065. As a finding of the statistical verification for the null hypothesis ($\alpha_1 + \alpha_2 + \alpha_3 = 1$), it did not reject the null hypothesis, so the production of the coastal purse seine fishery was considered to have a constant returns to scale.

The average technical efficiency of the coastal purse seine fishery, estimated by SFA, was 0.60 (0.14~1.00), so inefficient production of the vessels was found to be quite high. It was, thus, thought that the productivity of coastal purse seine fishery would increase by a large number once efficient production gets realized by vessels. To be specific, Table 3 shows the estimates of the technical efficiencies for each vessel. The difference in the technical efficiencies was found out to be significantly large per vessel, based on the finding

that the number of the vessels with the technical efficiency being 1 was 46 (17%) and that of the vessels with the technical efficiency being more than 0.8 was 78 (28%), while that of the vessels with the technical efficiency being less than 0.5 was 107 (40%).

Table 3. Frequency distribution of technical efficiency (TE) from the SFA

Efficiency score	Number of vessels
< 0.30	46
0.30~0.40	28
0.40~0.50	33
0.50~0.60	35
0.60~0.70	29
0.70~0.80	26
0.80~0.90	23
0.90~1.00	9
1.00	46
Mean	0.60
Minimum	0.14
Maximum	1.00
Standard deviation	0.28

To obtain a specific range of technical efficiencies per vessel, the mean values of technical efficiencies for each scale of vessels were figured out and the difference in the technical efficiencies among the vessels of different scales was verified by analysis of variance (ANOVA). As shown in Table 4, the vessels were divided into those of less than 3 tons, 3 tons to less than 5 tons and 5 tons and more and the average technical efficiencies for each scale were estimated.

The average technical efficiency was highest in the vessels of 5 tons and more (0.648), followed by those of less than 3 tons (0.576) and those of 3 tons to less than 5 tons (0.562). As a result of ANOVA for the difference of technical efficiencies among the vessels of different scales, the difference was found out to be statistically significant at the level of 10%, so it was considered that there is difference in technical efficiencies of vessels according to vessel scales.

Table 4. Results of ANOVA analysis

Vessel tonnage	Sample size	Relative efficiency	Std. Dev.	F-statistics (p-value)
less than 3ton	122	0.576	0.282	2.457 (0.088)*
between 3ton and 5ton	61	0.562	0.255	
over 5 ton	92	0.648	0.280	

Notes : *statistically significant at the 0.10 level.

4. Summary and conclusions

In this study, technical efficiencies of coastal purse seine fishery in Korea were estimated by SFA. For the SFA method, the Cobb-Douglas production function where the inefficiency term is assumed to have a half-normal distribution was used; and the output variable was the total production value, for which production values of each fish were summed up and the input variables were physical production factors, i.e. the numbers of tons, fishing days and employed working people.

The average technical efficiency of the sample vessels for coastal purse seine fishery, estimated by SFA, was 60%, which meant there was a relatively high degree of inefficient production in the vessels. It was, thus, expected that productivity and profitability of coastal purse seine fishery would increase by a large number once efficient production gets realized by vessels. Based on the results of the analysis on technical efficiencies, the production of coastal purse seine fishery was estimated to increase by 36.6% at maximum if efficient production is made possible by vessels. The technical efficiencies for each vessel were observed to spread evenly over a wide range between 14% and 100%.

As a result of analyzing the difference in technical efficiencies among the vessels of different scales, there was statistically significant difference in the technical efficiencies according to vessel scales: the technical efficiency was highest in the vessels of 5 tons and more (0.648), followed by those of less than 3 tons (0.576) and those of 3 tons to less than 5 tons (0.562). Therefore, as shown in the output elasticities of the input variables, it was thought that enlargement of vessel scale would lead to increase in vessel productivity.

Since this study used data of a year in analyzing technical efficiencies of coastal purse seine fishery, it was impossible to present changes in technical efficiencies of coastal purse seine fishery with time. Therefore, the results of the study would have limitations in generalizing technical efficiencies of coastal purse seine fishery. It was, however, considered that the study is meaningful as a static analysis, in the sense that it was conducted to understand the present degree of technical efficiencies of coastal purse seine fishery and based on the understanding, suggested management strategies and policies for each vessel to improve in productivity and profitability.

Lastly, it is hoped that further research into related data and dynamic analyses on changes in technical efficiencies will enable us to take more useful management strategies and policies for improving productivity and profitability of coastal purse seine fishery.

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Assessment of effectiveness of improved fisheries management techniques

Seong-Kwae Park^{*}

ABSTRACT

The main objective of this research is to review Korean fisheries structural adjustment policy and to evaluate the resource status and fishing capacity in the Yellow Sea. The Korean authorities have for some time followed a structural adjustment policy in fisheries, largely focusing on buyback of fishing vessels. This policy appears to have a significant contribution to reducing the rate of fisheries resource decline and some fish species, such as squid, Spanish mackerel and Jack mackerel, show signs of recovery. Nevertheless, even though a large number of fishing vessels has been retired for the last 15 years, the effective fishing capacity(i.e. engine power) has tended to increase. Thus, increased engine power has to a certain extent replaced decommissioned vessels. This trade-off, often observed under buyback programs, has occurred because of lack of effective institutional arrangements.

In order to make the buyback policy more effective, the central and provincial governments need to develop an integrated policy including buyback, resource enhancement, off-fisheries income promotion, fuel subsidy reorientation and self (or co)-management programs. Also, the package program should be supported by a new R&D system that is focused on enhancing and maintaining the Yellow Sea's environment and ecosystem. This will require far closer cooperative work among South/North Korea, China, and related international bodies.

Key words: structural adjustment policy, fishing capacity, engine power, subsidy, ecosystem and the Yellow Sea.

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1. Introduction

Fishing communities in the west coast has been long involved in fisheries of the Yellow Sea and there have been keen competitions for fish stocks among Korea, China and Japan. Now, this Far Eastern region including these coastal states is the largest producer as well as the largest consumer of fish in the world (FAO FISHSTAT). However, they have never agreed upon creating any forms of joint Yellow Sea fisheries resource management.

Recently, bilateral fishery agreements were concluded among three states, based on the UN Convention on the Law of the Sea (Choi, 2000). Contracting the bilateral treaties, since the late 1990s Korea began to facilitate its fisheries structural adjustment policy, focusing on fisheries resource restoration and conservation. The primary instrument is buyback programs of reducing fishing capacity (Shin *et al.*, 2001). Many fisheries experts agree that so far the buyback programs have made a significant contribution to lowering the rate of resource decline in the entire Korean waters but the programs are not yet sufficient to allow full recovery of resource stocks to the optimal levels (i.e. MSY). Thus, many fishing communities/fisheries (especially fisheries dependent on bottom fishery resources) are facing serious economic hardship.

The entire Yellow Sea of the Korean peninsula is a single vast continental shelf and one of the most productive fishing grounds in the world. Since however the Yellow Sea is a semi-closed sea, its ocean ecosystems are known to be very sensitive and vulnerable to external shocks such as overexploitation, pollution and climate change (Park, 2009). For the last three decades the Yellow Sea has suffered from severe overexploitation and pollution problems. Overexploitation has been much more intensified by fishing capacity expansion of Korean and China (Hong, 2007). Ocean pollution also has been getting worse than ever before and in recent years. And climate change seems to add much more to such problems than any other factors (Park, 2009).

In this context, the main objectives of this research are to review Korean fisheries structural adjustment policy, to develop and estimate an analytical model for evaluating the fishery resource status and fishing capacity of the Yellow Sea and to draw some policy implications based on the research results.

2. Structural adjustment policy: Buyback programs

2.1. Goal and background

The main goal of Korean fisheries structural adjustment policy is to promote their productivity, competitiveness and sustainability by reducing the current fishing capacity to a level that is appropriate to fishery resource stocks. There are by and large three reasons that Korean government started the fisheries structural adjustment policy(Kim *et al.*, 2006). First, there has been a continuous decline of fisheries resources over time since the mid 1970s in entire Korean waters. Such problem began to get much more serious since early 1990s.

Second, Korean fisheries have begun to face the trade liberalization since 1984. Starting of World Trade Organization(WTO) and expansion of free trade agreements provided a momentum for facilitating to open Korean fish market to the international community. Third, the bilateral fisheries agreements among Korea, Japan and China made narrow Korean adjacent fishing grounds and limited much Korean fishing freedom in the Far East region. This resulted in overcapacity and thus keener competition among on-and off-shore fishing vessels on the entire Korean waters and led to beginning buyback programs.

2.2. Process

A research on fisheries resource stock assessment showed that fishing capacity exceeded the optimal level by 23~53%(Korea Rural Economic Institute, 1992). The first general buyback program was launched in 1993, based on a survey & research for fisheries structural adjustment (buyback programs) and the buyback programs started with a legal base in 1994(i.e. Special Law of Dealing with Agricultural and Fishing Village Problems, 1990).

There are two types of buyback programs: one is the general buyback program and the other is the international buyback program. The general buyback priority in 1994~2007 was placed on on-shore fishing boats(i.e. on-shore stow net on anchors, gape net with wings, etc : 1,175 boats) which use very small mesh nets and the off-shore fishing vessels(i.e. large purse seine, large otter trawl, etc) which most affect fishery resources. The international buyback program started to alleviate off-shore fisheries' economic hardship due to Korea-Japan(1999) and Korea-China Fisheries(2001) Agreements. In order to deal with such fishermen's difficulty, the government has legislated "Special Law for Fishermen's Aid and Fisheries Development Due to the Bilateral Fisheries Agreements (Choi, 1999, 2002)."

2.3. Implementation/delivery system/main bodies

The main bodies of the program are comprised of i) Ministry for Food, Agriculture, Forestry and Fisheries(MIFAFF), ii) metropolitan city mayor/province governor (non-metropolitan city/county/guchung chief), iii) fisherman, iv) legal persons of appraisal and evaluation and v) fisheries-loss-evaluation organization (designated universities, etc.). Implementation and delivery system is as follows (Fig. 1).

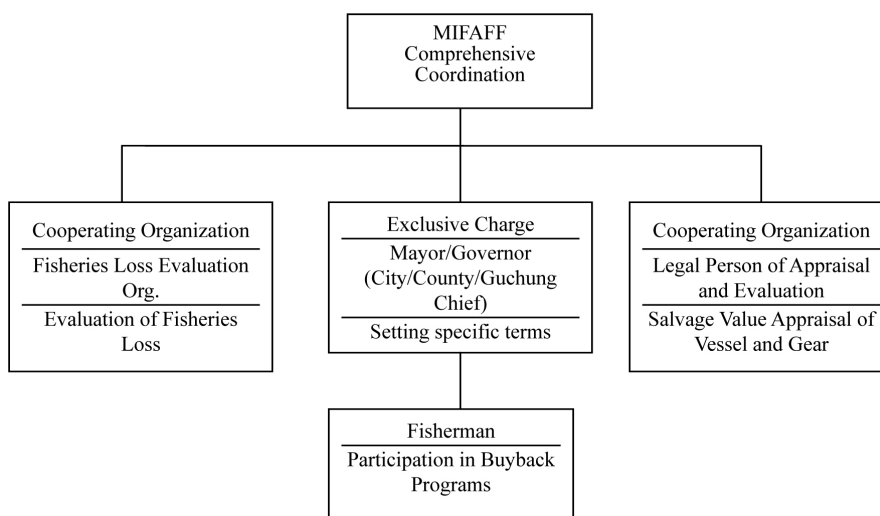


Figure 1. Implementation/delivery system/main bodies

2.4. Target fisheries and interest groups

The buyback program targeted the on-and off-shore fishing vessels, which have relatively large impact on fishery resources and low competitiveness due to change in domestic/international environment or lowered average productivity(or catch (mt) per vessel). During the period from 1995 to 1997, the number of off-shore fisheries vessels was reduced to 59,176 from 42,331. However, horse power(HP) per vessel increased to 481 from 381.

Policy target fisheries include eight on-shore fisheries. Priority is placed on the order of purse seine, gill net, trap, composite fisheries and stow net on boat/on anchor. Lift net is possible to apply to the buyback program as subsidiary fisheries. During the period from, 2005 to 2006, the buyback program was not applied to off-shore fishing vessels (Kim *et al.*, 2006). However, in 2007, 84 vessels of off-shore fisheries were retired because of foreign regulation, fishing disputes and overexploitation nature. Now, the government has a plan to reduce 30%(1,050 vessels) of the entire off-shore fishing capacity(Kim *et al.*, 2006).

There are indirect targets and other interest groups in relation to the buyback program. They include the fishermen who did not participate in the fisheries structural adjustment programs: fishermen who engage in fisheries with license, except for fishermen with on- and off-shore fishing permits(articles 27 and 28 of enforcement regulations of fishery law), fishermen who engage in report fisheries and the crews who are discharged from the retired fishing vessels.

2.5. Fishing vessel reduction through the buyback programs

During the period from 1994 to 2007 the buyback programs have been implemented in two ways: one was a general buyback program and the other was an international one. In the first year(1994) of the program 54 vessels were decommissioned and 730 boats in 1999 were reduced in a large scale under both of the general and the international buyback programs.

Since, however, the law regarding the international buyback program was legislated to deal with the fisheries problems dictated by the Korea-Japan(1999) and the Korea-China (2001) fisheries agreement, the international buyback program was placed for the limited period from 1999 to 2002. The total number of fishing vessels reduced in 1994~2007 was 8,324(on-shore 6,357 and off-shore 1,967) and the public fund of 1,067 billion Korean won was used for decommissioning the boats(Department of Fisheries Policy).

3. Assessments of resource stocks and fishing efforts

3.1 Assessment model: Surplus production model

Surplus production models are relatively simple and most widely used for resource evaluation. There are three models(i.e. Schaefer, 1954, Fox, 1970, Pella-Tomlinson, 1969) that require minimum data set. The concept of surplus production is as follows:

$$S_{t+1} = S_t + R_t + G_t - FM_t - NM_t$$

Where S_{t+1} =next year stock, S_t =current year stock, R_t =recruitment, G_t =body growth, FM_t =fishing mortality, NM_t =natural mortality.

If there is no catch in current year, $S_{t+1} = S_t + R_t + G_t - NM_t - NM_t$. Here, an increase in stock is $R_t + G_t$. Surplus production is $R_t + G_t - NM_t$. Thus, next year stock is current year stock + surplus production-natural mortality. That is, $S_{t+1} = S_t + R_t + G_t - NM_t$.

The simplest and perhaps the most useful example is obtained when $r(B) \rightarrow r(1 - \frac{B}{K})$

(r =net proportional growth rate of the population, B =population size (kg or M/T), K =environmental carrying capacity), so that $\frac{dB}{dt}=r(B) \cdot B$ becomes $\frac{dB}{dt}=r(B) \left(1 - \frac{B}{K}\right)$. This is the famous logistic equation, first proposed as population model by P. F. Verhulst (1983). Expressing this equation as a discrete function, the following is obtained.

$$B_{t+1} = B_t + rB_t \left(1 - \frac{B_t}{K}\right)$$

Adding catch element to the equation above, the standard biomass-dynamic model, that is, Schaefer surplus production model is obtained where Y_t =harvest, q =catchability coefficient and f =fishing effort

$$B_{t+1} = B_t + rB_t \left(1 - \frac{B_t}{K}\right) - Y_t$$

$$Y_t = qfB_t$$

Denoting that $F(B)=rB_t \left(1 - \frac{B_t}{K}\right)$, if $F(B) > Y_t$, the population size would increase. In case $F(B) < Y_t$, the population size would decline. The reference point necessary for resource management can be derived from the Schaefer model where MSY is maximum sustainable yield, B_{MSY} is biomass(e.g. M/T) at MSY and E_{MSY} is fishing effort at MSY .

$$MSY = rK/4$$

$$B_{MSY} = K/2$$

$$E_{MSY} = r/2q$$

With two time series data of catch and fishing effort, the Schaefer model parameters and the reference points are obtained.

$$U = (a + b \cdot E), \quad Y = (a + b \cdot E) \cdot E,$$

$$MSY = -\frac{a^2}{4b},$$

$$E_{MSY} = -\frac{a}{2b}$$

where a and b are parameters, U is catch per unit effort, E is fishing effort and Y is catch or production.

Another surplus production model is Fox model(1970), developed based on Gompertz growth model.. $B_{t+1} = B_t + rB_t \left(1 - \frac{\ln B_t}{\ln k}\right) - Y_t$. The following reference points for resource management are derived from the Fox model.

With two time series data of catch and fishing effort, the Fox model parameters and the reference points are obtained as follows.

$$U = (ae(b \cdot E)), Y = (a \cdot \exp(b \cdot E)) \cdot E,$$

$$MSY = -\frac{\exp(a-1)}{b}, \text{ and}$$

$$E_{MSY} = -\frac{1}{b}.$$

3.2 Management reference points

There are several management reference points(i.e. reference point RP, target reference point TRP and limit reference point LRP) as indices. Management reference points that can be estimated by using the models above include MSY , F_{MSY} , $2/3 MSY$, $2/3 F_{MSY}$, $F_{0.1}$, etc. Because the reference point($2/3 F_{MSY}$), that Doubleday(1976) suggested, may add much to reducing risk and uncertainty that are accompanied by inaccuracy or lack of data, F_{MSY} (or F_{MSY}) and $2/3 F_{MSY}$ (or $2/3 F_{MSY}$) were used in this research.

3.3 Presentation of the resource status

Recently, traffic light display methods are used to visualize the fisheries resource status(Caddy, 1999, Caddy, 2002, ICCAT, 2008). The display method classifies the resource status into three stages and colors: green is safe, yellow is middle and red is risky. This method is to visually evaluate the resource status by the traffic light colors. This research employed the display method that ICCAT uses widely: from the resource stock's perspective, "red is overexploited" and "green is non-overexploited"; from the fishing effort's perspective, "red is overcapacity" and "green is non-overcapacity." For both of the relative stock and the relative fishing effort, "upper yellow is non-overexploited/non-overcapacity" and "lower yellow is overexploited/non-overcapacity"(Fig. 2)."

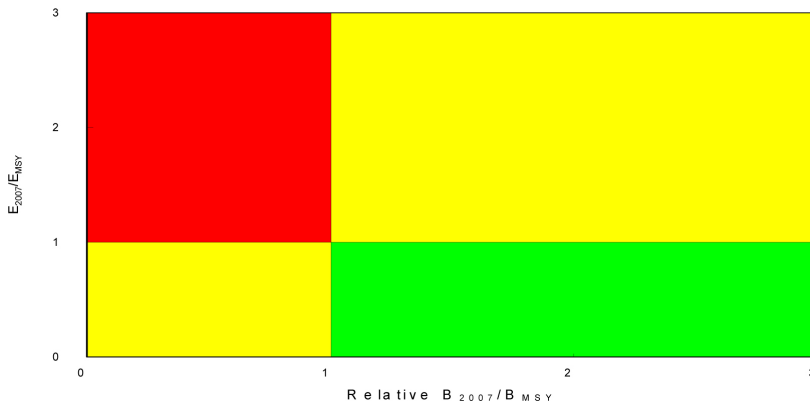


Figure 2. Distribution of relationship between B-ratio and E-ratio

3.4 Estimation of relative fishing efforts by species and estimation of management reference points by region and by species

Assessment of resource management reference points is made, including all marine zones and all kinds of fisheries. In this case were chosen the typical fisheries of exploiting major target species and the CPUE(catch per unit effort) by species were calculated, based on their horse power. Relative total fishing efforts necessary for estimating the model parameters for each species were calculated, dividing the total catch of each species by the CPUEs of the typical fisheries. Overall MSY (maximum sustainable yield) and RP are estimated by the following formulas where RP is the reference point of species r_i , cr_i is the contribution ratio of species or fishery to total catch and w_i is the by-species catch ratio of marine zone or fishery.

$$\begin{aligned}\text{Overall } MSY &= \sum cr_i \cdot MSY_i \\ \text{Overall } RP &= \sum w_i \cdot RP_i\end{aligned}$$

3.5 Data sources and geography of the Yellow Sea

The assessment and analysis used the data that collected from several government sources: National Statistical Office(catch volume), National Fisheries R&D Institute(catch by region and by marine zone) and Ministry of Food, Agriculture, Fisheries and Forestry (fishing efforts by fishery: horse power).

