INTERNATIONAL WORKSHOP ON FISHING VESSEL AND LICENSE BUY-BACK PROGRAMS
March 22-24, 2004, La Jolla, California
Southwest Fisheries Science Center and the Office of Science and Technology, NOAA Fisheries (NMFS); CERUM and Department of Economics, University of California, San Diego

Effectiveness of Vessel Buyback Program on the Offshore Fishery in Taiwan

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Abstract

Since 1978, offshore fishery harvests in Taiwan have followed a downward trend, while the number of fishing vessels, the total vessel tonnage, and the total horsepower of vessels steadily increased until an overall vessel building restriction was put in place in 1992.

By using annual offshore fisheries harvests and aggregate data on fishing vessels for the period 1953 to 1993, Sun (1998) estimated fishing capacity of Taiwan's offshore fishing fleet under maximum sustainable yields (MSY) and evaluated different legislative strategies designed to reduce the fishing fleet. Based on the technological efficiency in 1993, the fishing capacity under MSY should be restricted to be 40% less than the vessel tones in 1993.

In order to maintain sustainable offshore fishery stocks and to avoid overfishing, the government has implemented the fisheries management policy which regulates harvests by suspending fishing licenses, restricting construction of fishing vessels, and buying back used vessels in order to reduce the offshore fleet size. The most recent measure, announced on Dec. 24, 1991 and which is still in effect, restricts the construction of all new fishing vessels, except for fish transport vessels over 2,000 tonnes. In addition to the overall restriction on the construction of fishing vessels, the government offered two voluntary vessel buy back programs in order to reduce the fleet size, from 1991-1995 and 2000-2004.

The aim of the second buyback program is to further reduce pressure on fishery resources in order to achieve resource sustainability. Hence, this study reviews Taiwan's past experiences with the vessel buy-back program and discusses the design features of the buy-back program to achieve the goals of resource conservation and economic viability of the fishing industry. By utilize the bioeconomic model present in Sun (1998, 2004), it is interesting to examine whether or not the current offshore fishing industry in Taiwan falls in a Pareto inferior situation with smaller output and higher price, such as shown in the backward bending potion of the supply curve.

Introduction

In 2002, total marine fish landing in Taiwan reached 1,059,142 metric tonnes with a total value NT$62,901 million. Around 72.7% of the total landing value was generated by the distant water fishery. The offshore and coastal fisheries only account for 19.9% and 7.3%, respectively, of the total landing value (Taiwan Fisheries Bureau, 1953-2002). The number of total fishing crafts in 2002 was 26,994. Of these only 972 were larger than 200 GT and all of these larger vessels were used in the distant water fishery, see Table 1.

More than 80% of fishing vessels are smaller than 20 GT. In the coastal region there were 13,273 fishing rafts built from plastic pipeline and equipped with gill net, set-net, beach seine fishing, fish fry catching and other hook gear. With such a great number of fishing craft all competing for the same resources, overfishing has occurred in Taiwan's coastal fisheries.

Excluding fishing rafts and sampans (small boats without builting in motors), still leaves 9,453 fishing vessels. Grouping these vessels by type of fishery and vessel tonnages (see Figures 1 and 2), it becomes apparent that tuna long line, trawl, and torch light net are the three major harvest technologies in use. Furthermore, most vessels are smaller than 50 gross tonnes.

Since 1978, offshore harvests have followed a downward trend, but the number of fishing vessels, total vessel tonnage, and total horsepower of vessels increased steadily until 1992, when an overall restriction on the construction of fishing vessels was imposed. Documenting the growth of the fishing industry, figure 3 shows that offshore harvests, vessel numbers, total vessel tonnage, and total horsepower in 1993, were 5.5, 3.2, 7.8, and 35.2 times their respective levels of 1953. Average harvest per vessel tonne has followed a decreasing trend since 1963, pointing out ever increasing overcapitalization. In order to preserve the sustainability of Taiwan's offshore fishery stocks and to avoid overfishing, the government has implemented a fisheries management policy which regulates harvests by suspending fishing licenses, restricting construction of fishing vessels, and buying back used vessels in order to reduce the offshore fleet size.