The Yellow Sea area is defined in this research as follows: the sea area north of the line connecting west edge of Jindo, west edge of Jeju-do and the mouth of Yangtze river(excluding Bohai and Korea bays). Since catch data in the Yellow Sea is not available, the catch volumes by region and by fishery were estimated based on the catch data of Korea National Statistical Office(NSO) and the data(by fishery/marine zone) of National R&D Institute(NFRDI). Since, however, the catch data by marine zone for off-shore fisheries is not available and neither is the catch data of some on-shore fisheries, the NSO catch volumes of Incheon city, Kyonggi-do, Chungnam-do, Jeonbuk-do and Jeonnam-do were included in the analysis. In case of Jeonnam, it is presumed that 50% of its production is exploited in the Yellow Sea.

Regarding the off-shore fisheries(i.e. large purse seine, squid angling, large pair trawl, large Danish seine, large otter trawl and west southern pair trawl) that operate over the entire fishing grounds, their catches in the Yellow Sea were separated from their total catches and the Yellow Sea catch proportions were calculated, based on the catch data (by marine zone) of NFRDI. Then the total catch by species in the Yellow Sea was recalculated, based on the estimated marine zone catch data.

3.6 Stock assessments by major species in the Yellow Sea

3.6.1 Hair tail (or Ribbon fish)

Stock assessment in this research covers ten major fish species that have been caught in the Yellow Sea. In 2007 the Yellow Sea's contribution to total Korean hair tail catch in the entire Korea waters(*cr*) accounted for 8.1% and its relative weight of total Yellow Sea's catch of all species(*w*) was 1.82%. Hair tail stock status, based on the resource management criterion(B_{2007}/B_{MSY}) was estimated 0.7 that show overexploitation. In terms of fishing effort or capacity, the ratio of B_{2007}/B_{MSY} was estimated 0.9 which is not in overcapacity but in risk(Fig. 3).

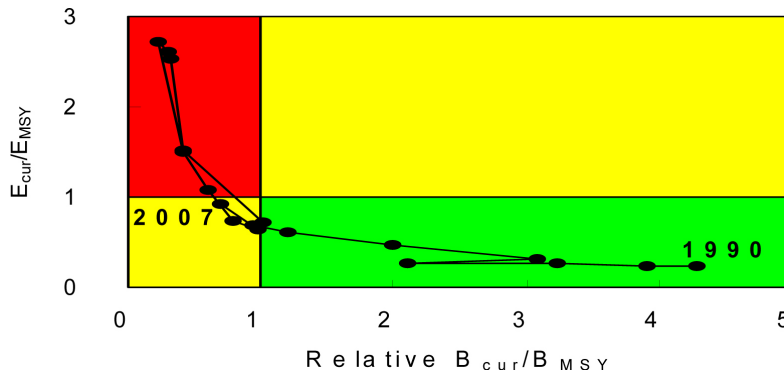


Figure 3. Stock status of hair tail in the Yellow Sea

3.6.2 Yellow croaker

The Yellow Sea's relative share of yellow croaker catch (*cr*) in 2007 held 27.0% and its relative weight of total Yellow Sea's catch of all species(*w*) was 3.2%. The yellow

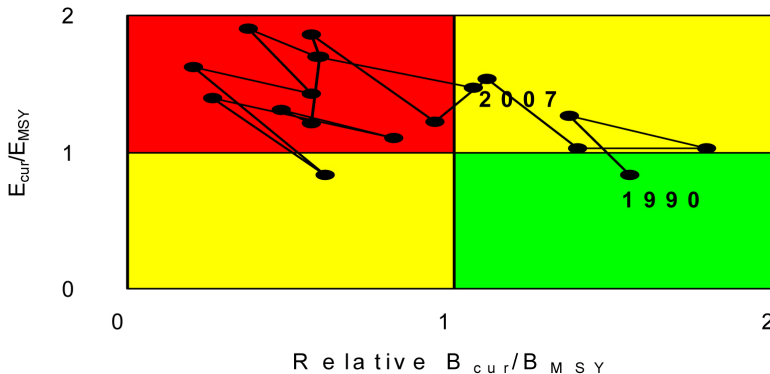


Figure 4. Stock of catch for yellow croaker in the Yellow Sea

croaker stock status, based on the resource management criterion(B_{2007}/B_{MSY}) was estimated 1.07 that implies non-overexploitation. In terms of fishing effort or capacity, the ratio of was estimated at 1.47 which implies overcapacity(Fig. 4).

3.6.3 Chub mackerel

The Yellow Sea's relative contribution(cr) was 52.2% in 2007 and its relative weight of total Yellow Sea's catch of all species(w) was 25.6%. Korean chub mackerel stock status, based on the resource management criterion(B_{2007}/B_{MSY}) was estimated 1.06 that implies a good resource status. In terms of fishing effort or capacity, the ratio of B_{2007}/B_{MSY} was 0.92 which is not in overcapacity(Fig. 5).

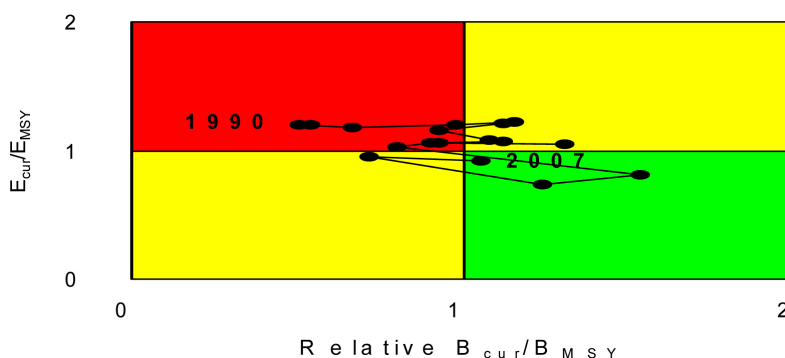


Figure 5. Stock of catch for chub mackerel in the Yellow Sea

3.6.4 Anchovy

The anchovy production in the Yellow Sea has been maintained at a high level for the last two decades. The Yellow Sea's relative contribution anchovy(cr) in 2007 occu

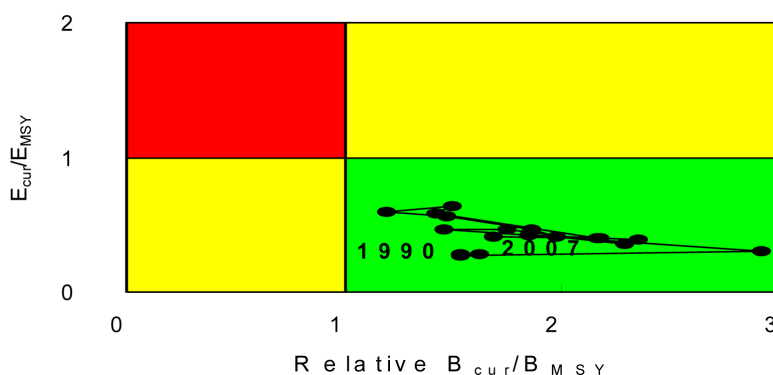


Figure 6. Stock of catch for anchovy in the Yellow Sea

ped 16.3% and its relative weight of total Yellow Sea's catch of all species(w) took 12.3%. The anchovy stock status, based on the resource management criterion(B_{2007}/B_{MSY}) was estimated 1.85 that implies a good resource status. In terms of fishing effort or capacity, the ratio of B_{2007}/B_{MSY} was 0.42 which is not in overcapacity(Fig. 6).

3.6.7 Blue crab

Blue crab catch has shown an increasing trend. The Yellow Sea's relative share of blue crab catch(cr) was 91.4% in 2007 and its relative weight of total Yellow Sea's catch of all species(w) accounted for 4.24%. The blue crab stock status, based on the resource management criterion(B_{2007}/B_{MSY}) was estimated 0.32 that implies overexploitation. In terms of fishing effort or capacity, the ratio of B_{2007}/B_{MSY} was 2.75 which indicate overcapacity(Fig. 7).

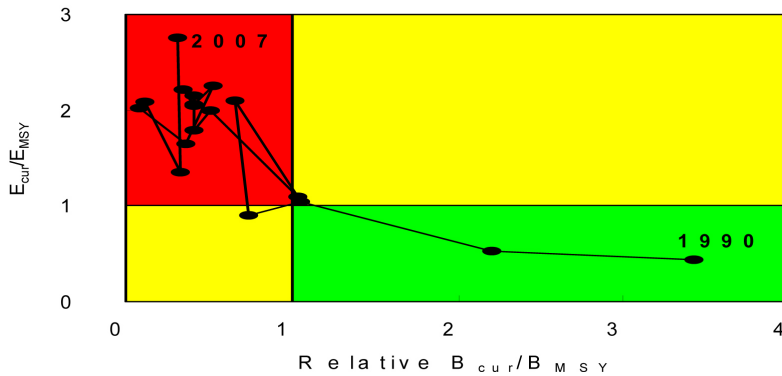


Figure 7. Stock of catch for common squid in the Yellow Sea

3.6.8 Common squid

Common squid production has shown an increasing trend since 2005.

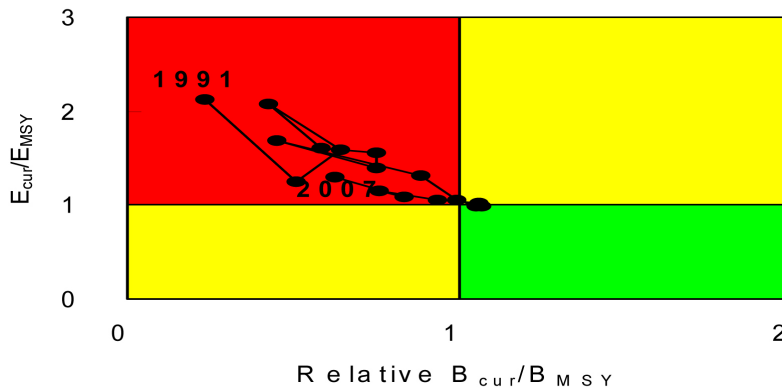


Figure 8. Stock of catch for common squid in the Yellow Sea

In 2007 Common squid catch in the Yellow Sea contributed 5.58%(cr) to total Korean squid production and its relative weight of total Yellow Sea's catch of all species(w) was 3.48%. The common squid stock status, based on the resource management criterion (B_{2007}/B_{MSY}) was estimated 0.63 that implies overexploitation. In terms of fishing effort or capacity, the ratio of B_{2007}/B_{MSY} was 1.29 which indicate overcapacity(Fig. 8).

3.6.9 Sea bass

Sea bass catch has shown a decreasing trend since 2007. The Yellow Sea's contribution(cr) in 2007 accounted for 28.5% and its relative weight of total Yellow Sea's catch of all species(w) was 1.21%. The sea bass stock status, based on the resource management criterion(B_{2007}/B_{MSY}) was estimated 1.71 that implies non-overexploitation. In terms of fishing effort or capacity, the ratio of B_{2007}/B_{MSY} was 0.15 which indicate non-over-capacity(Fig. 9).

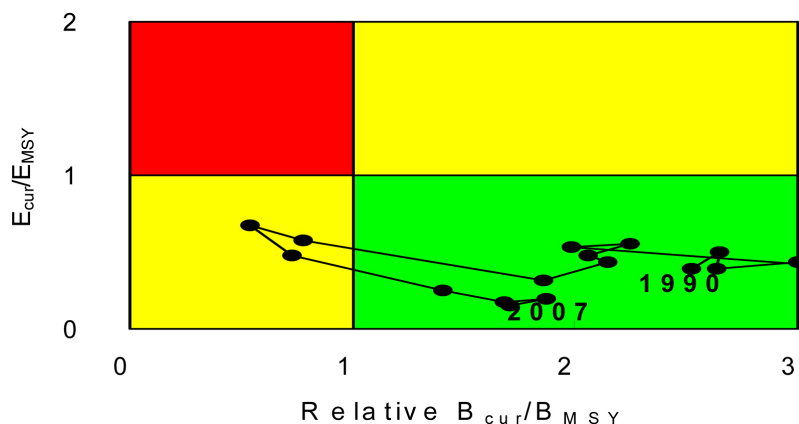


Figure 9. Stock of catch for sea bass in the Yellow Sea

3.6.10 Pomfrets

The Yellow Sea's relative share of pomfrets catch(cr) in 2007 held 0.93% and its relative weight of total Yellow Sea's catch of all species(w) was 28.9%. The pomfret stock status, based on the resource management criterion(B_{2007}/B_{MSY}) was estimated 0.73 that implies non-overexploitation. In terms of fishing effort or capacity, the ratio of B_{2007}/B_{MSY} was 1.25 which indicate a good status of the stock(Fig. 10).

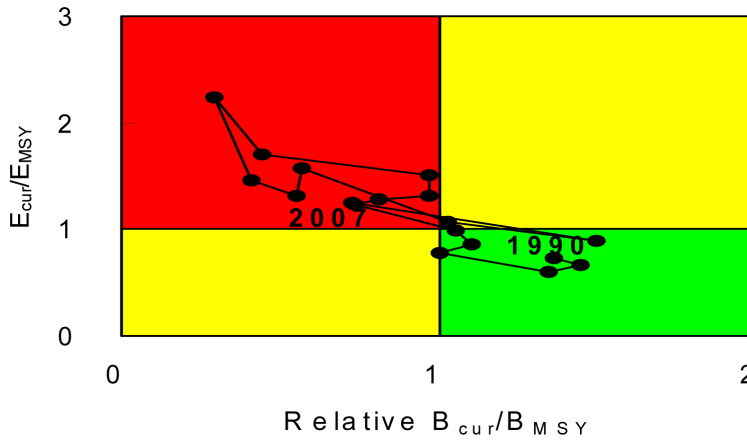


Figure 10. Stock of catch for pomfrets in the Yellow Sea

3.6.11 Monkfish

The Yellow Sea's relative catch of monkfish(cr) in 2007 occupied 16.5% and its relative weight of total Yellow Sea's catch of all species(w) was 0.81%. The monkfish status, based on the resource management criterion(B_{2007}/B_{MSY}) was estimated 2.53 that implies non-overexploitation. In terms of fishing effort or capacity, the ratio of B_{2007}/B_{MSY} was 0.73 which indicate non-overcapacity(Fig. 11).

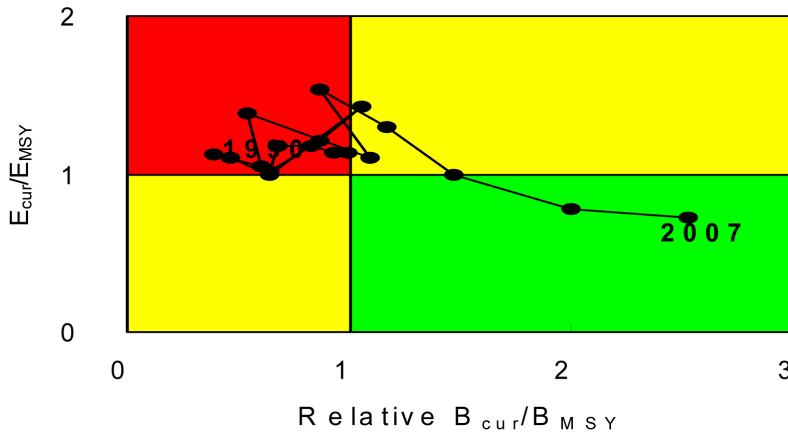


Figure 11. Stock of catch for monkfish in the Yellow Sea

3.6.12 Brown croaker

The Yellow Sea's contribution to total brown croaker catch(cr) accounted for 28.4% in 2007 and its relative weight of total Yellow Sea's catch of all species(w) was

0.29%. The brown croaker status, based on the resource management criterion (B_{2007}/B_{MSY}) was estimated 0.64 that implies overexploitation. Regarding fishing effort or capacity, the ratio of B_{2007}/B_{MSY} was 1.27 which indicate overcapacity (Fig. 12).

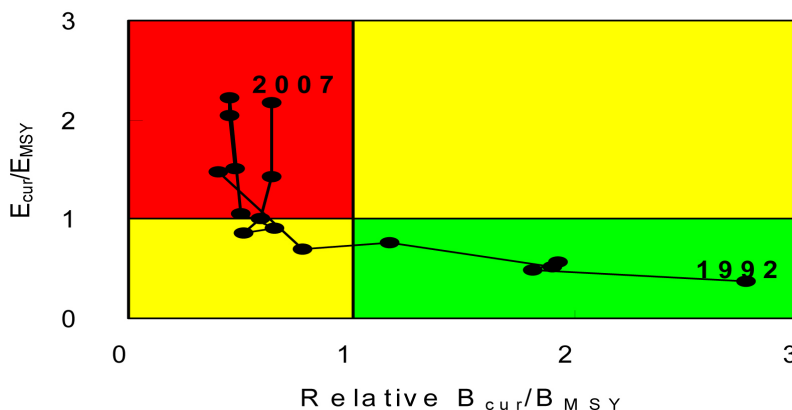


Figure 12. Stock of catch for brown croaker in the Yellow Sea

3.7 Resource utilization assessment by major fisheries in the Yellow Sea

3.7.1 Large pair trawl (LPT)

Major target species of the LPT are Spanish mackerels, sea bass, hair tail, anchovy and pomfrets. Evaluating the resource status of these species by the multi-species approach, the relative fishing effort E_{2007}/E_{MSY} was 0.63, implying that large pair trawls in the Yellow Sea do not have yet overcapacity problem (Fig. 13, Table 1).

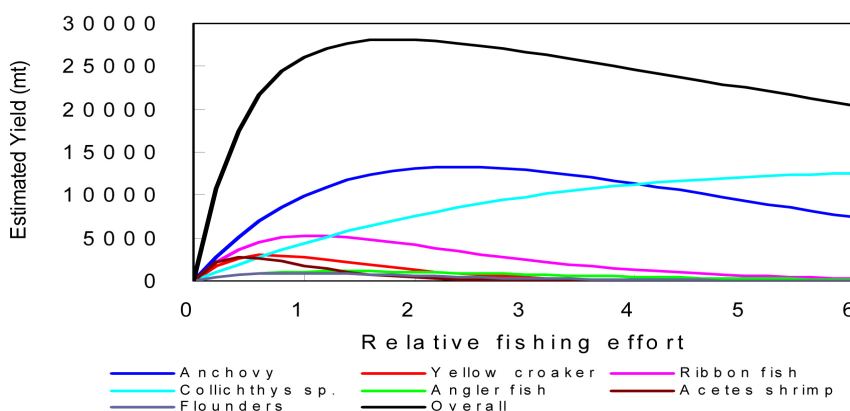


Figure 13. Multi-species equilibrium yield obtained from Fox's surplus production model for LPT in the Yellow Sea from 1990 to 2007.

Table 1. Status of stock utilization of LPT in the Yellow Sea

Species	Catch in 2007 (mt)	Percentage of species (wi, %)	Contribution rate (cr, %)	E_{07}/E_{MSY}	$2/3E_{MSY}/E_{05-07}$ (%)	E_{MSY}/E_{05-07} (%)
Overall	16,505	100.00	1.43	0.63	80.4	94.3
Spanish mackerel	4,037	24.46	9.57	0.99	77.0	100.0
Sea bass	2,575	15.60	18.63	0.15	100.0	100.0
Hair tail	2,130	12.91	3.23	0.92	86.6	100.0
Yellow croaker	1,644	9.96	4.80	1.47	39.4	59.1
Anchovy	1,522	9.22	0.69	0.42	100.0	100.0
Pomfrets	683	4.14	7.19	1.25	62.5	93.7

However, considering resource fluctuations and uncertainty of stock status assessment, the optimal average fishing effort over the recent three years(2005~2007), based on the and criteria is estimated at 80.4~94.3%, implying that LPT fishing capacity should be reduced by 5.7~19.6%(Table 1).

3.7.2 Large danish seine (LDS)

LDS production has decline over time since 1995. Major target species are brown croaker, yellow croaker, sea bass, monkfish, red fish, cuttle fish, etc. Evaluating the resource status of these species by multi-species approach, the relative fishing effort E_{2007}/E_{MSY} was 1.67, implying that its fishing effort in the Yellow Sea exceeds the reference point($E_{current}/E_{MSY}$)(Fig. 14, Table 2).

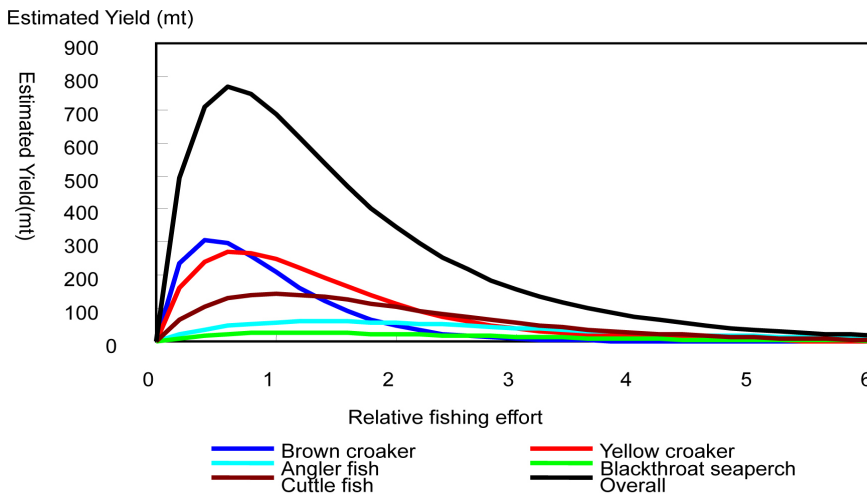


Figure 14. Multi-species equilibrium yield obtained from Fox's surplus production model for LDS in the Yellow Sea from 1990 to 2007.