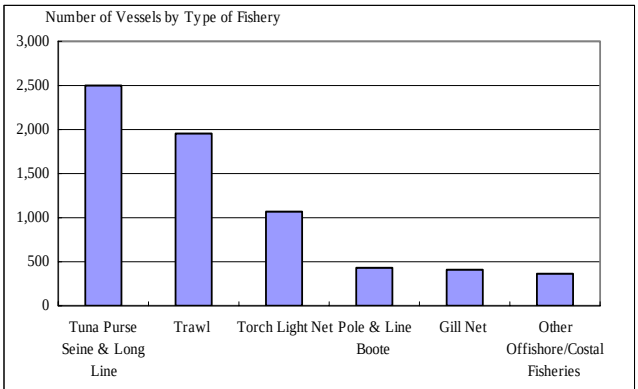

Figure 1. Fishing Vessels by Fishing Gear in Taiwan (2002)

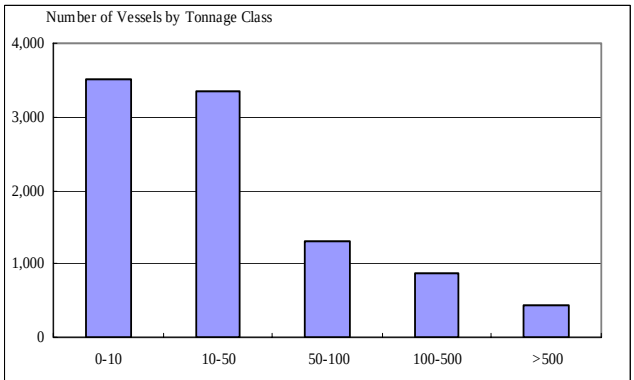

Figure 2. Fishing Vessels by Tonnage Class in Taiwan (2002)