Table 2. Status of stock utilization of LDS in the Yellow Sea

Species	Catch in 2007 (mt)	Percentage of species (wi, %)	Contribution rate(cr, %)	E_{07}/E_{MSY}	$2/3E_{MSY}/E_{05-07}$ (%)	E_{MSY}/E_{05-07} (%)
Overall	1,583	100.0	0.14	1.67	57.4	74.8
Brown croaker	432	27.3	14.25	2.17	43.4	65.1
Yellow croaker	427	27.0	1.25	1.47	39.4	59.1
Sea bass.	264	16.7	1.91	0.15	100.0	100.0
Angler fish	112	7.1	0.78	0.73	79.9	100.0
Blackthroat seaperch	91	5.7	3.15	0.87	69.9	100.0
Cuttle fish	76	4.8	3.90	1.02	42.3	63.4

Considering resource fluctuations and uncertainty of stock assessment, the optimal average fishing effort over the recent three years (2005~2007) on the E_{MSY} and $2/3E_{MSY}$ criteria is estimated at the level of 57.4~74.8%, indicating that LDS fishing capacity should be reduced by 25.2~42.8% (Table 2).

3.7.3 Off-shore stow net (OSSN)

OSSN production has declined over time since 1990 but it has shown a stable trend at the low level. Major target species are brown croaker, yellow croaker, sea bass, monkfish, red fish, cuttle fish, etc. Evaluating the resource status of these species by using the multi-species approach, the relative fishing effort E_{2007}/E_{MSY} was 1.67, implying that its fishing effort in the Yellow Sea exceeds the reference point(Fig. 15, Table 3).

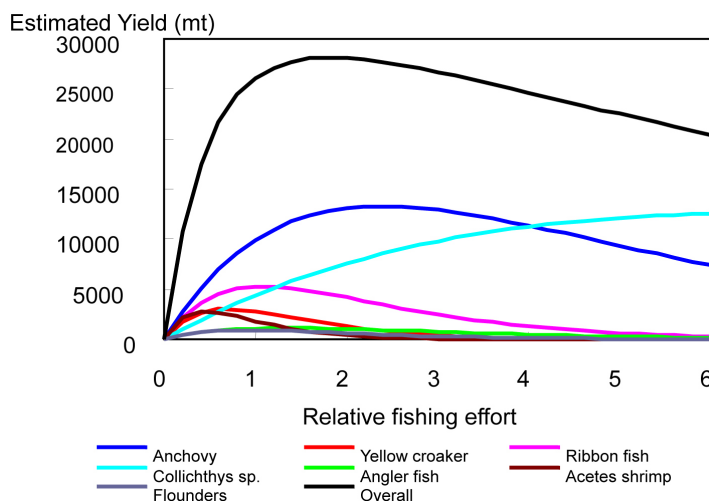


Figure 15. Multi-species equilibrium yield obtained from Fox's surplus production model for OSSN in the Yellow Sea from 1990 to 2007.

Taking into account resource fluctuations and uncertainty of stock status assessment, the optimal average fishing effort over the recent three years(2005~2007) on the E_{MSY} and $2/3 E_{MSY}$ criteria is estimated at 79.5~89.1%, indicating that OSSN fishing capacity should be reduced by 10.9~20.5%(Table 3).

Table 3. Status of stock utilization of OSSN in the Yellow Sea

Species	Catch in 2007(mt)	Percentage of species (wi, %)	Contribution rate(cr, %)	E_{07}/E_{MSY}	$2/3 E_{MSY}/E_{05-07}$ (%)	E_{MSY}/E_{05-07} (%)
Overall	34,024	100.00	2.95	1.67	79.5	89.1
Anchovy	10,225	30.05	4.62	0.42	100.0	100.0
Yellow croaker	4,754	13.97	13.89	1.47	39.4	59.1
Hair tail	3,391	9.97	5.14	0.92	86.6	100.0
Sea bass	3,208	9.43	23.22	0.15	100.0	100.0
Angler fish	2,061	6.06	14.30	0.73	79.9	100.0
Acetes shrimp	1,962	5.77	15.63	2.23	38.3	57.4
Flounders	1,451	4.27	5.96	1.11	58.8	88.1

3.7.4 Medium danish seine (MDS)

MDS production has declined rapidly over time since 1995 but currently it shows a stable trend at a very low level. Major target species are brown croaker, monkfish, flounders, sea eel, red horsehead, etc. Evaluating the resource status of these species by the multi-species approach, the relative fishing effort E_{2007}/E_{MSY} was 1.67, implying that its fishing effort in the Yellow Sea exceeds the reference point(Fig. 15, Table 4).

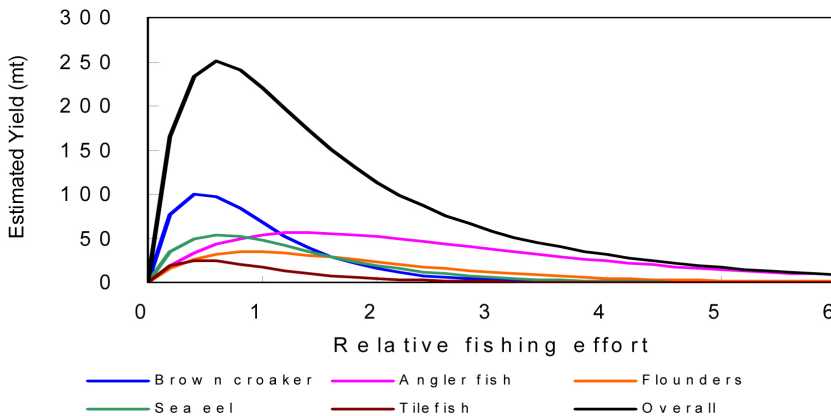


Figure 16. Multi-species equilibrium yield obtained from Fox's surplus production model for MDS in the Yellow Sea from 1990 to 2007.

Considering resource fluctuations and uncertainty of stock status assessment, the optimal average fishing effort over the recent three years(2005~2007) on the E_{MSY} and $2/3 E_{MSY}$ criteria is estimated at 53.8~75.2%, indicating that MDS fishing capacity should be reduced by 19.9~24.8%(Table 4).

Table 4. Status of stock utilization of MDS in the Yellow Sea

Species	Catch in 2007(mt)	Percentage of species (wi, %)	Contribution rate(cr, %)	E_{07}/E_{MSY}	$2/3E_{MSY}/E_{05-07}$ (%)	E_{MSY}/E_{05-07} (%)
Overall	697	100.00	0.06	1.67	53.8	75.20
Brown croaker	140	20.09	4.62	2.17	43.37	65.06
Angler fish	104	14.92	0.72	0.73	79.89	100.00
Flounders	54	7.68	0.22	1.11	58.75	88.13
Sea eel	53	7.53	0.27	1.60	33.80	50.70
Tile fish	21	3.01	1.34	2.10	32.07	48.10

3.7.5 Medium pair trawl(MPT)

MPT catch has increased rapidly over time since 2000. Major target species are anchovy, Spanish mackerel, squid and monkfish. Evaluating the resource status of these species by multi-species approach indicated the relative fishing effort E_{2007}/E_{MSY} was 0.56, implying that its fishing effort in the Yellow Sea exceeds the management reference point (Fig. 17, Table 5).

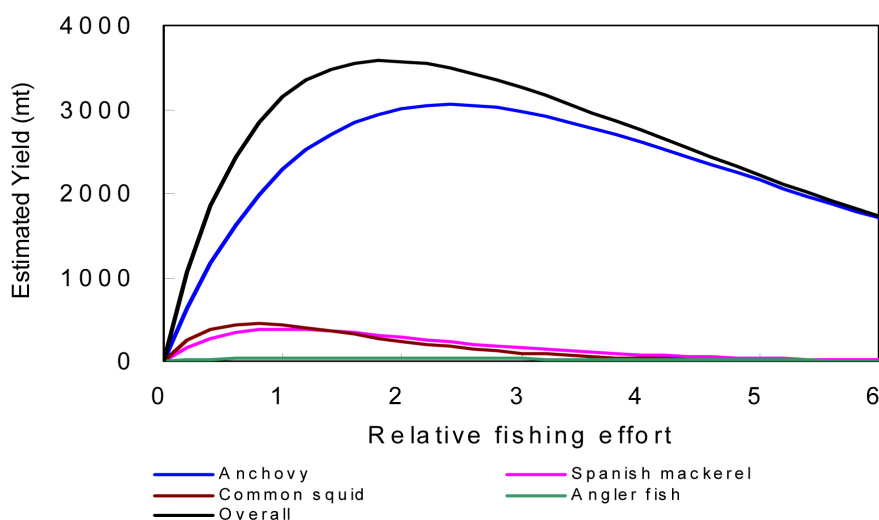


Figure 17. Multi-species equilibrium yield obtained from Fox's surplus production model for MPT in the Yellow Sea from 1990 to 2007.

Considering stock fluctuations and uncertainty of stock assessment, the optimal average fishing effort over the recent three years(2005~2007) on the E_{MSY} and $2/3 E_{MSY}$ criteria is estimated at 91.0~98.3%, indicating that MPT fishing capacity should be reduced by 1.7~9.0%(Table 5).

Table 5. Status of stock utilization of MPT in the Yellow Sea

Species	Catch in 2007(mt)	Percentage of species (wi, %)	Contribution rate(cr, %)	E_{07}/E_{MSY}	$2/3 E_{MSY}/E_{05-07}$ (%)	E_{MSY}/E_{05-07} (%)
Overall	3,894	100.0	0.34	0.56	91.0	98.3
Anchovy	2,357	60.5	1.07	0.42	100.00	100.00
Spanish mackerel	536	13.8	1.27	0.99	76.96	100.00
Common squid	367	9.4	0.21	1.29	56.55	84.82
Angler fish	80	2.1	0.56	0.73	79.89	100.00

3.7.6 Squid angling (SA)

SA catch began to increase rapidly over time since 2000. Major target species is common squid, one of the pelagic species abundant in Korean waters. Evaluating the resource status of the species, the relative fishing effort E_{2007}/E_{MSY} was 1.25, implying that its fishing effort in the Yellow Sea exceeds the management reference point (Fig. 18, Table 6).

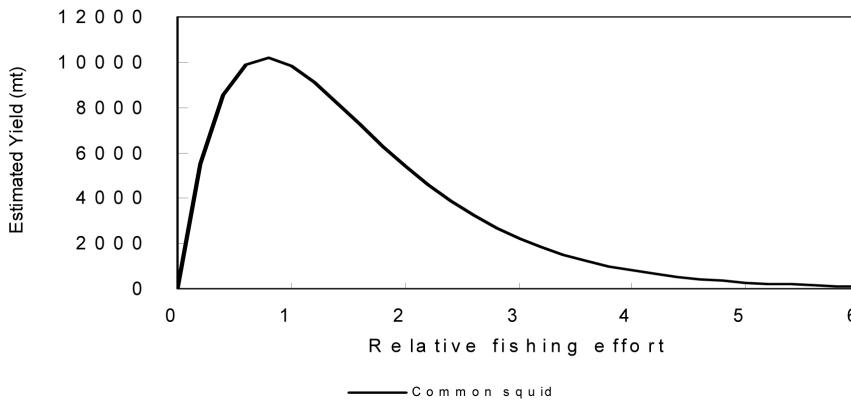


Figure 18. Multi-species equilibrium yield obtained from Fox's surplus production model for SA in the Yellow Sea from 1990 to 2007.

Taking into account stock fluctuations and uncertainty of stock assessment, the optimal average fishing effort over the recent three years(2005~2007) on the E_{MSY} and $2/3 E_{MSY}$ criteria is estimated at 56.5~84.5%, indicating that AS fishing capacity should be reduced by 15.5~43.5%(Table 6).

Table 6. Status of stock utilization of SA in the Yellow Sea

Species	Catch in 2007(mt)	Percentage of species(wi, %)	Contribution rate(cr, %)	E_{07}/E_{MSY}	$2/3E_{MSY}/E_{05-07}$ (%)	E_{MSY}/E_{05-07} (%)
Common squid	8,269	100.0	4.74	1.25	56.5	84.8

3.7.7 Large purse seine (LPS)

LPS production began to increase gradually over time since 2000. Major target species are mackerel, Spanish mackerel, hair tail, Jack mackerel, squid and yellow tail. Evaluating the resource status of these species by the multi-species approach, the relative fishing effort E_{2007}/E_{MSY} was 1.0, implying that it's fishing effort in the Yellow Sea does not exceed the management reference point(Fig. 19, Table 7).

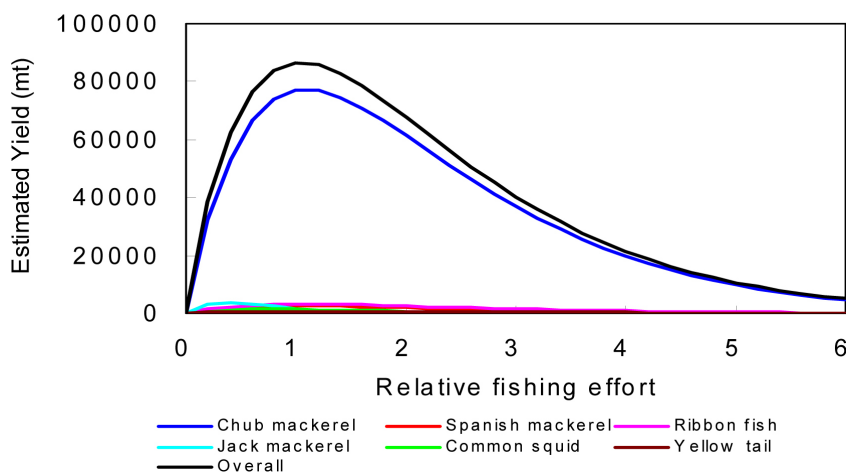


Figure 19. Multi-species equilibrium yield obtained from Fox's surplus production model LPS in the Yellow Sea from 1990 to 2007.

Table 7. Status of stock utilization of LPS in the Yellow Sea

Species	Catch in 2007(mt)	Percentage of species(wi, %)	Contribution rate(cr, %)	E_{07}/E_{MSY}	$2/3E_{MSY}/E_{05-07}$ (%)	E_{MSY}/E_{05-07} (%)
Overall	85,405	100.00	7.41	1.0	75.8	98.6
Chub mackerel	74,752	87.53	51.99	0.92	76.85	100.00
Spanish mackerel	3,689	4.32	8.74	0.99	76.96	100.00
Hair tail	2,049	2.40	3.10	0.92	86.62	100.00
Jack mackerel	1,910	2.24	10.00	2.68	29.82	44.73
Common squid	1,130	1.32	0.65	1.29	56.55	84.82
Yellowtail	1,030	1.21	15.79	0.78	80.56	100.00

Considering stock fluctuations and uncertainty of stock assessment, the optimal average fishing effort over the recent three years(2005~2007) on the E_{2007}/E_{MSY} criteria is estimated at 75.8~98.6%, suggesting that LPS fishing capacity should be reduced by 1.4~24.2% (Table 7).

3.7.8 Large otter trawl (LOT)

LOT production began to increase gradually over time since 2000. Major target species are squid, hair tail, anchovy and Spanish mackerel. Evaluating the resource status of these species by the multi-species approach indicated the relative fishing effort E_{2007}/E_{MSY} was 1.0 implying that its fishing effort in the Yellow Sea does not exceed the management reference point(Fig. 20, Table 8).

Taking into account stock fluctuations and uncertainty of stock assessment, the optimal average fishing effort over the recent three years(2005~2007) on the E_{MSY} and $2/3E_{MSY}$ criteria is estimated at 73.7~92.7%, suggesting that the LOT fishing capacity should be reduced by 7.3~26.3%(Table 8).

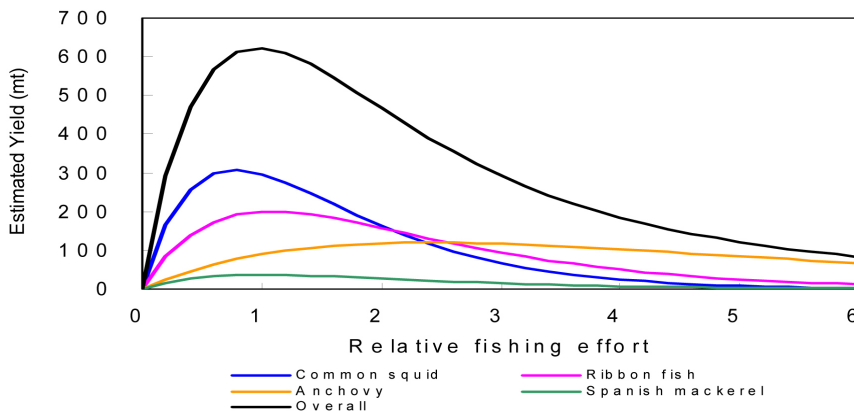


Figure 20. Multi-species equilibrium yield obtained from Fox's surplus production model LOT in the Yellow Sea from 1990 to 2007

Table 8. Status of stock utilization LOT in the Yellow Sea

Species	Catch in 2007(mt)	Percentage of species (wi, %)	Contribution rate(cr,%)	E_{07}/E_{MSY}	$2/3E_{MSY}/E_{05-07}$ (%)	E_{MSY}/E_{05-07} (%)
Overall	563	100.00	0.05	1.00	73.7	92.7
Common squid	250	44.36	0.14	1.29	56.55	84.82
Hair tail	129	22.94	0.20	0.92	86.62	100.00
Anchovy	92	16.39	0.04	0.42	100.00	100.00
Spanish mackerel	52	9.15	0.12	0.99	76.96	100.00

3.8 Overall assessment of resource utilization in the Yellow Sea

Annual production in the Yellow Sea was 307,135 mt in 1990, 406,110 mt in 1995, 293,794 mt in 2000, 269,821 mt in 2005 and 293,239 mt in 2007. The catch in 2000s decreased in comparison with that in 1990s. The catch composition in 2007 by species with catches greater than 5,000 mt shows that mackerel accounted for 25.6%, anchovy 12.3%, blue crab 4.2%, common squid 3.5%, yellow croaker 3.2%, Spanish mackerel 3.0%, small shrimp 2.6%, pen shell 2.5%, mullets 2.1%, hair tail 1.8%. The Yellow Sea' contribution (cr_i) to total Korean catch by species appeared that pen shell held 92.9%, blue crab 91.4%, small shrimp 61.9%, mullets 55.1%, mackerel 52.2% and yellow croaker 27.0% (Fig. 21, Fig. 22).

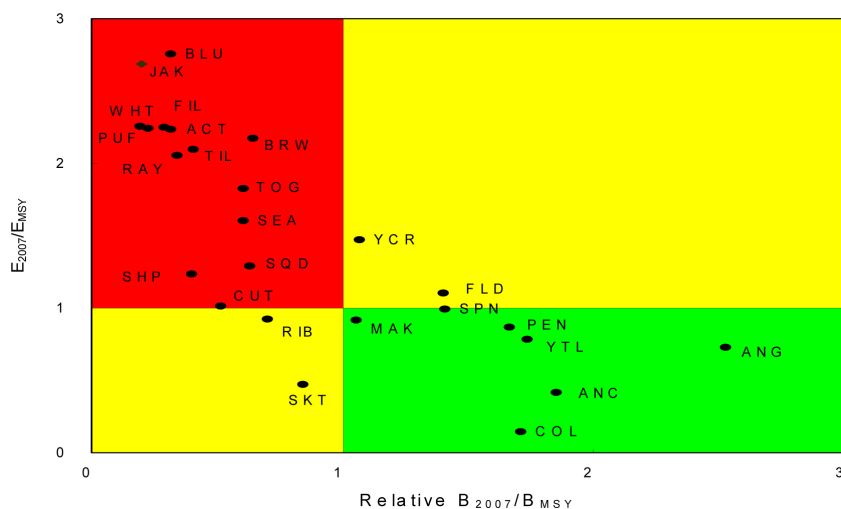
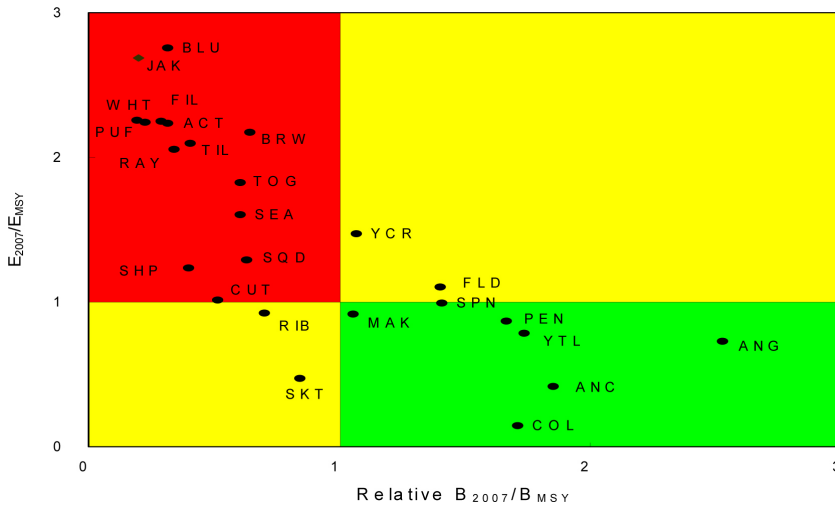


Figure 21. Change of total catch in the Yellow Sea from 1990 to 2007.

Regarding the stock status by species, the assessment results suggest that i) red fish, monkfish, anchovy, sea bass, yellow tail, pen shell and Spanish mackerel are not in overexploitation/overcapacity, ii) hair tail and skate ray are in overexploitation but in non-overcapacity and iii) yellow croaker is in non-overexploitation but in overcapacity. However, considering stock fluctuations and assessment uncertainties, the average optimal fishing effort over the last three years(2005~2007) on and criteria was evaluated at 73.4~90.2. This result suggests that the current level of total fishing capacity in the Yellow Sea need to be reduced by 9.8~26.6%.



Notes : Hair tail, RIB; Rays, RAY; Flounders, FLD; Cuttle fish, CTL; Sea bass., COL; Sharp toothed eel, SHP; Chub mackerel, MAK; Blue crab, BLU; File fish, FIL; Anchovy, ANC; Brown croaker, BRW; Yellow tail, YTL; Pomfrets, POM; White croaker, WHT; Puffers, PUF; Sea eel, SEA; Spanish mackerel, SPN; Tongue fish, TOG; Angler fish, ANG; Common squid, SQD; Tile fish, TIL; Jack mackerel, JAK; Acetes shrimp, ACT; Yellow croaker, YCR; Pen shell, PEN; Skate ray, SKT.

Figure 21. B_{2007}/B_{MSY} and E_{2007}/E_{MSY} in 2007.

4. Marine resources and ecosystem impacts

4.1 Objectives of the fisheries structural adjustment (FSA)

The ultimate long-term goal of FSA policy is ecosystem-based, environmentally-sustainable management and use of Korean marine ecosystem by reducing fisheries development stress and promoting sustainable exploitation of the ecosystem from a densely populated, heavily urbanized and industrialized semi-enclosed shelf sea.

The focus of FSA on sustainable fisheries management and reducing stress to the ecosystem provides an opportunity for exploring how the FSA can further national and regional commitments to certain international conventions and agreements, such as the United Nations Convention on the Law of the Sea, the FAO Code of Conduct for Responsible Fisheries, the Global Program of Action for the Protection of the Marine Environment from Land-based Activities and the bilateral fisheries agreements among Korea, China and Japan.

Its mid-term objectives are i) to enhance national capacities in protection of marine environment and sustainable use of marine and coastal resources, through the buyback programs and the resource enhancement projects, ii) to strengthen fishermen-government part-

nership in marine environment protection and management through establishment of regional fisheries coordination/cooperation mechanisms and iii) facilitate self-management practices dealing with marine environmental/living resource management (Ministry of Maritime Affairs and Fisheries 2007).

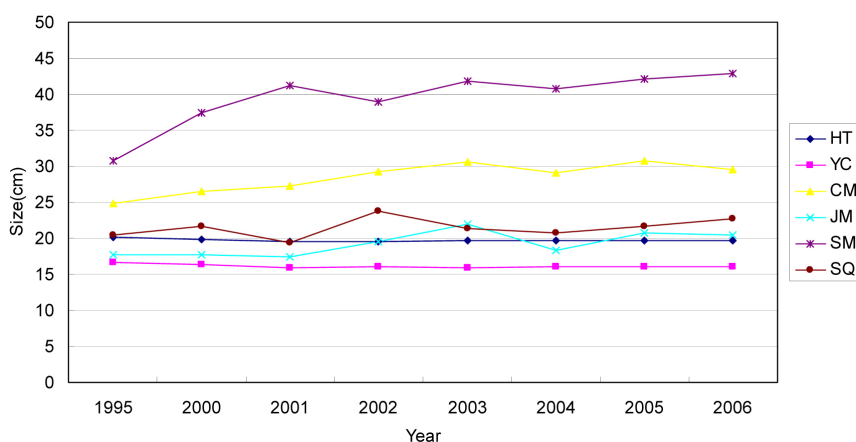
4.2 Impacts of the fisheries structural adjustment(FSA) policy

In practice, it is extremely difficult to distinguish the FSA's impacts on the Yellow Sea ecosystem from those of other drivers such as climate change and land-based pollution. At this moment it is only possible to draw some conclusions as to what are the probable implications of the FSA on the Yellow Sea ecosystem from other scientific research results on the Yellow Sea.

Lee *et al.* (2007) developed fish reproduction potential indices in the coastal and offshore ecosystem in Korea. The research results showed that i) the average annual catch from the Yellow Sea ecosystem in 1975~2004 was 130 thousand mt with coefficient of variation (CV) of 16.8, which was 4.5~6.5 times less than that of the southern sea, ii) the fishing effort increased gradually over time from 1990s, iii) the ratio of adult to small fish has tended to increase since 1997 mainly due to an increase in the ratio of adult to small anchovy in the Yellow Sea and iv) the fish reproduction potential index in the Yellow Sea is still in a low level of 1.22 because of ever-increasing overcapacity.

Another data source that may suggest the ecosystem change is the observation data on the mean capture sizes of major fish species (i.e. hair tail, yellow croaker, chub mackerel, Spanish mackerel and common squid) caught in the Yellow sea. The size (length) of hair tail and yellow croaker after 1995 have tended to be shorter more or less than those in 1995, but since 1995 their size appears to be pretty much stable at 19.7cm and 16.1cm, respectively (Fig. 23). The other three fish species have tended to increase in size.

The study by Lee *et al.* (2007) and the increase in the size at capture of most fish species seem to suggest that the food web and ecosystem of the Yellow Sea in part of Korea have been getting healthier after the introduction of the buyback programs. However, until more and longer scientific observations and analyses, it would be difficult to come up with any meaningful objective conclusion about comprehensive impacts of Korean fisheries structural adjustment policies on the Yellow Sea's fishery resources and ecosystem.



Source : Internal Data Base of Department of Fishery Resource Research, Division of Fishery Resources and Ocean Environment, NFRDI.

Figure 23. Size change in fish species over time (hair tail (HT), yellow croaker (YC), cub mackerel (CM), Spanish mackerel (SM) and common squid (SQ))

However, fishermen on the west coast are aware of the benefits that have been generated by the FSA. They recognize that the fish species on which the buyback programs have had the largest positive effect are in order of bottom, middle-layer and pelagic fish. In spite of such positive effects of the FSA, they tend to believe that further substantial reduction of fishing capacity (5.7-19.6%) needs to be made. Their belief is consistent with the scientific assessment results of stock status and fishing effort in the Yellow Sea.

4.3 Comparison with buyback activities in other countries: China, Japan and Australia

Many countries in the world have adopted and implemented buyback programs for sustainable fisheries development. All of the fishing states (e.g. Korea, China and Japan) that operate in the Yellow Sea and the East China Sea have implemented buyback schemes. Korea started the programs in 1994, Japan in 1981 and China in 2002.

Korean buyback programs have been operated under the individual vessel-catch permit system with input controls and the TAC (total allowable catch) system. Between 1994 and 2007 the buyback programs have been implemented in two ways: one was a general buyback program and the other was an international one. In the first year (1994) of the program 54 vessels were decommissioned and 730 boats in 1999 were reduced in a large scale under both of the general and the international buyback program.

Since, however, the law regarding the international buyback program was legislated to deal with the fisheries problems dictated by the Korea-Japan (1999) and the Korea-China (2001) fisheries agreement, the international buyback program was placed for the limited

period from 1999 to 2002. The total number of fishing vessels reduced in 1994–2007 was 8,324 (in-shore 6,357 and off-shore 1,967) and the public fund of 1,067 billion Korean won was used for decommissioning the boats.

The results of a study (Lee *et al.*, 2003) showed that the buyback programs did not make a positive net contribution to resources recovery, but it helped the declining rate of resource stocks be reduced and forecasted that resources status and fishing household's management performance would be improved significantly in the long run where the buyback programs with input controls, resource enhancements and TACs goes together.

Chinese ocean fisheries faced new fisheries problems because the existing fishing grounds were much squeezed due to the China-Japan, Korea-China and China-Vietnam bilateral-fisheries agreement. Since the fisheries agreements, more than 30 thousand vessels that operated in the off-shore were out of business. 300 thousand fishermen and more than 3 million fisheries population were affected. A variety of fisheries-related industries such as distribution, processing, transportation, fishing gear manufacturers and fishing port services were influenced directly and/or indirectly. Under such circumstances, fishing intensity of the off-shore fisheries have increased and safety problems on the seas have been getting serious. Thus, the Chinese government began to realize that vessel reduction and fisheries structural adjustments are imperative. Major goals of vessel reduction policy are placed in fisheries resource conservation and fishing-community's economic vitalization and structural adjustment. Ministry of Agriculture and National Management Bureau of Safety, Production and Overseas announced a tentative code for fishing vessel disuse (Cho *et al.*, 2003).

In 1999 Chinese government put a moratorium on the southern sea. At the same time it extended the moratorium period over the Yellow Sea so that fishing time at the Sea was significantly reduced. Also, in 1999 it established a zero-growth goal for quantity harvested. This policy was a practical step to resource conservation and fisheries sustainable development. In addition, China strengthened the regulations for limiting new boat construction. The government increased the number of ocean-administrative officials and strengthened the rules of implementing vessel reduction policy in a unified manner. The policy package has helped Chinese capture fisheries production with resource stabilization increase by 9.5 thousand mt between 1998 and 1999 (Cho *et al.*, 2003).

Japanese buyback programs were divided into two stages: stage 1 (1989–2000) was focused on vessel reduction that management performance got worse and stage 2 (2001–) aimed at active fishing effort adjustment to the optimal level of stocks for domestic/international resources restoration, following 『The Resources Recovery Plan』 (Cho *et al.*, 2003). Because of excessive fishing effort against target fish species and/or deterioration of natural aquatic environments on which reproduction of species depends, the stock statuses of certain species are worsened. The necessity to rebuild important marine living resources by reducing excessive fishing effort and restoring fishing grounds and nursery areas, are increasingly

recognized.

In accordance with the Basic Plan of Japanese Fishery, which was adopted in 2002, a framework for “Resource Recovery Plan” to implement the necessary measures for rebuilding resources in a comprehensive and planned manner was established. Under the framework, either national or prefecture governments assume a role of formulating specific resource recovery plan according to the nature of the stock or fishery in question. The plan will be developed and implemented in cooperation with stakeholders including fishermen utilizing such resources. In order to implement the plan, various measures such as the reduction of fishing efforts(e.g., decrease in the number of boats, suspension of operations, modification of fishing gear), active resource enhancement(e.g., release of fry) and preservation and rehabilitation of the environment of fishing grounds(e.g., maintain of sea grass beds or tidal flats) are employed. As of February 2008, 51 plans for specific fish species and 20 comprehensive plans in area and fishing type are already developed or under development either by central or prefecture governments. Total number of the plan is increasing over years and the area in which plan was developed has been widely extended throughout Japan(OECD, 2009).

Australian buyback scheme was unique in the sense that the buyback was implemented in a fishery managed by individual vessel tradeable harvesting rights rather than input controls. Profits for all vessel classes rose over the period 1997~2000 following the 1997 buyback of 27 fishing licenses, but some of the gains were due to a rise in output prices that were independent of the adjustment program (Fox *et al.*, 2003). All vessel classes (small and large) also experienced substantial productivity gains immediately following the 1997 license buyback with an average increase over all vessels of 39%. This increase, coincident with a decline in catch per unit of effort for key species, provides strong support that the buyback was successful at improving economic performance. Ongoing productivity improvements for small vessels over the period 1998~2000 following the buyback is attributed to the existence of individual tradeable harvesting rights in the fishery(Fox *et al.*, 2003, OECD, 2009).

The comparison of Korean buyback programs with those of other three states(e.g. China, Japan and Australia) implies that the common denominator of buyback programs is effectiveness for resource conservation and restoration and would be more effective where they are implemented with input and/or output controls, resource enhancement programs and in some cases space and/or time moratorium. In addition, decommissioned vessels need to be thoroughly monitored not to reenter and the states of adopting buyback schemes do not allow new vessels to be constructed.

5. Conclusions and policy implications

The Korean fisheries authorities have for some time followed a structural adjustment policy in fisheries, largely focusing on buyback of fishing vessels. This policy appears to have a significant contribution to reducing the rate of fisheries resource decline. Some fish species, such as squid, Spanish mackerel and Jack mackerel, showed signs of recovery. Even though a large number of fishing vessels has been reduced for the last 15 years, the effective fishing capacity (i.e. engine power) has tended to increase. Thus, increased engine power has to a certain extent replaced decommissioned vessels. This trade-off, often observed under buyback programs has occurred because of lack of institutional arrangements.¹ Now, the ministry of food, agriculture, fisheries and forestry(MFAFF) began to search for a way of effectively controlling vessel engine power.

In addition, it is known that fisheries resource management problems are compounded by land-based pollution and climate change. Korean government has begun to much actively manage land-based pollution through the intergovernmental cooperative mechanism. To respond to climate change, the government declared low carbon/green growth strategy as a new national policy toward six decades ahead. In particular, dealing with land-based pollution problems in the Yellow Sea is much more important than other seas in Korean peninsular since most of large industrial complexes and metropolitan cities are located in the east coast of China and in the west coast of Korea

Following such national initiative, the central and provincial governments should be able to develop integrated green policy package including buyback, resource enhancement, off-fisheries income promotion, fuel subsidy reorientation and self (or co)-management programs.² Also, the package program should be supported by new R&D system that is focused on enhancing and maintaining the Yellow Sea's environment and ecosystem. This will require far closer cooperative work among South/North Korea, China and related international bodies.

1 During the buyback period there is no additional new-boat construction. Since however higher engine power was allowed where two existing boats were put together into one, engine power has much increased without construction of extra new boats. Most of the decommissioned boats were scraped or used for artificial reef establishment. Small number of boats was given to the few Asian developing coastal states.

2 Fuel subsidy(tax exemption) is a type of cost-saving support, which amounted to about 754 billion won in 2007(Ministry of Food, Agriculture, fisheries and Forestry, Fisheries Annual Report, 2008). Green policy package needs to include reorientation schemes for fuel subsidy so as to provide fishermen with some incentives to save fuel consumption.

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Analysis of competitive relationship among East Asian ports by Cointegration Test

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ABSTRACT

Expansion of port competition is growing very fast to attract more container throughput due to international specialization which MNCs have moved into low-cost cluster for saving cost and expanding market. East Asia is the center of this relationship because the ports in this region are connected in competitive or complementary relationship related to a number of container throughputs. This study shows the competitive relationship by cointegration test with time series data to prove the broad expansion of port competition. East Asian ports keep Hub & Spoke relationship for the past 20 years and multiple transshipment system has been introduced recently. Taiwanese ports are shrinking and Chinese Eastern ports are growing. This study identifies the role of Busan port as the hub port in Northeast Asia and the competitive relationship between Incheon and Chinese ports. This study shows the analysis of the past 20 years but don't deal with the fierce competition among East Asian ports in recent years in terms of limitation of this study.

Key words: international specialization, Cointegration test, competitive relationship, expansion of competition

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1. Introduction

Multinational companies established their production facilities in Asian countries as low cost clusters with prevailing international specialization strategy since 1980. This specialization significantly boosts international trade. Especially, the international specialization has been quite sophisticated in East Asia due to the gap of technology and cost between developed countries such as Japan, Korea, Taiwan and Singapore and developing countries such as China, Malaysia, Indonesia, Thailand and Vietnam. This sophistication leads a continuous growth in regional container throughput.¹

The soaring container traffic bring a huge change in competition relationship among major ports.² The competition exists only among nearby ports which share the same hinterland in the past time. However, another competition has created among the ports in long distance due to vessel enlargement, intermodal logistics system, advancement of transportation technologies and change of transshipment pattern in recent years. Many studies have dealt with theoretical analysis of this phenomena in a limited scope but few studies figures out whether this trend is a sophistication of new competition or a creation of complimentary relationship. This trend has been rapidly developed in recent years but many studies are still focusing on the nearby ports and data from statistic analysis are limited.

Therefore, I would like to do an actual analysis on the expansion of competitive relationship cause by sophisticated international specialization and Chinese economic advance.³ This study will focus on East Asian ports which have sophisticated competition and complimentary relationship.

This study choose cointegration test on time series container throughput to analyze the competitive relationship among the major East Asian ports. This test assumes that competitive relationship or complimentary relationship does exist among the target ports. A review on previous studies about international specialization and port competition will be covered in chapter 2. An analytical tool will be designed for Cointegration test in chapter 3. I will analyze the competition relationship among target ports by Cointegration test and interpret the result. Finally, I will mention the limitation of this study and suggest additional studies which are necessary.

1 Lee, S. W., 2009. Target cargoes and biz model for Korea's port FEZ by analysis of trade among Korea, China and Japan, *The Journal of Shipping and Logistics* 25, pp.101-102.

2 Lee, S. W. and G. S. Kim, 2009. Port challenge in Northeast Asia: Korea's two-hub port strategy. In: T. E. Notteboom, P. W. DeLangen and C. Ducruet (eds.), *Portsin Proximity: Essays on Competition and Cooperation among Adjacent Seaports*, Ashgate, London.

3 "China is likely to overtake the U.S. economy in size by mid-century. And as the world's economic center of gravity shifts to Asia. U. S. preeminence will inevitably diminish" mentioned by Jeffrey D. Sachs (in U.S. Economy in Size, Fortune, Jan. 12., 2004).

2. Review of previous studies

The expansion of port competition was noticed since late 1990s. The initial study was done by Nottenboom (1997). He divided competitive relationship of European container ports into three region (Hambrug-Le Havre, Atlantic, Meditterinan) and analyze the centrality between target ports and regional ports. He mentioned that the concentration on existing ports will gradually reveal some limitation and concluded that the competitive relationship will change from competition among few major ports to competition among many regional ports. However, his study focused on centrality among major ports rather than on broad competitive relationship. In addition, his study is limited to European ports which have lower competition comparing the ports in other regions. Han (2002) studied the cargo allocation and change among 25 Asian ports by positioning analysis. He showed actual cargo loss and acquisition focusing on Busan port and proposed that convenience, connectivity and priority of cost are the competitive factors. However, his analysis is based not on transshipment traffic which is the main international competitive factor but on total cargo traffic. Thus, his study is limited to show the competitive relationship among countries. On the other hand, KIM (2009) studied how to strengthen the competitiveness of Busan port by analyzing the competitive relationship among East Asian ports. He also derived a competitive factor by analysing the seasonal centrality and competition among East Asian ports. However, he still did not analyze transshipment throughput but total throughput and included some ports which don't have any transshipment function. Afterwards, Drucet (2009) analyzed competition relationship and change in the regional status based on vessel traffic analysis but couldn't produce the detailed result for correlations among selected ports.

Besides, there were a few studies on port competitive relationship within limited region such as Strategy Positioning Analysis by Haezendonck (2001) which focused on the competitiveness of Antwerp, Competition Relationship Analysis on Pearl River Delta ports by Slack & Wang (2003), Analysis of reasonable factors to dominate in competitive relationship among the ports which share the same hinterlands by Haezendonck & Notteboom (2002). However, most studies dealt with competitive relationship within a limited region and the relationship among the ports with the same hinterland. Therefore, these studies are also quite limited to explain the geographic expansion of competitive relationship.