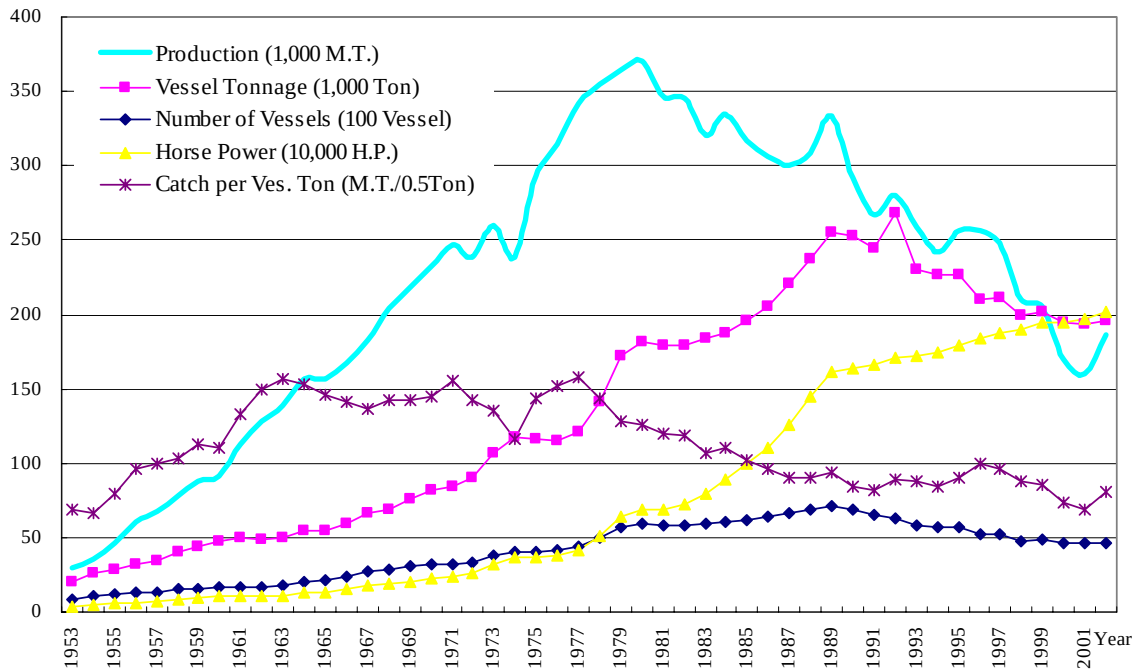

Figure 3 Structure of Powered Fishing Vessels of Offshore Fisheries (1953-2002)

This study tries to examine whether or not the current offshore fishing industry in Taiwan falls in a Pareto inferior situation with smaller output and higher price, such as shown in the backward bending potion of the supply curve. By using annual offshore fisheries harvest and the total tonnage and horse power of fishing vessels for the period 1953 to 2002, this paper utilize the bioeconomic model present in Sun (1998, 2004) to simulate the backward bending supply curve under various fishing capacity.

Vessel Buy Back Program in Taiwan

A major revision of the Fisheries Act in 1991 gave the government the explicit right to adjust fishing effort depending on resource abundance. The government can limit the number of vessels, total vessel tonnage, fishing area, fishing period, and design all other aspects of fishing vessel management policy for the following reasons: (1) fisheries conservation; (2) fisheries structural adjustment; and (3) restrictions resulting from international agreements or cooperation.

Over the years, four amendments regulating the number of offshore fishing vessels in Taiwan were enacted (1967, 1980, 1989, and 1991). I the first amendment of 1967, the Council of Agriculture applied measures to restrict the construction of pair and otter types of trawlers to prevent any further increase in the existing number of pair trawlers under 120 tonnes and otter trawlers under 200 tonnes (Department of Agriculture and Forestry 1993). In 1989, the Council of Agriculture further amended the already existing fishing boat building restrictions to accept only: tuna purse seiners over 1,000 tonnes, group purse seiners for mackerel, fish transporting vessels of 2,000 tonnes and over, and factory vessels of 2,000 tonnes and over

(Department of Agriculture and Forestry 1993). The most recent measure, announced on Dec. 24, 1991, which is still in effect, restricts the construction of all fishing vessels, except for fish transport vessels over 2,000 tonnes.

In addition to the overall restriction on the construction of fishing vessels, the government adopted two voluntary vessel buy back programs in order to reduce fleet size, one from 1991-1995 and the other from 2000-2004. The amount of government expenditure and the number of vessels bought back during both periods are shown in Figure 4. Note that 2,319 vessels were bought back between 1991-1995 at a total government expenditure of NT$1,721 million (US$52.16 million). The purchase price of the vessel was based on the price per gross tonne which was around NT$14,552 (US$440) in 1991-1995.

During the first year of the second phase buyback program (2000) only 5 vessels were bought back at NT$18,000 per gross tonne. Hence, in 2001 a new scheme was to set up increasing the price per gross tonne to NT$50,000 for vessels less than 5 gross tonnes. Still, the buy back program was not very successful as fishermen with rational expectations were holding out, waiting for higher payment scheme to be introduced in the near future. Only 28 vessels were bought back in 2001.

This prompted the government to announce a new payment scheme in 2002. It was designed to speed up the buy back effort by offering even higher payments for 2002 but decreasing amount for subsequent years. The specific rates per gross tonne were as follows:

(1) NT$70,000 if purchased in 2002, NT$60,000 for 2003, and NT$50,000 for 2004, for each gross tonne for vessels less than 5 tonnes;

(2) NT$60,000 if purchased in 2002, NT$50,000 for 2003, and NT$40,000 for 2004, for each gross tonne for vessels between 6 to 10 vessel tonnes;

(3) NT$50,000 if purchased in 2002, NT$40,000 for 2003, and NT$30,000 for 2004, for each gross tonne for vessels between 11 to 20 vessel tonnes,

(4) NT$40,000 if purchased in 2002, NT$30,000 for 2003, and NT$20,000 for 2004, for each gross tonne for vessels between 21 to 50 vessel tonnes,

(5) NT$35,000 if purchased in 2002, NT$25,000 for 2003, and NT$20,000 for 2004, for each gross tonne for vessels between 51 to 100 vessel tonnes,

(6) NT$18,000 if purchased in 2002, NT$60,000 for 2003, and NT$50,000 for 2004, for each gross tonne for vessels over 100 vessel tonnes.

(7) The total payment per vessel could not exceed 9.5 million for any vessel purchased, in 2002, NT$8.5 million for 2003, and NT$7.9 million for 2004.

It is interesting to note that 251 vessels were bought back at a total value of NT$615 million in 2002, and 131 vessels were bought back at a total value of NT$149 million in 2003 (Figure 4). Figures 5, 6 and 7 show the number of vessels bought back by tonnage class, fishing gear and region in Taiwan. It is interesting to note that the 2002 buyback program was successful in buying vessels across all tonnage classes and region, but most of them are long line and trawl fisheries. In summary, the effect of the second buy back program from 2000 to 2003 had purchased only 20,344 vessel tonnage, which is less than one fifth of the vessel

tonnage that had been brought back during the first buyback program from 1991 to 1995, but it cost almost half of the expenditure as before. It is clearly that a higher expectation had been accumulated among fishermen to wait for higher payment for the compensation per vessel tonnage during the second buy back period.

Economic Performance of Offshore Fisheries in 2002

Offshore fisheries are defined as the fishing carried out by powered vessels within the Exclusive Economic Zone (EEZ) around Taiwan. This EEZ is under the Taiwan's jurisdiction by the Law of Fishery. Fishing vessels operating here are generally smaller than 100 gross tones and are owned by individual families or small-scale fishing companies. Some of these small-scale, individual vessels switch

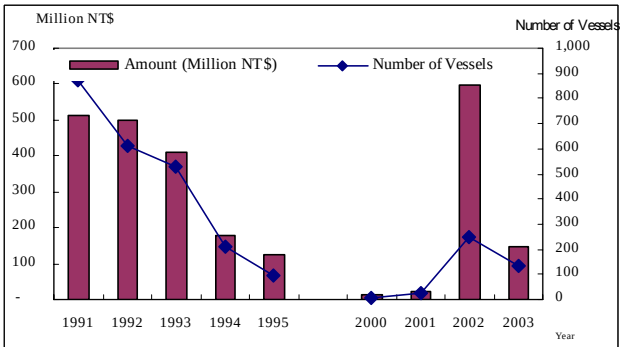

Figure 4. Government Expenditure on Vessel Buyback Program (1991-1995 and 2000-2003)

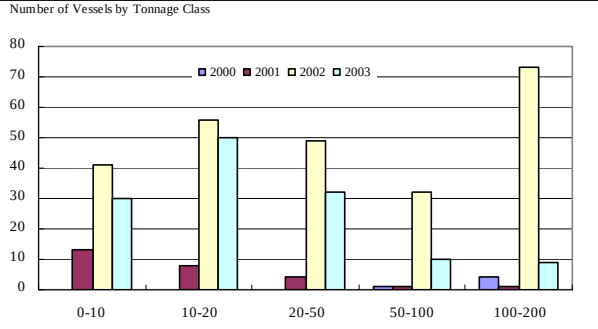

Figure 5. Number of Vessels Bought Back by Tonnage Class in Taiwan (2000-2003)