This study started from the weakness of existing studies. I will analyze the competitive relationship among ports in long distance and study the phenomena of wide expansion of competitive relationship. This study will use an analyzing tool by W.Y.Yap & J.S.Lam (2006) which analyzed the competitive relationship and competitive factors of East Asian major ports (Hong Kong, Busan, Kaoshiung) excluding China ports. They derived Busan and Hong Kong as competitive ports and analyzed corelation between the cargoes originated from China and neighbouring ports.

3. Design of analysing tool

3.1 Data for analysis

The target ports should have enough throughput and should compete each other for cointegration test. Many years of time series data should be secured to strengthen the validity of statistic analysis. Therefore, I selected the East Asian ports which handles more than 100 million TEUs provided by Containerisation International Yearbook (2007)⁴ but I excluded a few ports such as Gwangyang port which cannot provide time series data due to the short operation period.

Table 1. Target ports

Classification	Korea	China	Japan	Taiwan
Port	Busan, Incheon	Shanghai, Tianjin, Dalian, HK, Qingdao	Kobe, Tokyo, Yokohama, Osaka	Kaoshiung, Keelung, Taichung
Quantity (Total 14)	2	5	4	3

This study uses the annual container throughput (TEU) per port from CI Yearbook and the analysis period is from 1980 to 2006. In case of Qingdao the period is from 1982 to 2006 considering the commencement of the port. All data was converted to natural log figure for convenience.

3.2 Understanding of Cointegration

If non-stationary time series variables are in the following relationship, Cointegration exist among the variables.

$$a_1 y_{1,t} + a_2 y_{2,t} = z_t \sim I(0) \quad (1)$$

$$\text{if, } \begin{matrix} y_{1,t} \sim I(1) \\ y_{2,t} \sim I(1) \end{matrix}$$

The two variables with common stochastic trend made non-stationary time series. If the two variables have common stochastic trend, they are balanced. If the signs of a_1 and a_2 are same in the cointegration formular (1), the signs of $y_{1,t}$ and $y_{2,t}$ should be

⁴ CI Yearbook is used as an worldwide reliable source in port and logistics (Source: Yap *et al.*, 2006).

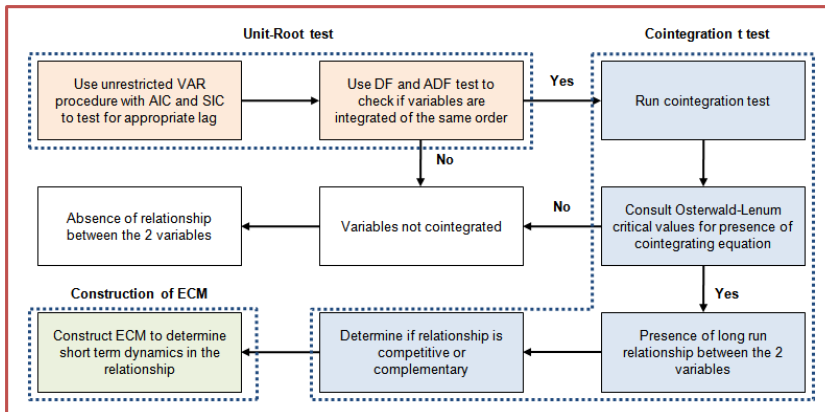
different to maintain a constant z_t . If the signs are different, the signs of $y_{1,t}$ and $y_{2,t}$ should be same.

If we apply this to competitive relationship among ports, the first one shows two ports are in competition and the later shows that two ports are complementary. W. Y. Yap & J. S. L. Lam (2006) decided the competitive relationship by this cointegration test.

3.3 Method of analysis

W. Y. Yap & J. S. L. Lam (2006) proposed a cointegration test method to check the competitive relationship by time series throughput per port.⁵ This is an advanced study comparing their pervious study of W. Y. Yap & J. S. L. Lam (2004), which conceptualize the port relationship as competition and complement. In this study, they use cointegration test to check the long-term relationship between two time series data.⁶ If cointegration relationship does not exist, the two data don't have long-term relationship and arbitrarily change.

Based on this theoretical background which is provided in figure 1, this study distinguishes the existence of time-series unit roots as shown in the figure. Then, this study derives the long-term relationship and apply Vector Error Correction to analyze the short-term trend. I analyzed the cointegration relationship on annual throughput of each port.



Source : Modified from Yap, W.Y. & Lam, J.S.L., (2006), p.41

Figure 1. Process of Cointegration test in port competitive relationship

5 Son (2008) applied this concept to East Asian and European Ports, respectively in order to find the relationship among container ports in long distance.

6 Cointegration refers to a linear combination of non-stationary variables. Theoretically, it is quite possible that nonlinear long-run relationships exist among a set of integrated variables. (Source: Walter Enders, Applied Econometric Time Series, 1995, p.358).

4. Empirical analysis

4.1 Analysis of competition relationship

4.1.1 Unit-Root test

This study uses the time-series throughput data of 14 East Asian ports. First, It does Unit-Root test because cointegration test is only effective when two variables are non-stationary. This study uses Augmented Dickey-Fuller Test⁷ for Unit-Root test. I assumes that trend and intercept do exist.⁸

This study classifies the ports into two groups upon the result of Unit-Root test. The ports I(1) which shows stable series by first difference are Group 1 and the ports I(2) which shows stable series by second difference are Group 2. Unit-Root test is basically based on 5% variance but I loosen the variance to 10% and classifies into a separate group to overcome the limitation which can arise from the analysis of port competition.⁹

Dalian, Osaka, Shanghai and Tianjin were I(0) upon Unit-Root test but their results are non-stationary after screening graph. This study arbitrarily neglects I(0) and tests again with the figures by first difference and second difference. The result is as the following Table 2.

Table 2. Result of Unit-Root test for throughput among East Asian ports

Classification	5% Variance	Group	10% Variance	Group
Busan	$I(1)$	Group 1-1	$I(1)$	Group 1-2
Dalian	$I(1)$	Group 1-1	$I(1)$	Group 1-2
Hong Kong	$I(2)$	Group 2-1	$I(1)$	Group 1-2
Incheon	$I(2)$	Group 2-1	$I(2)$	Group 2-2
Kaoshiung	unstable	excluded	$I(2)$	Group 2-2
Keelung	$I(1)$	Group 1-1	$I(1)$	Group 1-2
Kobe	$I(1)$	Group 1-1	$I(1)$	Group 1-2
Osaka	$I(1)$	Group 1-1	$I(1)$	Group 1-2
Qingdao	$I(1)$	Group 1-1	$I(1)$	Group 1-2
Shanghai	$I(1)$	Group 1-1	$I(1)$	Group 1-2
Taichung	$I(1)$	Group 1-1	$I(1)$	Group 1-2
Tianjin	$I(2)$	Group 2-1	$I(2)$	Group 2-2
Tokyo	$I(1)$	Group 1-1	$I(1)$	Group 1-2
Yokohama	$I(1)$	Group 1-1	$I(1)$	Group 1-2

⁷ Augmented Dickey-Fuller Test is being widely used because of the assumption that standard error in regression formula is iid is loosened.

⁸ I assumed this by reviewing data.

⁹ Group 1-1 and Group 2-1 are based on 5% Unit-Root test; Group 1-2 and Group 2-2 are 10% Unit-Root test.

4.1.2 Cointegration test

This study establishes VAR model per group and acquired the optimal time difference upon Akaike Information Criterion.¹⁰ The maximum time difference is 6 because the size of sample is small. This study uses Johansen Test¹¹ for cointegration test. It testes per port and establishes VAR model and derives a cointegration formular if cointegration relationship does exist.

4.2 Analysis of competitive relationship

The result is similar with the previous studies but I could achieve competition, compliment, no relationship beyond simple competitive relationship and redirection of throughput.

The East Asian ports have complimentary relationship or no relation rather than have competitive relationship in macro-perspective. Surprisingly, Busan, Shanghai and Hong Kong are complimentary or have no relation. This reflects that Hub & Spock transshipment system is running and there is a trend of multiple transshipment system among the large ports.¹² However, the ports in Taiwan have shrunk or maintain fierce competition. This result is similar to the study of Yap, W. Y. & Lam, J. S. L. (2006) and other studies in the recent ports competition but does not reflect the trend of competition between Busan and Shanghai or between Busan and Qingdao, which is suggested by recent studies. This difference comes from the fact that I analysed the 20 years data which is a long-term.

If we see the result of 5% confidence test in Group 1-1 (Table 3), Busan is complementary to Dalian, Osaka, Qingdao, Taichung and Yokohama. This shows that Busan takes a role as a transshipment hub port against the other ports. The complementary relationship between Busan and Qingdao still exists even though the relationship become weak in recent years. However, Busan has a competitive relationship with Keelung as it does in the study of Yap, W. Y. & Lam, J. S. L. (2006) but has no relationship with Kobe, Shanghai and Tokyo. The large ports in East Asia seems to have the equal relationship caused by transshipment system change rather than competition relationship. Most ports in East Asia are complementary but Dalian competes with Taichung, Kobe competes with Qingdao and Keelung

10 Adding the possibility of serial correlation in error term to the assumptions of Dickey-Fuller Test (DF Test), we can apply the Augmented Dickey-Fuller Test (ADF Test). So ADF Test is being widely used because of the assumption is more loosened. Applying DF Test, we generally use models like $\Delta Y_t = \beta_0 + \beta_1 t + \gamma Y_{t-1} + e_t$. However applying ADF Test, we use models like the following:

$$\Delta Y_t = \beta_0 + \beta_1 t + \gamma Y_{t-1} + \alpha_i \sum_{i=1}^m \Delta Y_{t-i} + e_t$$

11 This study uses EVIEWS (ver 4.1) for analysis and the Cointegration test is based on Johansen Test. Unrestricted Cointegration Rank Test was done with trace statistics.

12 Jung, B. M. (2005) explained the competition relationship with a Hub&Spoke concept that single or multiple transshipment ports exist and handles cross transshipment.

competes with Qingdao, Osaka competes with Yokohama and Taichung competes with Tokyo. The results do not reflect all trends but these quite reflect the trend of Keelung, Qingdao and Osaka.

In the long-term relationship in Group 2-1, there is a competition between Incheon and Hong Kong and between Incheon and Tianjin. However, this might be a statistical error. Only the competition relationship between Incheon and Tianjin is reasonable because the direct service to Tianjin has been increased.

Table 3. Long-term relationship of Group 1-1

Port	Busan	Dalian	Kobe	Keelung	Osaka	Qingdao	Shanghai	Taichung	Tokyo	Yokohama
Busan	-		N	C	Y	Y	N	Y	N	Y
Dalian	-	-	N	Y	Y	Y	Y	C	Y	Y
Kobe	-	-	-	Y	N	C	N	N	N	N
Keelung	-	-	-	-	N	C	Y	Y	N	Y
Osaka	-	-	-	-	-	N	Y	Y	N	C
Qingdao	-	-	-	-	-	-	Y	Y	N	Y
Shanghai	-	-	-	-	-	-	-	Y	Y	N
Taichung	-	-	-	-	-	-	-	-	C	Y
Tokyo	-	-	-	-	-	-	-	-	-	N
Yokohama	-	-	-	-	-	-	-	-	-	-

Notes: N-No relationship, C-Competition, Y-Complementary

Table 4. Long-term relationship of Group 2-1

Port	Hong Kong	Incheon	Tianjin
Hong Kong	-	-	-
Incheon	Competition	-	-
Tianjin	Competition	Competition	-

The result from the analysis of Table 5 of Group 1-2 with 10% confidence interval. However, the analysis from Table 6 of Group 2-2 shows that Kaoshiung has kept to compete with Incheon and Tianjin. This reflects decreasing throughput of Kaoshiung port, resulting from competition relationship with the neighboring ports.

Overall, Busan keeps a relatively good status comparing other rival ports. This result is similar to these of W. Y. Yam & J. S. L. Lam (2006) and Drucet (2009). However, this result is estimated from the past 20 years data which doesn't reflect the most recent change. Especially, it could not explain which Busan port has recent problems and threats. On the other hands, Incheon only supports Seoul metropolitan area but it is growing as one of major ports in East Asia. In addition, I could notice that Incheon has competitive relationship with Chinese and Taiwanese ports.

Table 5. Long-term relationship of Group 1-2

Port	Busan	Dalian	Hong Kong	Kobe	Keelung	Osaka	Qingdao	Shanghai	Taichung	Tokyo	Yokohama
Busan	-	Y	Y	N	C	Y	Y	N	Y	N	Y
Dalian	-	-	Y	N	Y	Y	Y	Y	C	Y	Y
Hong Kong	-	-	-	Y	N	N	N	Y	Y	N	Y
Kobe	-	-	-	-	Y	N	C	N	N	N	N
Keelung	-	-	-	-	-	N	C	Y	Y	N	Y
Osaka	-	-	-	-	-	-	N	Y	Y	N	C
Qingdao	-	-	-	-	-	-	-	Y	Y	N	Y
Shanghai	-	-	-	-	-	-	-	-	Y	Y	N
Taichung	-	-	-	-	-	-	-	-	-	C	Y
Tokyo	-	-	-	-	-	-	-	-	-	-	N
Yokohama	-	-	-	-	-	-	-	-	-	-	-

Notes : N-No relationship, C-Competition, Y-Complementary

Table 6. Long-term relationship of Group 2-2

Port	Kaoshiung	Incheon	Tianjin
Kaoshiung	-	-	-
Incheon	Competition	-	-
Tianjin	Competition	Competition	-

5. Conclusions

East Asia is the largest production base in the world which has advanced, middle and developing industrial structures at the same time. This strengthened international specialization in the region and created a lot of container traffic. Therefore, if the logistics network can be centered in Korea, Korea will enjoy economic profit and will secure strategic value which surpass other regions.

In this environment, Busan takes a role as a complementary port for neighboring ports during the past 20 years. In addition, recently grown Incheon port is also growing as a major port in East Asia which has a competitive relationship with Chinese and Taiwanese ports. This shows that there is a competitive relationship between Incheon and Chinese ports for Northeast Asian container traffic. Meanwhile, Busan keeps a complementary role for East Asian container throughput as a connection port between hub port and feeder port. The competitive relationship of Taiwanese ports is caused by the decreasing

container throughput and this shows the growth of Chinese Northeastern ports which were behind of Taiwanese ports.

Busan port keeps a role as a central port in East Asia as this analysis and Loo & Hook (2002)'s study showed. In addition, we could see the growth of Incheon port. This study does not show the role of Busan is threatened due to the development of Shanghai and Qingdao and other domestic ports as Kim and Kwak (2009) and Brucret (2009) pointed. As of matter of fact, the role of Busan port is weakening by the development of new container terminals in neighboring ports, increase of direct calling service, overseas exodus of Korean factories and aggressive marketing of neighboring ports.

In conclusion, a highly efficient and effective port sector in Korean ports will make a significant contribution to achieving success in the development as a logistics hub. Not only this will prove helpful in reducing the cost of gateway traffic, it will also make Korea's ports more competitive in the battle to win transshipment business within the Northeast Asian region. However, for keeping this position, they should continuously monitor the quickly changing trend and do their own strategies for overcome the obstacles.

This study seems to have a limitation of analysis on the recent trend. The long-term relationship was found by reviewing 20 years time series data but the recent trend since 2000 could not be found in this study. Therefore, more meaningful result could be produced if further research does more sophisticated analysis on short-term time series data and relationship between short-term and long-term analysis in complete ports in East Asia.

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International rules on the continental shelf delimitation

Jian-Jun Gao^{*}

ABSTRACT

The continental shelf delimitation is a distinct type of delimitation, and the legality of the single maritime delimitation is based upon the agreement of the states concerned, expressly or tacitly. Where one of the parties expressly objects to the single delimitation, the international tribunal to which the particular dispute has been submitted, will have no competence to undertake a single delimitation. The international rules on the continental shelf delimitation consist of delimitation by agreement, delimitation on the basis of international law, and achieving an equitable solution. Maritime delimitation, including the establishment of the provisional arrangements, must be effected through the agreement of the states concerned. One basic requirement of equity is to giving equal treatment to states with equal natural situations, while giving unequal treatment to states with unequal natural situations. An equidistance line is not appropriate for the delimitation of a disrupted continental shelf, for it will cause areas which are the natural prolongation of the territory of the wide-margin state to be attributed to the narrow-margin state, thus violating the non-encroachment principle. Coastal geography is the most important relevant circumstance and the geological and geomorphological factors of the relevant seabed area should be considered in the continental shelf delimitation. In order to demonstrate the equity of the delimitation line, the test of proportionality may be a useful means.

Key words: continental shelf, exclusive economic zone, EEZ, coastal geography, proportionality

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1. Introduction

“Delimitation of the continental shelf between States with opposite or adjacent coasts” is provided for in Article 83 of the United Nations Convention on the Law of the Sea (LOS Convention),¹ standing side by side with the delimitation of the exclusive economic zone (EEZ) which is governed by Article 74. Although the wordings of these two articles are virtually identical, the rules relating to the EEZ delimitation and those relating to the continental shelf delimitation are not naturally the same, because, as the International Court of Justice (ICJ) commented in the 1985 *Libya/Malta* case, “The Convention sets a goal to be achieved, but is silent as to the method to be followed to achieve it.”² Therefore, a boundary that might be equitable for EEZ purposes might not be equitable for continental shelf purposes because of, *inter alia*, the different considerations that are relevant to achieving an equitable solution in each case. For example, the fish stocks in the case of EEZ and the geological characteristics of the seabed in the case of continental shelf.³ It follows that, in principle, states concerned will normally effect separate delimitations for the continental shelf and the EEZ respectively. Of course, where distinct lines result from the separate delimitations, the parties have to resolve the jurisdiction issue within the areas of one party’s EEZ overlapping the seabed of the other.⁴

However, with the emergence of the so-called single maritime delimitation, it has been argued that the continental shelf should not be delimited in isolation,⁵ and the rules on the continental shelf delimitation have been taken as similar to those for the single delimitation.⁶ Meanwhile, the rules on the continental shelf tend to be ignored by international lawyers in their recent research. In the view of the author, these arguments are not correct. The purposes of this paper are to establish that the continental shelf delimitation

1 Opened for signature on 10 December, 1982 and entered into force on 16 November, 1994 (www.UN.org/depts/los).

2 Continental Shelf (*Libya/Malta*), 1985. *ICJ Reports* 13 [*Libya/Malta*], para. 28.

3 Churchill, R. R. and A. V. Lowe, 1999. *The Law of the Sea* (Juris Publishing, Manchester University Press, 3rd edition), p.196.

4 Faraj Abdullah Ahnish, *The International Law of Maritime Boundaries and the Practice of States in the Mediterranean Sea* (Clarendon Press, 1993), p.139.

5 For example, the ICJ held in the *Libya/Malta* case that “even though the present case relates only to the delimitation of the continental shelf and not to that of the exclusive economic zone, the principles and rules underlying the latter concept cannot be left out of consideration. As the 1982 Convention demonstrates, the two institutions - continental shelf and exclusive economic zone - are linked together in modern law [...], one of the relevant circumstances to be taken into account for the delimitation of the continental shelf of a State is the legally permissible extent of the exclusive economic zone appertaining to that same State.” *Libya/Malta*, para. 33.

6 For example, the ICJ declared in the *Black Sea* case that “When called upon to delimit the continental shelf or exclusive economic zones, or to draw a single delimitation line, the Court proceeds in defined stages”. Case concerning Maritime Delimitation in the Black Sea (*Romania v. Ukraine*), Judgment of 3 February, 2009 (www.icj-cij.org) [*Black Sea*], para. 115. Note that the ICJ did not intend to differentiate the rules on the continental shelf delimitation from the rules on the EEZ delimitation or for the single delimitation.

is still a distinct type of maritime delimitation and to expound the rules on the continental shelf delimitation by interpreting Article 83, paragraph 1 of the LOS Convention, taking the relevant jurisprudence of the international court and tribunal into account.

2. Continental shelf delimitation has not been absorbed by the single maritime delimitation

In order to “avoid as far as possible the disadvantages inherent in a plurality of separate delimitations,” the concept of single maritime delimitation has come into being.⁷ The “single maritime delimitation” is a delimitation procedure by which different kinds

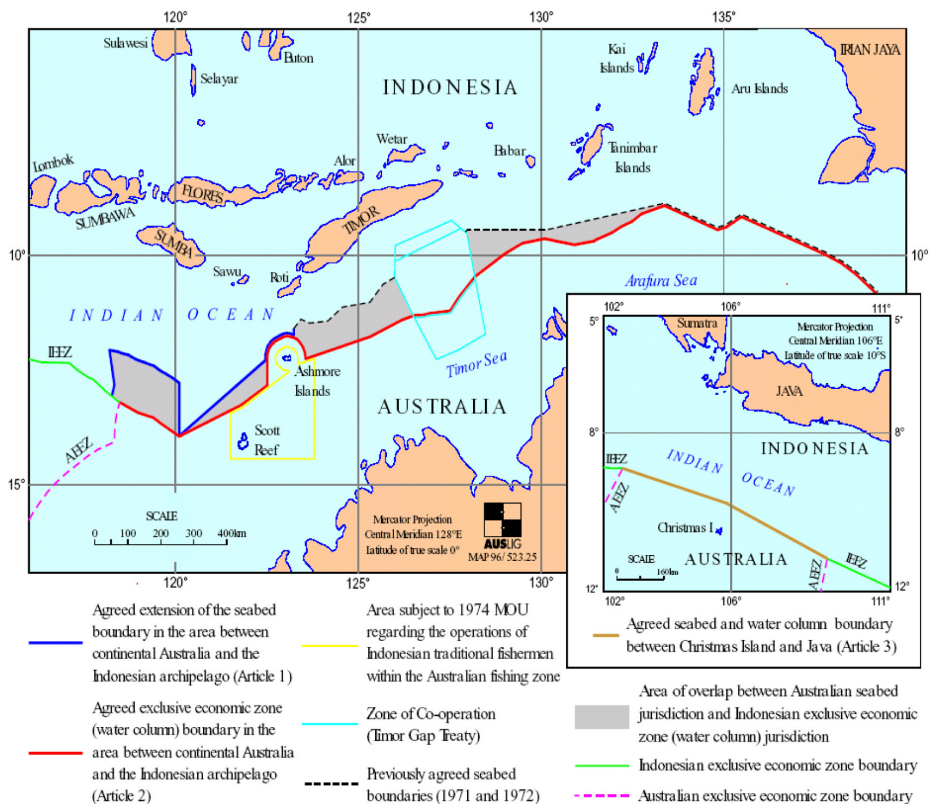


Figure1. Australia-Indonesia maritime boundaries

⁷ Delimitation in the Gulf of Maine (Canada/U.S.), 1984. *ICJ Reports* 246 (Gulf of Maine), para. 194.

of delimitations otherwise should be carried out separately are put into one “integrated, comprehensive and synthetic” operation.⁸ It is worth noting that not all the delimitations with only one line drawn belong to the single maritime delimitation. The term “single” refers to both the delimitation process and the delimitation result, rather than the result only. Thus, the drawing of a single line for sea-bed, subsoil and superjacent waters and the drawing of two coincident lines for sea-bed and subsoil on the one hand and superjacent waters on the other, amounts in practical terms to the same thing, but there is important difference between them, that is, while the single line results from one delimitation operation, “the two lines, even if coincident in location, stem from different strands of the applicable law”.⁹ Compared with separate delimitations the advantages of single delimitation are obvious. However, different from the delimitation of the continental shelf and the EEZ, “the concept of a single maritime boundary does not stem from multilateral treaty law but from State practice and that it finds its explanation in the wish of States to establish one uninterrupted boundary line delimiting the various-partially coincident-zones of maritime jurisdiction appertaining to them.”¹⁰ It is true that state practice exhibits an overwhelming trend towards the single maritime delimitation, but there is no provision in the LOS Convention or the customary international rule prescribing such a course of action. Therefore, states concerned can choose to delimit their continental shelf boundary and their EEZ boundary separately and to delimit the seabed line alone. The recent examples in this regard are, in 2003, Russia, Azerbaijan and Kazakhstan divided their continental shelves in the Caspian Sea,¹¹ while Vietnam and Indonesia delimited their continental shelf boundary in the South China Sea.¹² Furthermore, states can delimit two different boundaries for the seabed and the superjacent waters, such as the 1978 delimitation between Australia and Papua-New Guinea in the Torres Strait,¹³ and the 1997 Australia-Indonesia delimitation

8 Delimitation of the Maritime Areas between Canada and France, Award of 10 June, 1992, reprinted in 31 ILM 1145 (1992) (St. Pierre and Miquelon), Dissenting Opinion of Mr. Prosper Well, para. 39.

9 Maritime Delimitation in the Area between Greenland and Jan Mayen (Denmark v. Norway), 1993. *ICJ Reports* 38 (Jan Mayen), para. 42.

10 Case concerning Maritime Delimitation and Territorial Questions between Qatar and Bahrain (Qatar v. Bahrain), 2001. *ICJ Reports* 40 (Qatar v. Bahrain), para. 173.

11 The texts of the agreements between Kazakhstan-Russia, Azerbaijan-Russia, Azerbaijan-Kazakhstan, as well as the agreement of Azerbaijan-Kazakhstan-Russia are available in David A. Colson & Robert W. Smith (eds.), *International Maritime Boundaries* (Martinus Nijhoff Publishers, 2005), Vol. V, pp.4009-4056.

12 Agreement between the Government of the Socialist Republic of Vietnam and the Government of the Republic of Indonesia concerning the Delimitation of the Continental Shelf Boundary, signed on 26 June, 2003 and entered into force on 29 May, 2007 (http://en.wikipedia.org/wiki/Indonesia-Vietnam_border).

13 Treaty between Australia and the Independent State of Papua New Guinea concerning Sovereignty and Maritime Boundaries in the Area between the two Countries, including the Area known as Torres Strait and related Matters, signed on 18 December 1978 and entered into force on 15 February, 1985 (www.un.org/Depts/los/LEGISLATIONANDTREATIES/PDFFILES/TREATIES/AUS-PNG1978TS.PDF). For analysis, H. Burmester, *The Torres Strait Treaty: Ocean Boundary Delimitation by Agreement*, 76 *AJIL* 321 (1982).

in the Indian Ocean.¹⁴

This conclusion has also been evidenced by the judicial practices of the ICJ, for its decisions on the single delimitation have always been based on “the wish” of the parties, especially the agreement between them. Thus, though a single boundary has always been the result in all of the cases concerning maritime delimitation decided by the ICJ since 1984, with the exception of the *Libya/Malta* case, however, when such agreement existed, the Court would undertake a single maritime delimitation because it had the competence to do so, such as the 1984 *Gulf of Maine* case,¹⁵ the 2001 *Qatar v. Bahrain* case,¹⁶ the 2002 *Cameroon v. Nigeria* case,¹⁷ and the 2007 *Nicaragua v. Honduras* case.¹⁸ On the contrary, if no such agreement existed, the Court would delimit the continental shelf and the superjacent waters separately. Of course, in the latter case, the ICJ could use its discretion to determine two lines that are theoretically separate but in fact coincident, just as the 1993 *Jan Mayen* case. In that case, although Denmark asked for “a single line of delimitation of the fishery zone and continental shelf area,”¹⁹ Norway emphasized the absence of any such agreement of the parties for a single delimitation as in the *Gulf of Maine* case and contended that even the boundary for delimitation of the continental shelf and the boundary for the delimitation of the fishery zone would coincide, “the two boundaries would remain conceptually distinct.”²⁰ In this circumstance, the ICJ declared that “There is no agreement between the Parties for a single maritime boundary; the situation is thus quite different from that in the *Gulf of Maine* case. [...] The Court in the present case is not empowered-or constrained-by any such agreement for a single dual-purpose boundary.”²¹ On the other hand, the agreement between the parties for a single maritime boundary can be deemed to exist as long as no party put forward express objection to it. For example, in the 2009 *Black Sea* case (Romania v. Ukraine), Romania requested the ICJ to draw a single maritime boundary dividing the continental shelf and the EEZ of these two parties in the Black Sea.²² Though Ukraine did not mention the term “single maritime boundary”, it “submits that the Court adjudge and declare that the delimitation of the continental shelf and exclusive

14 Treaty between the Government of Australia and the Government of the Republic of Indonesia Establishing An Exclusive Economic Zone Boundary and Certain Seabed Boundaries, signed on 14 March, 1997 (www.un.org/Depts/los/LEGISLATIONANDTREATIES/PDFFILES/TREATIES/AUS-IDN1997EEZ.pdf). For analysis, Max Herriman & Martin Tsamenyi, The 1997 Australia-Indonesia Maritime Boundary Treaty: A Secure Legal Regime for Offshore Resource Development? 29 ODIL 361 (1998).

15 *Gulf of Maine*, p.246.

16 *Qatar v. Bahrain*, p.40.

17 Case Concerning the Land and Maritime Boundary between Cameroon and Nigeria (Cameroon v. Nigeria: Equatorial Guinea Intervening), ICJ Reports, 2002, 303 [Cameroon v. Nigeria], para. 286.

18 Territorial and Maritime Dispute (Nicaragua v. Honduras), Judgment of 8 October, 2007 (www.icj-cij.org) [Nicaragua v. Honduras], para. 261.

19 *Jan Mayen*, para. 41.

20 *Ibid.*

21 *Ibid.*, para. 43.

22 *Black Sea*, para. 12.

economic zones between the Parties is a delimitation line”²³ (emphasis). Thus, the ICJ decided that the subject-matter of the dispute “concerns the establishment of a single maritime boundary delimiting the continental shelf and exclusive economic zones between the two States in the Black Sea”.²⁴ The arbitral tribunals in the 1992 *St. Pierre and Miquelon* case²⁵ and the 2007 *Guyana v. Suriname* case²⁶ also followed this approach. In the 1985 *Guinea/Guinea-Bissau* case, the two parties requested the Tribunal to decide “the course of the boundary between the maritime territories appertaining respectively to” them,²⁷ while the Tribunal observed that “It is not disputed by the Parties that the maritime territories concerned are the territorial sea, exclusive economic zone and continental shelf; that these territories must be delimited by a single line”.²⁸ Similarly, in the 1999 *Eritrea/Yemen* case, the Tribunal, who was requested to provide rulings “delimiting maritime boundaries”,²⁹ decided that “the international boundary shall be a single all-purpose boundary”.³⁰

However, in the 2006 *Barbados v. Trinidad and Tobago* case, though Barbados sought a “single unified maritime boundary line, delimiting the exclusive economic zone and continental shelf between it and the Republic of Trinidad and Tobago,”³¹ Trinidad and Tobago expressly objected to this request on the basis that the continental shelf and the EEZ are separate and distinct institutions, that there may therefore be different lines of delimitation for each.³² Furthermore, Trinidad and Tobago argued that the parties had not agreed to request delimitation by means of a single maritime boundary, as in its view was required.³³ However, though recognized that Trinidad and Tobago had “conceptual reservations” in this regard,³⁴ the Tribunal, without any explanation, decided that “it has jurisdiction to delimit, by the drawing of a single maritime boundary, the continental shelf and EEZ appertaining to each of the Parties in the waters where their claims to these

23 *Ibid.*

24 *Ibid.*, para. 17.

25 *St. Pierre and Miquelon*, para. 1.

26 Arbitration between Guyana and Suriname (*Guyana v. Suriname*), Arbitral Tribunal constituted pursuant to Article 287 and in accordance with Annex VII, of the United Nations Convention on the Law of the Sea, Arbitration Award of 17 September, 2007 (www.pca-cpa.org) [*Guyana v. Suriname*], paras. 157, 161.

27 Article 2 of the Special Agreement, *Guinea/Guinea-Bissau Maritime Delimitation Case*, Decision of 14 February, 1985, reprinted in 77 *International Law Reports* (1988) [*Guinea/Guinea-Bissau*], para. 1.

28 *Guinea/Guinea-Bissau*, para. 42.

29 Permanent Court of Arbitration: *Eritrea-Yemen Arbitration*, Award of 17 December 1999 (Second Stage: Maritime Delimitation), reprinted in XL *ILM* 983 (2002) [*Eritrea/Yemen*], para. 6.

30 *Ibid.*, para. 132.

31 Barbados’ Statement of Claim and the Grounds on which It Is Based (www.pca-cpa.org/upload/files/SOC%20Barbados.pdf), para.15.

32 Case between Barbados and the Republic of Trinidad and Tobago (*Barbados v. Trinidad and Tobago*), Arbitral Tribunal constituted pursuant to Article 287 and in accordance with Annex VII, of the United Nations Convention on the Law of the Sea, Arbitration Award of 11 April, 2006 (www.pca-cpa.org) [*Barbados v. Trinidad and Tobago*], para. 296.

33 *Ibid.*, para. 296.

34 *Ibid.*, para. 297.

maritime zones overlap.”³⁵ In the latter part of the Award, the Tribunal tried to defend its decision by pointing to the fact that “it is evident that State practice with very few exceptions [...] has overwhelmingly resorted to the establishment of single maritime boundary lines and that courts and tribunals have endorsed this practice.”³⁶ As mentioned above, the single maritime delimitation has not become compulsory under the international customary rule. So, it is obvious that in the present case, the Tribunal had no competence to undertake a single delimitation in the light of the serious objections from Trinidad and Tobago. Indeed, the Tribunal could delimit the boundary of the continental shelf and the boundary of the EEZ separately, but, where appropriate, the two boundaries would coincide in location.

3. Interpretation of Article 83(1) of the LOS Convention

Article 83, paragraph 1 provides that delimitation of the continental shelf “shall be effected by agreement on the basis of international law, as referred to in Article 38 of the Statute of the International Court of Justice, in order to achieve an equitable solution.” This simple provision lays down the path, means and goal of the delimitation, that is, delimitation by agreement, delimitation on the basis of international law and achieving an equitable solution.

3.1 *Delimitation by agreement*

The Chamber of the ICJ stated in the *Gulf of Maine* case that “delimitation must above all be sought, while always respecting international law, through agreement between the parties concerned.”³⁷ The delimitation by agreement rule, reflecting the general principle of the relationship between states, is the “primary rule” which has been accorded priority over all other delimitation rules.³⁸ According to this rule, “delimitation must be the object of agreement between the States concerned.”³⁹ That is to say, maritime delimitations have to be effected through agreements, “an attempt by a unilateral act to establish international maritime boundary lines regardless of the legal position of other States is contrary to recognized principles of international law.”⁴⁰ It should be noted that this rule applies not only

³⁵ *Ibid.*, para. 217(i).

³⁶ *Ibid.*, para. 235.

³⁷ *Gulf of Maine*, paras. 22, 154.

³⁸ *Ibid.*, para. 22.

³⁹ *North Sea Continental Shelf* (FRG/Den.; FRG/Neth.), ICJ Reports, 1969, 3 [North Sea Continental Shelf], para. 85.

⁴⁰ *Continental Shelf* (Tunisia/Libya), ICJ Reports, 1982, 18 [Tunisia/Libya], para. 87.

to the delimitation of the boundary line, but also to the establishment of the “provisional arrangements” pending delimitation in the sense of Article 83(3) of the LOS Convention.⁴¹ The “provisional arrangements” entered into under Article 83 are agreements concluded between the states concerned.⁴² This means that such provisional arrangements must be reached by mutual consent between two or more states concerned and therefore excludes any possibility that such arrangements could be the result of a unilateral conduct of one party to the dispute, or the automatic application of some line.

In order to reach an agreement, the states concerned have obligation to carry out negotiation. Negotiators must conduct “in good faith and with the genuine intention of achieving a positive result.”⁴³ “They are under an obligation so to conduct themselves that the negotiations are meaningful, which will not be the case when either of them insists upon its own position without contemplating any modification of it.”⁴⁴ According to paragraph 2 of Article 83, “[i]f no agreement can be reached within a reasonable period of time, the States concerned shall resort to the procedures provided for in Part XV.”⁴⁵ Part XV of the LOS Convention stipulates four kinds of compulsory procedures entailing binding decisions.⁴⁶ However, the possibility of resorting to these procedures to resolve the delimitation disputes is restricted, given the option available to states under Article 298 of the LOS Convention. According to paragraph 1 of the article, “When signing, ratifying or acceding to this Convention or at any time thereafter, a State may, without prejudice to the obligations arising under section 1, declare in writing that it does not accept any one or more of the procedures provided for in section 2 with respect to one or more of the following categories of disputes: (a) (i) disputes concerning the interpretation or application of Articles 15, 74 and 83 relating to sea boundary delimitations [...]”⁴⁷ It is worth noting that though this article just provides for the delimitations of the territorial sea, the continental shelf

41 Article 83(3) provides that : “Pending agreement as provided for in paragraph?1, the States concerned, in a spirit of understanding and cooperation, shall make every effort to enter into provisional arrangements of a practical nature and, during this transitional period, not to jeopardize or hamper the reaching of the final agreement. Such arrangements shall be without prejudice to the final delimitation.” The Tribunal in the *Guyana v. Suriname* case held that the obligation to make every effort to enter into provisional arrangements of a practical nature contained in Article 83(3) “is designed to promote interim regimes and practical measures that could pave the way for provisional utilization of disputed areas pending delimitation” and “[t]here have been a number of examples of arrangements for the joint exploration and exploitation of maritime resources, often referred to as joint development agreements.” *Guyana v. Suriname*, paras. 460, 462.

42 Rainer Lagoni, *Interim Measures Pending Maritime Delimitation Agreements*, 78 AJIL (1984), p.358.

43 *Gulf of Maine*, para. 112.

44 *North Sea Continental Shelf*, para. 85(a).

45 In the view of the ICJ, “Recourse to delimitation by arbitral or judicial means is in the final analysis simply an alternative to direct and friendly settlement between the parties.” *Gulf of Maine*, para. 22.

46 According to Article 287 of the LOS Convention, these procedures include: (a) the International Tribunal for the Law of the Sea established in accordance with Annex?VI; (b) the ICJ; (c) an arbitral tribunal constituted in accordance with Annex?VII; (d) a special arbitral tribunal constituted in accordance with Annex?VIII for one or more of the categories of disputes specified therein.

47 LOS Convention, Article 298 (1) (a) (i).

and the EEZ which states parties can opt out of the compulsory procedures and does not mention the delimitations of the contiguous zone and the fishery zone, as well as the single maritime delimitation all of which the LOS Convention does not provide for, once a state party declares that it does not accept the compulsory procedures entailing binding decisions with respect to the delimitation disputes in Article 298 (1)(a)(i), it should be deemed that this state party has opted out of the compulsory procedures of the LOS Convention for all of the delimitation disputes to which it is a party.⁴⁸

3.2 Delimitation on the basis of international law

The ICJ observed in the 1951 *Fisheries* case that “The delimitation of sea areas has always an international aspect; it cannot be dependent merely upon the will of the coastal State as expressed in its municipal law. [...] the validity of the delimitation with regard to other States depends upon international law.”⁴⁹

3.2.1 The equidistance/special circumstances rule

As far as the treaty law on the continental shelf delimitation is concerned, Article 6 of the 1958 Convention on the Continental Shelf provides for a clear rule, that is, the “equidistance/special circumstances rule.” According to this rule, in the absence of agreement and unless another boundary line is justified by special circumstances, the boundary is a median line in the case of delimitation between opposite coasts and an equidistance line in the case of delimitation between adjacent coasts.⁵⁰ No legal consequences flow from the use of the terms “median line” and “equidistance line” since “the method of delimitation is the same for both”- the equidistance method.⁵¹ It should be noted that what Article 6 provides for is not an independent equidistance rule, but an equidistance rule conditioned by the special circumstances rule, that is, “a combined equidistance-special circumstances rule.”⁵² The reason why the “special circumstances” condition was introduced

48 Until March, 2009, sixteen states have made such declarations. United Nations Convention on the Law of the Sea: Declarations made upon signature, ratification, accession or succession or anytime thereafter (www.un.org/Depts/los/convention_agreements/convention_declarations.htm).

49 *Fisheries Case* (United Kingdom v. Norway), ICJ Reports, 1951, 116, p.132.

50 Article 6 of the 1958 Convention on the Continental Shelf provides that “1. Where the same continental shelf is adjacent to the territories of two or more States whose coasts are opposite each other, the boundary of the continental shelf appertaining to such States shall be determined by agreement between them. In the absence of agreement and unless another boundary line is justified by special circumstances, the boundary is the median line, every point of which is equidistant from the nearest points of the baselines from which the breadth of the territorial sea of each State is measured. 2. Where the same continental shelf is adjacent to the territories of two adjacent States, the boundary of the continental shelf shall be determined by agreement between them. In the absence of agreement and unless another boundary line is justified by special circumstances, the boundary shall be determined by application of the principle of equidistance from the nearest points of the baselines from which the breadth of the territorial sea of each State is measured.”

51 *Black Sea*, para. 116.