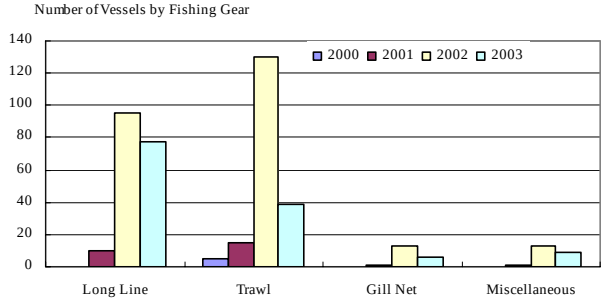

Figure 6. Number of Vessels Bought Back by Fishing Gear in Taiwan (2000-2003)

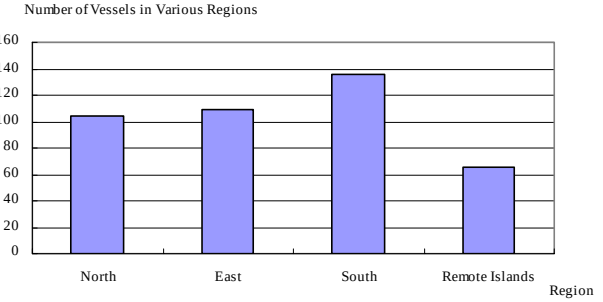

Figure 7. Number of Vessels Bought Back by Region in Taiwan (2000-2003)

back and forth between two or more types of fishing gear, according to season and target species. For target species that have a short life cycle, such as the small subpelagics, the proportional representation of the different species is fairly constant.

In order to make a comparison of the economic performance measure of offshore fisheries in 1992, which was provided in Sun (1998), the revenue and cost data for the different tonnage classes of offshore fishing vessels were updated from the database released by the *Annual Economic Survey of Offshore Fisheries and Aquaculture* (Taiwan Fisheries Bureau, 2002) with the same procedure proposed by Sun (1998). The revenue and cost data are used to approximate revenue-cost ratios for fishing vessels in the different tonnage classes. A weighted average revenue-cost ratio is calculated according to the distribution of the offshore fishing vessels in the different tonnage classes as follows:

$$ratio = \frac{R_1}{C_1} \cdot A_1 + \frac{R_2}{C_2} \cdot A_2 + \frac{R_3}{C_3} \cdot A_3 + \frac{R_4}{C_4} \cdot A_4 + \frac{R_5}{C_5} \cdot A_5$$

where ratio = weighted average revenue-cost ratio;

R_i = average revenue per vessel ton of the ith ton class (NT$/vessel ton);

C_i = average cost per vessel ton of the ith ton class (NT$/vessel ton);

A_i = percentage of total fishing vessel tonnage represented by vessels the ith ton class, where 1, 2, 3, 4, and 5 represent 0-5 tons, 5-10 tons, 10-20 tons, 20-50 tons, and 50-100 tons, respectively.

In 2002, the percentages of total vessel tonnage for the five tonnage classes were 2.94%, 4.38%, 11.05%, 35.32%, and 46.31%, respectively (Table 2). The average harvest per vessel tonne was 1,726 kg, and the average harvest value per vessel tonne was NT$117,883. When factoring out the cost of equipment, depreciation and interest cost of capital, the average cost per vessel tonne was NT$105,991 and the short-term variable cost[1] was NT$83,709.

In 2002, such as shown in Table 2, the revenue/cost ratio for each of the five tonnage classes ranges from 1.08 to 1.32, with a weighted average of 1.11, which is lower than the ratio in 1992, 1.14, cited in Sun (1998). This means that the average fishing fleet in 2002 earns less profit than ten years ago. It is worth to note that the revenue/cost ratio declines as the vessel tonnage increases, which illustrates the phenomenon of overcapitalization, i.e., while it may be true that smaller vessels are more profitable, it is also conceivable that larger vessels could be more profitable if the fisheries were less exploited.