52 Case concerning the Delimitation of the Continental Shelf between the United Kingdom of Great Britain and

into Article 6 is, “owing to particular geographical features or configurations, application of the equidistance principle might not infrequently result in an unreasonable or inequitable delimitation of the continental shelf. In short, the role of the ‘special circumstances’ condition in Article 6 is to ensure an equitable delimitation.”⁵³ Therefore, only where no another boundary line is justified by special circumstances, can the equidistance line be used as the delimitation line. Furthermore, the ICJ in the *Nicaragua v. Honduras* case, when dealing with the delimitation of the territorial sea, declared that “Nothing in the wording of Article 15 suggests that [...] ‘special circumstances’ may only be used as a corrective element to a line already drawn” on the basis of equidistance.⁵⁴ Article 15 of the LOS Convention concerns the delimitation of the territorial sea,⁵⁵ and the rule provided for in it is also referred to as the “equidistance/special circumstances” rule and regarded as having a customary character.⁵⁶ The findings of the ICJ imply that the existence of special circumstances may justify precluding the application of equidistance at the outset.⁵⁷ Anyway, as far as the continental shelf delimitation is concerned, the equidistance/special circumstances rule is a treaty law, therefore can only binds the state parties to the 1958 Convention and is not applicable in the delimitation involving non-states parties.

3.2.2 The equitable principles/relevant circumstances rule

As regards the customary rules on the continental shelf delimitation, they are expressed in the so-called “equitable principles/relevant circumstances rule”, which “has been developed since 1958 in case-law and State practice”.⁵⁸ This rule is based upon equitable principles and relevant circumstances,⁵⁹ and requires that “the delimitation is to be effected in accordance with equitable principles and taking account of all relevant circumstances.”⁶⁰

About the equitable principles for the continental shelf delimitation, the ICJ listed some “well-known examples” in the *Libya/Malta* case and observed that “The nature of equity is nowhere more evident than in these well-established principles”.⁶¹ They are: “the

Northern Ireland and the French Republic, Decision of 30 June, 1977, reprinted in 18 ILM 397 (1979) [Anglo-French], para. 68.

⁵³ *Ibid.*, para. 70.

⁵⁴ *Nicaragua v. Honduras*, para. 280.

⁵⁵ Article 15 of the LOS Convention provides that “Where the coasts of two States are opposite or adjacent to each other, neither of the two States is entitled, failing agreement between them to the contrary, to extend its territorial sea beyond the median line every point of which is equidistant from the nearest point on the baselines from which the breadth of the territorial seas of each of the two States is measured. The above provision does not apply, however, where it is necessary by reason of historic title or other special circumstances to delimit the territorial seas of the two States in a way which is at variance therewith.”

⁵⁶ *Qatar v. Bahrain*, para. 176.

⁵⁷ *Nicaragua v. Honduras*, para. 281.

⁵⁸ *Qatar v. Bahrain*, para. 231.

⁵⁹ Jan Mayen, para. 56.

⁶⁰ *Libya/Malta*, para. 79(A).

⁶¹ *Ibid.*, paras. 46, 47.

principle that there is to be no question of refashioning geography, or compensating for the inequalities of nature; the related principle of non-encroachment by one party on the natural prolongation of the other, which is no more than the negative expression of the positive rule that the coastal State enjoys sovereign rights over the continental shelf off its coasts to the full extent authorized by international law in the relevant circumstances; the principle of respect due to all such relevant circumstances; the principle that although all States are equal before the law and are entitled to equal treatment, ‘equity does not necessarily imply equality’ [...], nor does it seek to make equal what nature has made unequal; and the principle that there can be no question of distributive justice”.⁶² Regarding the non-refashioning nature principle, the ICJ declared in the *North Sea Continental Shelf* cases that “There can never be any question of completely refashioning nature and equity does not require that a State without access to the sea should be allotted an area of continental shelf, any more than there could be a question of rendering the situation of a State with an extensive coastline similar to that of a State with a restricted coastline [...] and it is not such natural inequalities as these that equity could remedy. [...] It is therefore not a question of totally refashioning geography whatever the facts of the situation but, given a geographical situation of quasi-equality as between a number of States, of abating the effects of an incidental special feature from which an unjustifiable difference of treatment could result.”⁶³ What one can learn from these findings is that the essential requirement of equity is, giving equal treatment to states with equal geographical situations, while giving unequal treatment to states with unequal natural situations. Concerning the non-encroachment by one party on the natural prolongation of the other principle, the ICJ declared that “delimitation is to be effected [...] in such a way as to leave as much as possible to each Party all those parts of the continental shelf that constitute a natural prolongation of its land territory into and under the sea, without encroachment on the natural prolongation of the land territory of the other”.⁶⁴ It is worth noting that while most of these equitable principles mentioned above can be applicable for the EEZ delimitation, the non-encroachment principle is obviously exclusive to the continental shelf delimitation.

Similar to the LOS Convention, the equitable principles/relevant circumstances rule provides “no single obligatory method of delimitation.”⁶⁵ Moreover, the ICJ and the arbitral tribunals repeatedly emphasized that “equidistance is not [...] either a mandatory legal principle, or a method having some privileged status in relation to other methods.”⁶⁶ The ICJ declared in the *Libya/Malta* case that it “is unable to accept that, even as a preliminary and provisional step towards the drawing of a delimitation line, the equidistance method

⁶² *Ibid.*, para. 46.

⁶³ *North Sea Continental Shelf*, para. 91.

⁶⁴ *Ibid.*, para. 101 (C).

⁶⁵ *Tunisia/Libya*, para. 111.

⁶⁶ *Ibid.*, para. 110.

is one which must be used, or that the Court is required, as a first step, to examine the effects of a delimitation by application of the equidistance method.”⁶⁷ The application of equidistance depends on the “appreciating the appropriateness of the equidistance method as a means of achieving an equitable solution,”⁶⁸ and “[t]he application of equitable principles in the particular relevant circumstances may [...] require the adoption of another method, or combination of methods, of delimitation, even from the outset.”⁶⁹ It is true that since the 1993 *Jan Mayen* case the ICJ has changed its attitude towards equidistance dramatically and tended to “begin the process of delimitation by a median line provisionally drawn”.⁷⁰ However, the two litigants in the *Jan Mayen* case are parties to the 1958 Continental Shelf Convention and the following cases all concerned the single delimitation, instead of the delimitation of the continental shelf. What’s more important is, “the essence of the method normally followed in international practice is that the equidistance line is only a provisional line which serves as the starting point for the consideration of relevant circumstances that might require its adjustment in order to achieve the equitable solution that the law requires.”⁷¹ For the purpose of equity, the provisional equidistance line is subject to modification or adjustment,⁷² since “under existing law, it must be demonstrated that the equidistance method leads to an equitable result in the case in question.”⁷³ Until now, among the nine delimitation cases heard by the ICJ, the strict equidistance line was used as the delimitation line only in two cases.⁷⁴ Third, though widely applied in the single maritime delimitation, the status of equidistance as a delimitation method has not changed. As the Tribunal in the 2006 *Barbados v. Trinidad and Tobago* case put it, “no method of delimitation can be considered of and by itself compulsory and no court or tribunal has so held,” and if “a well-founded justification” exists, “A different method” would be applied.⁷⁵ It is worth noting that in the 2007 *Nicaragua v. Honduras* case, the ICJ not only repeated that “the equidistance method does not automatically have priority over other methods of delimitation and, in particular circumstances, there may be factors which make the application of the equidistance method inappropriate,”⁷⁶ but also applied the method of bisector from the outset in the delimitation between the adjacent coasts of the parties’ mainland.⁷⁷

67 Libya/Malta, para. 43.

68 Anglo-French, para. 97.

69 Libya/Malta, para. 43.

70 Jan Mayen, para. 53.

71 Barbados v. Trinidad and Tobago, para. 317.

72 Cameroon v. Nigeria, para. 295.

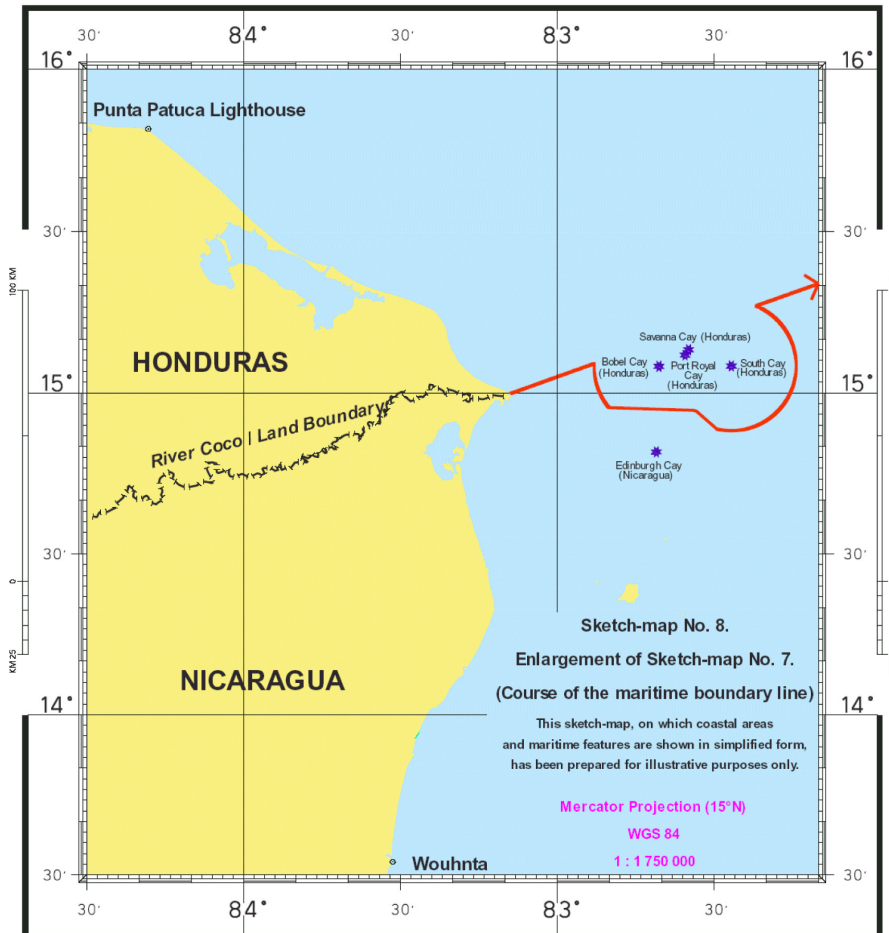
73 Libya/Malta, para. 63.

74 They are: the 2002 Cameroon v. Nigeria case and the 2009 Black Sea case.

75 Barbados v. Trinidad and Tobago, para. 306.

76 Nicaragua v. Honduras, para. 272.

77 *Ibid.*, paras. 287-298. But the ICJ used an equidistance line to delimit the territorial sea boundary between the opposite-facing islands of these two parties. *Ibid.*, paras. 304-305.



Source : Nicaragua v. Honduras case, ICJ Judgment, p.92.

Figure 2. The maritime delimitation in the 2007 Nicaragua v. Honduras case

The reason why equidistance can not be granted the status of compulsory method for the continental shelf delimitation is that the use of this method can “under certain circumstances” produce inequitable results,⁷⁸ in the sense that an equidistance line would give equal treatment to states with unequal natural situations, or give unequal treatment to states with equal situations, thus leaving “one of the States concerned areas that are a natural prolongation of the territory of the other”.⁷⁹ These circumstances may particularly occur in the case where the continental shelf area to be delimited consists of not one unitary natural prolongation common to both parties, but “two separate natural prolongations”.⁸⁰

⁷⁸ North Sea Continental Shelf, paras. 22, 24.

⁷⁹ *Ibid.*, paras. 57–58.

⁸⁰ Tunisia/Libya, para. 66.

Because the construction of the equidistance line is “heavily dependent on the physical geography”,⁸¹ and does not consider the geology and geomorphology of the seabed and subsoil, the use of the equidistance method in this situation would cause areas which are the natural prolongation of the territory of the wide-margin state to be attributed to the narrow-margin state. Indeed, the notion of equidistance is not “an inescapable a priori accompaniment of basic continental shelf doctrine”.⁸² Equidistance is based upon the notion of proximity and will leave “to each of the parties concerned all those portions of the continental shelf that are nearer to a point on its own coast than they are to any point on the coast of the other party”,⁸³ while “continental shelf doctrine from the start [...] does not imply any fundamental or inherent rule the ultimate effect of which would be to prohibit any State (otherwise than by agreement) from exercising continental shelf rights in respect of areas closer to the coast of another State”.⁸⁴ By contrast, “whenever a given submarine area does not constitute a natural-or the most natural-extension of the land territory of a coastal State, even though that area may be closer to it than it is to the territory of any other State, it cannot be regarded as appertaining to that State; -or at least it cannot be so regarded in the face of a competing claim by a State of whose land territory the submarine area concerned is to be regarded as a natural extension, even if it is less close to it.”⁸⁵ Of course, the introduction of the distance criterion into the concept of continental shelf “departs from the principle that natural prolongation is the sole basis of the title” to the continental shelf and “The legal concept of the continental shelf as based on the ‘species of platform’ has thus been modified by this criterion.”⁸⁶ However, the concept of natural prolongation remains “essential [element] in the juridical concept of the continental shelf”.⁸⁷ Thus, where the continental shelf to be delimited consists of two separate natural prolongations, one exceeds beyond the distance of 200 nautical miles and the other does not, it is not appropriate to use equidistance.

3.2.3 Relevant circumstances

The concept of relevant circumstance “can be described as a fact necessary to be taken into account in the delimitation process”.⁸⁸ According to the ICJ, “Yet although there may be no legal limit to the considerations which States may take account of, this can hardly be true for a court applying equitable procedures. For a court, although there is assuredly no closed list of considerations, it is evident that only those that are pertinent

81 Black Sea, para. 118.

82 North Sea Continental Shelf, para. 46.

83 *Ibid.*, para. 6.

84 *Ibid.*, para. 42.

85 *Ibid.*, para. 43.

86 Tunisia/Libya, paras. 47–48.

87 Libya/Malta, para. 34.

88 Jan Mayen, para. 55.

to the institution of the continental shelf as it has developed within the law and to the application of equitable principles to its delimitation, will qualify for inclusion.”⁸⁹ In practice, coastal geography is the most important relevant circumstance, mainly including islands, coastal configuration and the marked disparity between the lengths of the coastlines belonging to the states concerned.

Islands are the most frequently emerged relevant circumstances in the practice of maritime delimitation.⁹⁰ As the jurisprudence has indicated, the ICJ may on occasion decide not to take account of very small islands or decide not to give them their full potential entitlement to maritime zones, should such an approach have a disproportionate effect on the delimitation line under consideration.⁹¹ Generally speaking, the effect of a given island in a specific delimitation primarily depends upon the following considerations, though no uniform standard in this regard has come into being. First of all, the factual status of the relevant island in the delimitation should be considered, that is to say, whether the island itself constitutes one indispensable component of the delimitation area,⁹² or just an incidental physical feature appearing in the delimitation. The dividing criterion for these two situations is whether the particular island constitutes the primary components of the geographical region relevant to the delimitation, in a sense that if it were not exist, the delimitation in the region would be substantially different. For example, in the *Jan Mayen* case, if the island of Jan Mayen had not existed, there would be no delimitation at all. Therefore, in responding to Denmark’s claim that Jan Mayen was a special circumstance, Norway contended that Jan Mayen was not an incidental physical feature but was itself one of the components of the delimitation area.⁹³ In addition, the ICJ in the *Libya/Malta* case also noted that the relationship of Malta’s coasts with the coasts of its neighbors was different from what it would be if it were a part of the territory of one of them. In other words, it might well be that the sea boundaries in this region would be different if the islands of Malta did not constitute an independent state, but formed a part of the territory of one of the surrounding countries.⁹⁴ Where the island concerned itself constitutes the primary component of the delimitation area, it cannot be regarded as a special circumstance and its effect in the delimitation therefore cannot be reduced for this reason, because no feature can become a special circumstance in the delimitation of its own coastal projections.⁹⁵ While in the latter case, any island may be considered as a special circumstance, regardless

⁸⁹ *Libya/Malta*, para. 48.

⁹⁰ generally, Derek Bowett, *Islands, Rocks and Low-Tide Elevations in Maritime Boundary Delimitation*, in 1 Jonathan I. Charney & Lewis M. Alexander (eds), *International Maritime Boundaries* (Martinus Nijhoff Pub. 1993), pp.131-151.

⁹¹ *Black Sea*, para. 185.

⁹² Whether the island in question is independent or not does not matter for the purpose of maritime delimitation. For example, *St. Pierre and Miquelon*, para. 42.

⁹³ *Jan Mayen*, (Shahabuddeen, J., sep. op.).

⁹⁴ *Libya/Malta*, para. 59.

⁹⁵ *Jan Mayen*, (Shahabuddeen, J., sep. op.).

of its population and size. The Saint Pierre and Miquelon islands in the 1992 arbitration between Canada and France and the Channel Islands in the 1977 *Anglo-French* case provide good examples for these two situations respectively. While in the former case there is no French coast opposite Newfoundland, in the latter the mainland coasts of France and the United Kingdom are opposite each other.⁹⁶ The Tribunal in the 1977 case just left to the Channel Islands a 12-nautical-mile zone of seabed and subsoil,⁹⁷ while the 1992 Tribunal granted to Saint Pierre and Miquelon an additional twelve nautical miles from the limit of its territorial sea, for its EEZ in the western sector,⁹⁸ and a full 200 nautical miles EEZ in the southern sector, though Saint Pierre and Miquelon is much smaller and less developed than the Channel Islands,⁹⁹ for the situation of the Channel Islands was substantially different from that of the Saint Pierre and Miquelon, “because of the proximity of the English coast. The Channel Islands were seen [...] as an incidental feature in a delimitation between two mainland and approximately commensurate, coasts.”¹⁰⁰

Second, for those islands which are regarded as incidental features, the effect of them in delimitation is up to the balance between their importance and their potential influence on the delimitation line. That is to say, in the light of their importance, if given certain effect, whether they will distort the boundary line disproportionately. The ICJ in the *Libya/Malta* case said that “the equitableness of an equidistance line depends on whether the precaution is taken of eliminating the disproportionate effect of certain ‘islets, rocks and minor coastal projections’.”¹⁰¹ The importance of an island includes such elements as its population, size and economic development. The location of the island in relation to the delimitation line fixed by reference to the primary components of the relevant geographical region determines the influence it could exert on the line. According to the distance between the islands and the coasts of the mainland which they belong to, islands can roughly be divided into four groups from near to far: 1) offshore islands within 24 nautical miles away of the mainland; 2) offlying islands beyond 24 nautical miles away of the mainland; 3) “islands in the median zone”, including Island on the right side, Island astride and Island on the wrong side; and 4) detached islands.¹⁰² Under international jurisprudence and state practice, the nearer an island closes to the delimitation line, the higher requirement it has to satisfy in order to be granted some effect. Therefore, the effect of these four groups

96 The Tribunal in the 1977 case referred to the islands of St. Pierre and Miquelon and declared that case differed from the present case “in important respects. First, that case is not one of islands situated [...] between the coasts of opposite States, so that no question arises there of a delimitation between States, whose coastlines are in an approximately equal relation to the continental shelf to be delimited.” *Anglo-French*, para. 200.

97 *Ibid.*, paras. 202–203.

98 *St. Pierre and Miquelon*, para. 69.

99 It has an area of 237 square kilometres and consists of two main islands, Miquelon and Saint Pierre, several smaller islands and islets and many drying rocks. *Ibid.*, para. 22.

100 *St. Pierre and Miquelon*, para. 42.

101 *Libya/Malta*, para. 64.

102 Hiran W. Jayewardene, *The Regime of Islands in International Law* (Martinus Nijhoff Pub. 1990), p.354.

of islands in delimitation is usually reduced in subsequence and the islands in the median zone as well as the detached islands have generally been given very reduced or no effect.¹⁰³ Besides, the sovereign status of the island should also be taken into account and the fact that the sovereignty over the island in question is subject to dispute usually reduces the effect of the island in delimitation or even makes it disregard completely.¹⁰⁴ For examples, the disputed Al Baina and Al Kabir were used as the turning points of the boundary in the 1958 delimitation between Bahrain and Saudi Arabia, therefore have no maritime area at all and the Farsi and Arabi in the delimitation between Iran and Saudi Arabia of 1968 were given only 12 nautical miles territorial sea.¹⁰⁵ This approach is more obvious in the cases where the disputed islands are completely taken by one party. For example, in the *Eritrea/Yemen* case, the Tribunal, on the one hand, gave all of the disputed islands to Yemen;¹⁰⁶ on the other hand, gave them only 12 nautical miles territorial sea in the delimitation.¹⁰⁷

Third, the overall geography of the delimitation area has to be taken into consideration as well. Within the enclosed sea or relatively narrow waters, the effect of islands in delimitation is apt to be limited, for in the narrow waters, there is less scope for redressing inequities than in the open waters.¹⁰⁸

In this context, it is worth noting that the legal character of a maritime feature as “island” or “rock” in terms of Article 121 of the LOS Convention and its effect in the maritime delimitation are two different though related issues. The legal character is only one factor among those relevant to determining the effect of a feature in delimitation. As long as it is taken as exerting disproportionate effect on the boundary line, it will become a relevant circumstance and its effect in delimitation will be cut down accordingly. These are the reasons why Kerkennahs Islands, which have an area of 180 square kilometers, population of 15,000 and lie some 11 nautical miles east of the Tunisian coast, were given half effect in the *Tunisia/Libya* case.¹⁰⁹ Another example is the Channel Islands in the *Anglo-French* case. In order to support its arguments that the Channel Islands themselves constitute the relevant opposite coast for the purpose of delimiting the median line, the Britain emphasized the importance of the Channel Islands, including the total area of the

103 For details, GAO Jianjun, *International Maritime Delimitation* (in Chinese) (Peking University Press, 2005), pp.144~150.