Given that fixed costs are static, the investments in long term overhead are severely restricted, and the average fixed costs (i.e., equipment depreciation and cost of interest) are not taken into account in the short-run, the short-term revenue/cost ratio, which is defined as the average revenue divided by the average variable cost, ranges from 1.34 to 1.91, with a weighted average of 1.40, which is lower than the ratio in 1992, 1.62, cited in Sun (1998). Even though the economic performance is worse than before, the government still need to provide very attractive vessel reduction incentives before fishermen will relinquish such lucrative, short-term fishing opportunities.

Effectiveness of Vessel Buy Back Program in Resource Conservation

By using annual offshore fishery harvests and aggregate data on fishing vessels for the period 1953 to 1993, Sun (1998) estimated the harvest capacity of Taiwan's offshore fishing fleet under the maximum sustainable yields and evaluated different legislative strategies designed to reduce the fishing fleet. A generalized harvest function which permits the estimation of an unconstrained Cobb-Douglas production

[1] According to the original data source, this includes all direct and indirect costs. The annual variable cost per vessel tonne includes fuel, bait, ice, salt, water, box/basket, food, fish market administration and fee, transportation and storage charge, repair and replacement of fishing gear, salary, and interest cost of a revolving fund.

function (Comitini and Huang 1967; Hannesson 1983; Tomkins and Butlin 1975; Tsoa, Schrank and Roy 1984) and the dynamic movement of biomass functions of the offshore fisheries are specified and estimated.

Results show that fishery stock has been declining when the actual harvest had already exceeded the estimated MSY at 236,221 tonnes since 1973. By using 1993 values for technological efficiency, the vessel tonnage should be restricted 40% lower than the actual vessel tonnage in 1993 and allow for the biomass to recover to maintain the resource sustainability. Based on dynamic simulations, this study shows that a combination of imposing a ban on the construction of new vessels and the vessel retirement and buyback program in 1991-1995 is not sufficient to avoid the downward trend in harvests and a deterioration of fishery stocks.

Following Copes's (1970) argument about specifying the backward-bending supply curve for fishing industry to reflect fishermen's behavioral response to various market prices, Sun (2004) utilizes the bioeconomic model present in Sun (1998) to simulate a backward bending supply curve under various levels of fishing capacity.

For example, the average price and the unit cost per vessel tonne in various years were NT$66.30/kg and NT$98,522 per vessel tonne in 1993, and NT$78.84/kg and NT$105,991 per vessel tonne in 2002, respectively. Since the price/per vessel cost ratio in 2002 is higher than the price/per vessel cost ratio in 1993, there exists even larger pressure to explore the resource, i.e., the current offshore fishing industry in Taiwan falls in a Pareto inferior situation with smaller output and higher price.

Since 1973, the yearly harvest exceeds MSY and a lower level of the biomass lowers the yield further with the ever-increasing price. Subject to the fishing capacity and the unit cost per vessel tonne in various years, the supply schedule with respect to various price schedules in each year is derived from the production function under the perfect competition situation in Sun (2004). Such as shown in Figure 8, there is an equilibrium path of the supply schedule in 2002 and the demand-supply equilibrium is situated on the backward-bending potion of the supply curve. The bio-economic equilibrium situation in 2002 is even worse than the situation in 1993, since the harvest in 2002 is less than the harvest in 1993 and is far less than MSY.

Conclusion and Discussion

After entering WTO in 2002, the import tariff rates of seafood in Taiwan have decreased by an average of 35.5% from the level in 2001 and the fishery sector is expected to suffer serious losses due to trade liberalization. Fishery Agency in Taiwan had instituted a comprehensive program to remunerate fishermen for voluntarily reducing fishing effort in accordance with the bulletin of "In reward for closing fishery season procedure" starting from 2003.

This program has been running since September of 2003 with an annual budget of approximately US$12 million. It is targeted at all kinds of fishing vessels and covers all capture fisheries if they have valid fishing licenses in Taiwan. Excluded are illegal recreational vessels and vessels older than 30 years. Vessels shall be proved to have a minimum 100 days at sea and to be required to suspend their fishing voluntarily at least 120 days in a fiscal year.

Even though the government has administered two voluntary vessels buy back programs in order to reduce the fleet size and there is a successful buy back in 2002, the bio-economic equilibrium situation in end of 2002 is still worse than in 1993. Overfishing is still occurring and the need to further restrict capacity and rebuild biomass still exists.

The second buy back program was ended in 2004 and it is clearly that a higher expectation had been accumulated among fishermen to wait for higher payment for the compensation per vessel tonnage, even though the government had announced not to initiate another run of buy back program to reduce the fishing capacity furthermore in the near future.

To date, without unemployment insurance for fishermen in Taiwan, there are not enough incentives to fishermen for curbing fishing activity voluntarily. Since the buyback programs alone are not the effective way to reduce the overall fishing effort further, it is better to restrict the days at sea directly for various type of vessels under specific environmental and resource considerations and design a short-term unemployment insurance policy to increase the willingness of the fishermen to reduce the fishing effort further.

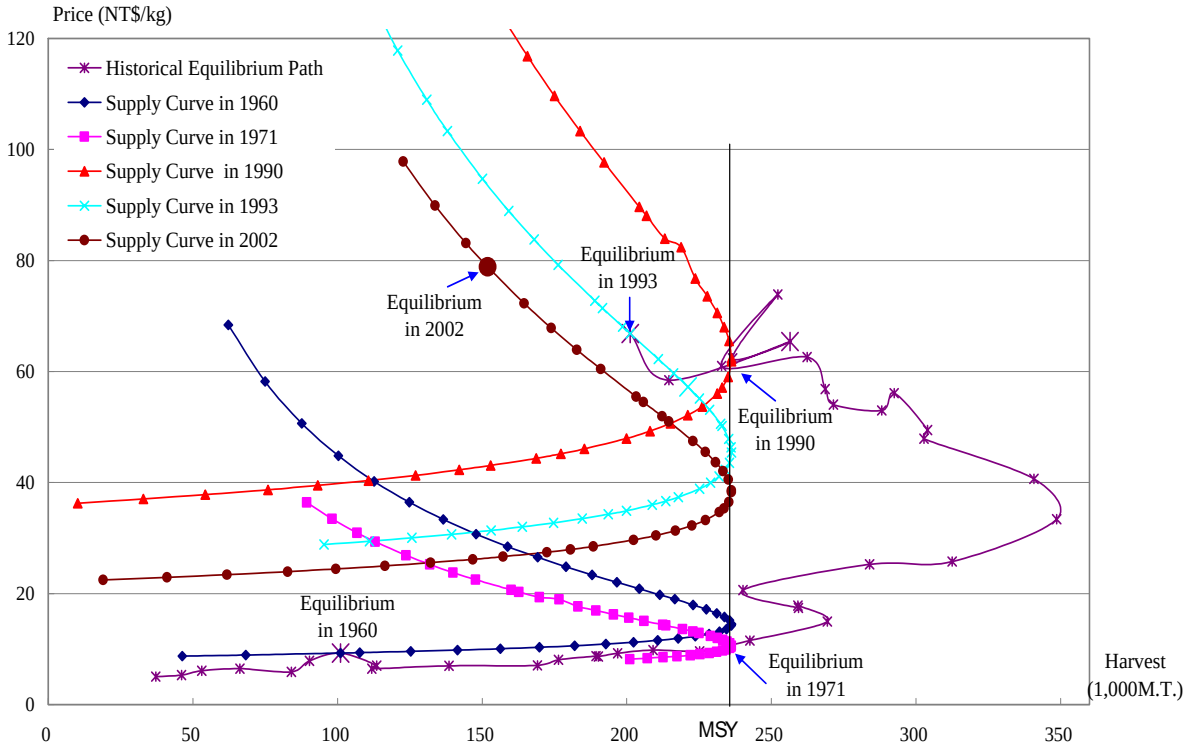

Figure 8 Simulation of the Backward-Bending Supply Curve under Various Offshore Fishing Capacity in Taiwan