104 Hiran W. Jayewardene, *The Regime of Islands in International Law*, p.487.

105 Agreement between Qatar and Abu Dhabi on the Settlement of Maritime Boundaries and Ownership of Islands, signed on 20 March, 1969 and entered on the same day (www.un.org/Depts/los/LEGISLATIONANDTREATIES/PDFFILES/TREATIES/QAT-ARE1969MB.PDF).

106 Permanent Court of Arbitration: *Eritrea-Yemen Arbitration*, Award of 9 October, 1998 (First Stage: Territorial Sovereignty and Scope of Dispute), reprinted in XL ILM 900 (2002), paras. 124, 475, 482, 508, 524.

107 *Eritrea/Yemen*, para. 160.

108 Faraj Abdullah Ahnish, *The International Law of Maritime Boundaries and the Practice of States in the Mediterranean Sea*, p.378. Also *Anglo-French*, para. 200.

109 *Tunisia/Libya*, paras. 128~129.

Islands is approximately 75 square miles, their total population is about 130,000, the volume of their sea and air traffic and their commerce is substantial, they are highly developed, busy territories which provide financial facilities of international repute, they have their own legislative assemblies, fiscal and legal systems, Courts of law and systems of local administration, as well as their own coinage and postal service and legally, they are part neither of the United Kingdom nor of the Colonies but have for several hundred years been direct dependencies of the Crown. However, the Tribunal found that for the purpose of delimitation, it must treat the Channel Islands only as islands of the United Kingdom, not as semi-independent states entitled in their own right to their own continental shelf vis-a-vis France,¹¹⁰ and decided to enclose them in an enclave of 12 nautical miles.¹¹¹ A more recent example comes from the Black Sea case, where the parties disagreed as to the proper characterization of Serpents' Island and the role this maritime feature should play in the delimitation. Serpents' Island is a natural feature situated in the north-western part of the Black Sea, approximately 20 nautical miles to the east of the Danube delta. Serpents' Island, with the highest point is 41 m above sea level,¹¹² is above water at high tide, has a surface area of approximately 0.17 square kilometres and a circumference of approximately 2,000 m.¹¹³ Romania maintained that Serpents' Island was a rock incapable of sustaining human habitation or economic life of its own and therefore had no EEZ or continental shelf, as provided for in Article 121, paragraph 3, of the LOS Convention,¹¹⁴ and should play no role in the delimitation beyond 12 nautical miles.¹¹⁵ On the contrary, Ukraine argued that Serpents' Island was indisputably an "island" under Article 121, paragraph 2, of the LOS Convention, rather than a "rock",¹¹⁶ and should be taken into account as one of the relevant base points for the construction of the provisional equidistance line.¹¹⁷ The conclusion of the ICJ was that "Serpents' Island should have no effect on the delimitation in this case, other than that stemming from the role of the 12-nautical-mile arc of its territorial sea".¹¹⁸ Meanwhile, the ICJ held that it did not need to consider whether Serpents' Island falls under paragraphs 2 or 3 of Article 121 of the LOS Convention nor their relevance to this case.¹¹⁹ Indeed, in such situations as the present case, whether

¹¹⁰ Anglo-French, para. 186.

¹¹¹ *Ibid.*, paras. 171, 202.

¹¹² Snake Island (Black Sea), available at Wikipedia website: [en.wikipedia.org/wiki/Snake_Island_\(Black_Sea\)](http://en.wikipedia.org/wiki/Snake_Island_(Black_Sea)).

¹¹³ Black Sea, para. 16.

¹¹⁴ *Ibid.*, para. 180. Article 121 (3) provides that "Rocks which cannot sustain human habitation or economic life of their own shall have no exclusive economic zone or continental shelf."

¹¹⁵ Black Sea, paras. 181~182.

¹¹⁶ *Ibid.*, para. 184. Article 121(2) provides that "Except as provided for in paragraph 3, the territorial sea, the contiguous zone, the exclusive economic zone and the continental shelf of an island are determined in accordance with the provisions of this Convention applicable to other land territory."

¹¹⁷ Black Sea, paras. 183, 125~126.

¹¹⁸ *Ibid.*, para. 188.

¹¹⁹ *Ibid.*, para. 187.

Serpents' Island falls under paragraph 2 or paragraph 3 of Article 121, the decision of the ICJ that it should be ignored in the delimitation will not be affected. First, because the delimitation is to be effected between the coasts of the mainland of the two parties, Serpents' Island is not one indispensable component of the delimitation area but an incidental physical feature. Second, though Serpents' Island is situated approximately 20 nautical miles to the coast of Ukraine and therefore belongs to the group of offshore islands, the distance between the island and the equidistance line fixed by reference to the general configuration of the coasts of the parties is less than 12 nautical miles, which means that Serpents' Island should be regarded as the island in the median zone. If Serpents' Island had been used as the base point, the equidistance line would have been suppressed much to the coast of Romania. On the other hand, though the two parties took different views as to the legal character of Serpents' Island, they did not dispute that it was a tiny feature with small population on it.¹²⁰ Thus, Serpents' Island, if given some effect, would "distort the boundary and have disproportionate effects".¹²¹ Moreover, according to Romania, the two states agreed in 1997 that Ukraine accepted that Serpents' Island could receive no effect in the maritime delimitation in exchange for the fact that Romania formally confirmed that Serpents' Island belonged to Ukraine.¹²² If it is true, it will be a typical arrangement for the effect of disputed islands in the maritime delimitation. Third, the Black Sea, where the delimitation in the present case is to be carried out, is an enclosed sea and consists of the territorial seas and EEZs of the coastal states which border it.¹²³

As far as the Diaoyu Islands (Senkaku Islands in Japanese) in the delimitation between China and Japan,¹²⁴ and the Dokdo in the delimitation between Korea and Japan

120 About 100 inhabitants live on the island, mostly frontier guard servicemen with their families and technical personnel. Snake Island (Black Sea).

121 Qatar v. Bahrain, para. 247.

122 Black Sea, para. 33. Also The Additional Agreement concluded with reference to Article 2 of the Treaty on the Relations of Good Neighbourliness and Co-operation between Romania and Ukraine, 2 June, 1997, paragraph 4, in Black Sea, para. 35.

123 *Ibid.*, para. 15. Romania argued that the Black Sea's nature as an enclosed sea constituted a relevant circumstance which must be taken into account in the delimitation. *Ibid.*, para. 171.

124 Besides, China and Japan are arguing over the legal status of the Japanese maritime feature Okinotori Shima, which consists of two tiny rocks. In the view of Japan, Okinotori is an island and therefore is entitled to its own EEZ and continental shelf. In 2008, Japan submitted the information concerning the outer limits of its continental shelf beyond 200 nautical miles, including those beyond 200 nautical miles measured from the Okinotori, to the Commission on the Limits of the Continental Shelf. However, China challenges the view of Japan. According to China, Okinotori, on its natural conditions, obviously cannot sustain human habitation or economic life of its own, so is in fact a rock as referred to in the Article 121(3) of the LOS Convention and therefore shall have no EEZ or continental shelf, even less shall it have the right to the extended continental shelf beyond 200 nautical miles. Accordingly, China requires the Commission take no action on the portions concerning Okinotori. the Note of China in relation to the Japanese Submission, available at (http://www.un.org/Depts/los/clcs_new/submissions_files/jpn08/chn_6feb09_e.pdf). Also Leticia Diaz, Barry Hart Dubner and Jason Parent, according to them, Okinotori is a rock and the Japanese behavior "is out of conformity with the intention and purpose of the 1982 LOS Convention". Leticia Diaz, Barry Hart Dubner

are concerned, both of them should be given no effect for the following reasons. First, these islands are not indispensable components of the relevant areas where the delimitations are to be effected, but only incidental physical features, therefore have no independent status in the delimitation concerned. Second, these islands belong to the so-called “islands in the median zone”.¹²⁵ Since islands of this kind will influence the boundary line very much, they are usually disregarded or given nominal effect in state practice and jurisprudences. In few cases where they were given full or major effect, the islands concerned normally have large areas and big population. However, none of the Diaoyu Islands or the Dokdo is densely inhabited or reportedly has much human economic activity. What’s more important is, the sovereignty over these islands is under serious dispute between the states concerned. Third, the maritime area where the delimitation is to be carried out is an enclosed sea (for the Dokdo) or a semi-enclosed sea (for the Diaoyu Islands). In sum, because of their small area, abominable natural circumstances, midway location, as well as their sovereignty being sharply disputed, in order to achieve an equitable solution, Diaoyu Islands and the Dokdo should be disregarded in the relevant maritime delimitations.

Besides the islands, the marked disproportion between lengths of the parties’ coasts is another relevant circumstance that has been frequently taken into account in the construction of a delimitation line. Indeed, whenever there existed marked disparity between the lengths of the coastlines belonging to the parties, the ICJ and arbitral tribunals would take it into consideration as an important or even decisive circumstance and modify the preliminary line in favor of the party who had a longer coastline. The Chamber of the ICJ in the *Gulf of Maine* case considered that “in certain circumstances, the appropriate consequences may be drawn from any inequalities in the extent of the coasts of two States into the same area of delimitation.”¹²⁶ It then further elaborated on this point by stating “that a substantial disproportion to the lengths of those coasts that resulted from a delimitation effected on a different basis would constitute a circumstance calling for an appropriate correction.”¹²⁷ In that case, although the ratio between the coastal fronts of the United States and Canada on the Gulf of Maine is only 1.38:1, however, in the Chamber’s view, “This difference in length is a special circumstance of some weight, which [...] justifies a correction of the equidistance line.” At last, the Chamber adjusted the provisional median line in favor of the America.¹²⁸ In the *Libya/Malta* case, the ICJ considered that “a considerable disparity” between the coastal lengths of the parties “constitutes a relevant circum-

and Jason Parent, When is a “Rock” an “Island”- Another Unilateral Declaration Defies “Norms” of International Law, 15 Michigan State Journal of International Law 519 (2007).

125 The Diaoyu Islands are located approximately midway between the Chinese island of Taiwan and Japanese Ryukyu Islands. The shortest distance between these islets and Japanese territory as well as China’s Taiwan is some 90 nautical miles.

126 *Gulf of Maine*, para. 157.

127 *Ibid.*, para. 185.

128 *Ibid.*, paras. 184, 222.

stance which should be reflected in the drawing of the delimitation line.”¹²⁹ In this case, the relevant coast of Libya is 192 miles long, while the relevant coast of Malta (excluding the islet of Filfla) is 24 miles long. “In the view of the Court, this difference is so great as to justify the adjustment of the median line so as to attribute a larger shelf area to Libya; the degree of such adjustment does not depend upon a mathematical operation”.¹³⁰ In the *Jan Mayen* case, the ICJ found that the disparity between the lengths of the coasts of Jan Mayen and Greenland (approximately 1:9) constituted a “special circumstance” requiring modification of the provisional median line, by moving it closer to the coast of Jan Mayen.¹³¹ In the *Cameroon v. Nigeria* case, the ICJ acknowledged “that a substantial difference in the lengths of the parties’ respective coastlines may be a factor to be taken into consideration in order to adjust or shift the provisional delimitation line”.¹³² In the *Black Sea* case, the ICJ repeated that “Where disparities in the lengths of coasts are particularly marked, the Court may choose to treat that fact of geography as a relevant circumstance that would require some adjustments to the provisional equidistance line to be made.”¹³³ In this case, the ratio of the coastal lengths of the parties is approximately 1:2.8 (Romania: Ukraine), but the ICJ “sees no such particularly marked disparities between the relevant coasts of Ukraine and Romania that would require it to adjust the provisional equidistance line”, because “Although there is doubtless a difference in the length of the relevant coasts of the Parties, the Court [...] cannot disregard the fact that a good portion of the Ukrainian coast which it considers as relevant projects into the same area as other segments of the Ukrainian coast, thus strengthening but not spatially expanding the Ukrainian entitlement”.¹³⁴ According to the Tribunal in *Barbados v. Trinidad and Tobago* case, the “reason for coastal length having a decided influence on delimitation is that it is the coast that is the basis of entitlement over maritime areas and hence constitutes a relevant circumstance that must be considered in the light of equitable criteria. To the extent that a coast is abutting on the area of overlapping claims, it is bound to have a strong influence on the delimitation, an influence which results not only from the general direction of the coast but also from its radial projection in the area in question.”¹³⁵

Regarding the general configuration of the coasts of the parties, the ICJ in the *North Sea Continental Shelf* cases took it as one of “the factors to be taken into account” in the course of the delimitation negotiations.¹³⁶ The particular coastal configuration of this case is that three adjoining states situated on a concave coast, it follows that the two

¹²⁹ Libya/Malta, para. 68.

¹³⁰ *Ibid.*

¹³¹ Jan Mayen, paras. 68–69.

¹³² Cameroon v. Nigeria, para. 301.

¹³³ Black Sea, para. 164.

¹³⁴ *Ibid.*, paras. 215, 168.

¹³⁵ Barbados v. Trinidad and Tobago, para. 239.

¹³⁶ North Sea Continental Shelf, para. 101(D).

equidistance lines between Germany and its neighbors will inevitably meet at a relatively short distance from the coast of Germany, thus cutting off Germany from the further areas of the continental shelf in the North Sea.¹³⁷ Another example comes from the 2007 *Nicaragua v. Honduras* case, where the end of the parties' land boundary is a sharply convex territorial projection abutting a concave coastline on either side to the north and south-west, with the consequence that the pair of base points to be identified would assume a considerable dominance in constructing an equidistance line, and, given the close proximity of these base points to each other, any variation or error in situating them would become disproportionately magnified in the resulting equidistance line. Moreover, the sediment carried to and deposited at sea by the River Coco has caused this part of coastline to exhibit a very active morpho-dynamism, which "might render any equidistance line so constructed today arbitrary and unreasonable in the near future".¹³⁸ In such a situation, the ICJ held that "a special configuration of the coast might require a different method of delimitation".¹³⁹ Finally, the Court decided to use the bisector method and found that "The justification for the application of the bisector method in maritime delimitation lies in the configuration of and relationship between the relevant coastal fronts and the maritime areas to be delimited. In instances where, as in the present case, any base points that could be determined by the Court are inherently unstable, the bisector method may be seen as an approximation of the equidistance method."¹⁴⁰

In addition to the coastal geography, the geological and geomorphological factors of the continental shelf area to be delimited are qualified for the inclusion of the list of relevant circumstances, because they are "pertinent to the institution of the continental shelf as it has developed within the law".¹⁴¹ In practice, the international tribunals have considered the geophysical factors in all of the continental shelf delimitations, though none of the tribunals has accepted the arguments based upon these factors on the ground that they were unpersuasive.¹⁴² Besides, the ICJ acknowledges that "the legitimate security considerations of the parties may play a role in determining the final delimitation line".¹⁴³

3.3 *An equitable solution*

Equitable solution "is the objective of every maritime delimitation based on law."¹⁴⁴

¹³⁷ *Ibid.*, para. 8.

¹³⁸ *Nicaragua v. Honduras*, para. 277.

¹³⁹ *Ibid.*, para. 280.

¹⁴⁰ *Ibid.*, para. 287.

¹⁴¹ *Libya/Malta*, para. 48.

¹⁴² For example, *Anglo-French*, para. 107; *Tunisia/Libya*, para. 66; *Gulf of Maine*, para. 46; *Libya/Malta*, para. 41.

¹⁴³ *Black Sea*, para. 204. Also *Libya/Malta*, para. 51.

¹⁴⁴ *Jan Mayen*, para. 70.

In order to demonstrate the equity of the delimitation line, the international tribunals often resort to the test of proportionality and use it “check the line of delimitation that might have been arrived at in consideration of various other factors.”¹⁴⁵ This test stemmed from the findings of the ICJ in the *North Sea Continental Shelf* cases, where the Court emphasized that a delimitation effected according to equitable principles ought to bring about “a reasonable degree of proportionality” between the extent of the maritime areas appertaining to the states concerned and the lengths of their respective coastlines.¹⁴⁶ Though the Tribunal in the Anglo-French case made some reservations to these findings,¹⁴⁷ the ICJ expressly put forward the concept “test of proportionality” in the *Tunisia/Libya* case and treated it “as an aspect of equity”.¹⁴⁸ Later, the emphasis of the checking shifted from whether the delimitation line brings about “a reasonable degree of proportionality” to whether the line leads to “any significant disproportionality”.¹⁴⁹ The ICJ considered in the Black Sea case that “A final check for an equitable outcome entails a confirmation that no great disproportionality of maritime areas is evident by comparison to the ratio of coastal lengths.”¹⁵⁰ Meanwhile, the Court emphasized that

“This checking can only be approximate. Diverse techniques have in the past been used for assessing coastal lengths, with no clear requirements of international law having been shown as to whether the real coastline should be followed, or baselines used, or whether or not coasts relating to internal waters should be excluded. The Court cannot but observe that various tribunals and the Court itself, have drawn different conclusions over the years as to what disparity in coastal lengths would constitute a significant disproportionality which suggested the delimitation line was inequitable and still required adjustment. This remains in each case a matter for the Court’s appreciation, which it will exercise by reference to the overall geography of the area.”¹⁵¹

Besides the test of proportionality, the tribunals have ascertained the equity of the delimitation line by proving that the overall result was not “likely to entail catastrophic

145 *Barbados v. Trinidad and Tobago*, para. 240.

146 *North Sea Continental Shelf*, para. 98. The ICJ in these cases called it as “[a] final factor to be taken account of.” *Ibid.*

147 The Tribunal “does not consider that the adoption in the *North Sea Continental Shelf* cases of the criterion of a reasonable degree of proportionality between the areas of continental shelf and the lengths of the coastlines means that this criterion is one for application in all cases. On the contrary, it was the particular geographical situation of three adjoining States situated on a concave coast which gave relevance to that criterion in those cases”. *Anglo-French*, para. 99.

148 *Tunisia/Libya*, para. 131.

149 *Black Sea*, para. 210.

150 *Ibid.*, para. 122.

151 *Ibid.*, paras. 212-213.

repercussions for the livelihood and economic well-being of the population of the countries concerned”,¹⁵² or “that the proposed demarcation will not have a radical impact on the existing pattern of fishing in the area”.¹⁵³

4. Conclusions

The continental shelf delimitation is a distinct type of delimitation, standing side by side with the EEZ delimitation and not absorbed by the latter. The legality of the so-called single maritime delimitation is based upon the agreement of the states concerned, expressly or tacitly. Where one of the parties expressly objects to the single delimitation, the international tribunal to which the particular dispute has been submitted, will have no competence to undertake a single delimitation, but it has discretion to delimit two lines that are theoretically separate but in fact coincident for the seabed and the superjacent waters respectively.

Maritime delimitation, including the establishment of the provisional arrangements, must be effected through the agreement of the states concerned. Though having been used widely, equidistance is a delimitation method, not a binding or appropriate starting point for all delimitations. Equitable result is superior to the application of the equidistance method. One basic requirement of equity is to giving equal treatment to states with equal natural situations, while giving unequal treatment to states with unequal natural situations. An equidistance line is not appropriate for the delimitation of a disrupted continental shelf, for it will cause areas which are the natural prolongation of the territory of the wide-margin state to be attributed to the narrow-margin state. Coastal geography is the most important relevant circumstance, mainly including islands, coastal configuration and the marked disparity between the lengths of the coastlines belonging to the states concerned. Besides, the geological and geomorphological factors of the relevant seabed area should also be considered. In order to demonstrate the equity of the delimitation line, the test of proportionality may be a useful means.

¹⁵² Gulf of Maine, paras. 237–238.

¹⁵³ St. Pierre and Miquelon, para. 85.

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