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Table1

Fishing Crafts by Type of Fishery in Taiwan

Type of fishery in Various Tonnage		Non-Powered Sampans	Non-Powered Rafts	Powered Rafts	Powered Sampans	<5 ton	5-10 ton	10-20 ton	20-50 ton	50-100 ton	100-200 ton	200-500 ton	>500 ton	Total
Far Sea Fisheries (9,158 boats)	Otter trawl				5	65	163	228	518	539	284	95	2	1,899
	Bull trawl										2	48	3	53
	Purse seine for tuna					97		39				0	39	175
	Tuna long line				13	99	125	208	757	530	22	362	229	2,345
	Misc. fish long line	122	135	568	1,187	807	526	589	419	188	8	12		4,561
	Squid jigging											2	123	125
Offshore and Coastal Fisheries (17,764 boats)	Gill net	141	447	6,891	1,047	155	69	95	56	22	2	1		8,926
	Purse seine for mackerel						1			16	5	19	0	41
	Purse seine				2			7	66					75
	Pole and line boote	30	52	1,107	1,163	361	29	33	15	0				2,790
	Troll line				7	64	2	1						74
	spear fishing				3	7	46	19						75
	Driving-in net													0
	Torch light net	62	1	19	427	698	160	159	50	1				1,577
	Others		53	109	38	10	25	43	25			1	0	304
	Set net		1	67										68
	Beach seine	12	59	88										159
	Other net		60	3,613										3,673
	Other angling	1		1										2
Others (72 boats)	Processing												1	1
	Carrier											5	20	25
	Official			1	8	5	3	3	5	3	2	5	5	40
	Set -net							4	1					5
	Mari culture			1										1
Total		368	808	12,465	3,900	2,368	1,149	1,428	1,912	1,299	325	550	422	26,994

Fisheries Yearbook in Taiwan Area, 2002, Taiwan Fisheries Bureau.

Table 2

Offshore Fisheries Production, Revenue, and Cost in Taiwan, 2002

	Average Yield per Vessel Ton (Kg./Ves. Tons) (O)	Average Revenue per Vessel Ton (NT$/Vessel Tons) (A)	Average Cost per Vessel Ton (NT$/Vessel Tons) (B)	Average Variable Cost per Ves. Ton (NT$/Vessel Tons) (C)	Revenue-Cost Ratio (D)	Short Term Revenue-Cost Ratio (E)	Percentage of Total Ton (F)
under 5 Tons	1,506	259,600	196,000	136,000	1.32	1.91	2.94%
5 - 10 Tons	2,276	183,467	157,333	124,667	1.17	1.47	4.38%
10 - 20 Tons	1,342	146,600	134,600	109,200	1.09	1.34	11.05%
20 - 50 Tons	1,612	126,000	116,857	91,371	1.08	1.38	35.32%
50 - 100 Tons	1,867	89,640	80,307	64,587	1.12	1.39	46.31%
Weighted Average	1,726	117,883	105,991	83,709	1.11	1.40	-

[a.] *Annual Economics Survey of Offshore Fisheries and Aquaculture in Taiwan*, 2002, Taiwan Fisheries Bureau.

[b.] $(D_i) = (A_i) / (B_i)$, $(E_i) = (A_i) / (C_i)$

[c.] *Fisheries Yearbook in Taiwan Area*, 2002, Taiwan Fisheries Bureau.

[d.] Weighted average of percentage of total tonnage, the formula equals to $\sum_{i=1}^{5} (k_i \times f_i)$, where k=(A), (B), (C), (D), (E); i=1, 2, 3, 4, or 5; 1 represents vessels under 5 tons; 2 represents vessels approx. 5 - 10 tons; 3 represents vessels approx. 10 - 20 tons; 4 represents vessels approx. 20 - 50 tons; and 5 represents vessels approx. 50 - 100 tons.