The Rational Exploitation of the Shrimp of El Salvador

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Abstract

In 1962, the government of the Republic of El Salvador discontinued issuing new fishing licenses for shrimp trawling within its territorial waters. This paper discusses the reasons for this restriction of fishing effort, the trends in the fishery since the restriction was imposed and possible measures which might be carried out to achieve more rational exploitation of the shrimp resources of the country.

INTRODUCTION

IN 1958, the government of the Republic of El Salvador requested technical assistance in shrimp biology from the Food and Agriculture Organization of the United Nations. Assistance was provided for a few months during 1959 and subsequent to February 1962. During 1965, the studies were incorporated in the Regional Project for Central American Fisheries Development, a joint project of the United Nations and the governments of the six countries of Central America.

The government of El Salvador felt that the principal aim of the studies should be to make recommendations on desirable management practices for the protection of existing investment and the maximizing of the landings of shrimp and fish from the territorial waters of the country. As a secondary aim, the government hoped that the studies might also indicate possibilities for new investment in the fishing industry. The shrimp exports of about US $6 million each year are third in value of the exports of El Salvador after coffee and cotton.

A preliminary evaluation of the statistical data collected prior to 1962 suggested a possible relation between increasing fishing effort and declining catches per day of the shrimp trawlers. A fleet limitation was recommended as an interim management measure. This was imposed by law and no further licenses for trawlers were issued after the middle of 1962.

This report summarizes the major trends in the shrimp fishery and includes a discussion on the possible causes of these trends. A discussion is also included on the experience obtained in the use of the fleet limitation as a management measure. No final answers are presented to the problem of achieving the most rational management of the fishery. An important function of this report is to identify future lines of study likely to approach a solution to the problem. In this short discussion, it has not been possible to deal with all the considerations associated with the concept of a fleet limitation as a management measure.

In the graphs to be discussed later in this report, "natural" instead of calendar years were used. For this purpose, it was assumed that most shrimp have a maximum life span of about 1 year. The beginning of the natural year was taken as the time when most of the shrimp resulting from the spawning of the previous year will have been removed from the stocks and before the peak of recruitment for the current year has been reached.

All weights of shrimp have been converted to the head-off basis.

Statistical data on the shrimp fishery of El Salvador between 1957 and 1967 are shown in the Appendix.

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DISCUSSION

Fishing operations

The standard 62-foot Florida shrimp vessel, using double-rig trawls, was introduced soon after the fishery started and almost all subsequent acquisitions were vessels of this type. It thus appears that the trends in the landings which will be discussed later have been caused by factors other than changes in vessel and gear design.

Because of administrative changes and improved facilities for repairs, the vessels have been able to spend a much greater time at sea than formerly. The average number of days of fishing per vessel per year increased from 179 in 1959 to 294 in 1965. Since the duration of the hauls increased, the average amount of trawling time each day also increased.

Changes in total landings and catches per day related to fishing effort

The logistic model has been chosen to attempt to determine the status of white shrimp fishing in El Salvador. This model has been described in detail by Schaefer (1954 and 1957) who applied it to yellowfin tuna in the eastern Pacific Ocean. Briefly, the total weight of an unexploited population of animals increases, except when the initial population is zero or when it is at its maximum weight, and the relationship of the rate of increase to the population size is expressed by a parabola. If the animals are harvested at the same rate as the natural increase of the population, the population will remain at the same level indefinitely. Obviously, the maximum yield on a sustained basis would result when the rate of increase is greatest. This occurs when the population is exactly half its maximum size. If the population is more or less than half its maximum size, it can be decreased or increased by harvesting it at more or less than its natural rate of increase at those levels in order to bring it to the level which will produce the maximum sustainable yield.

This model includes the implicit assumptions that the rate of natural increase responds immediately to changes in population size and that it is independent of the age composition of the animals in the population. Neither of these assumptions can be completely fulfilled in multicellular organisms, but for

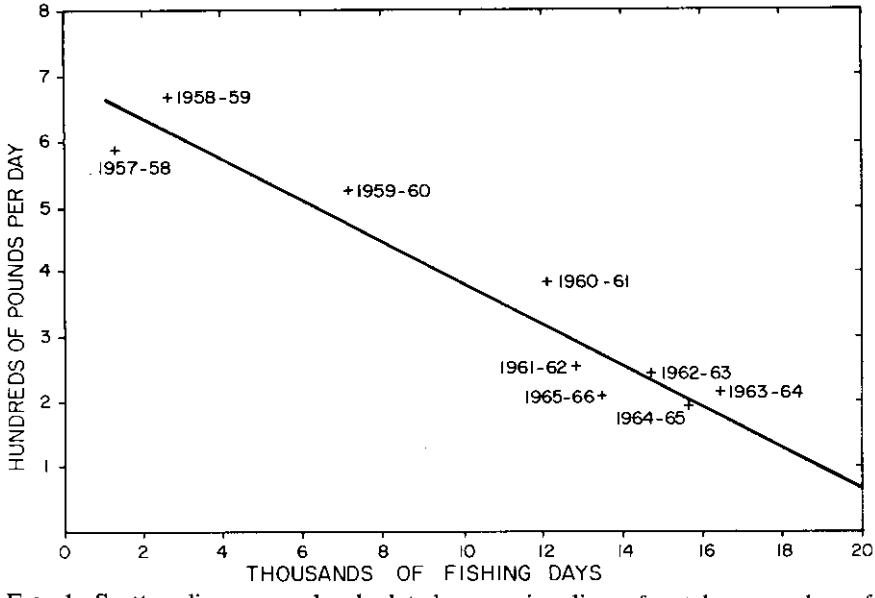

FIG. 1. Scatter diagram and calculated regression line of catches per day of white shrimp and days of fishing devoted to these, 1957-66.

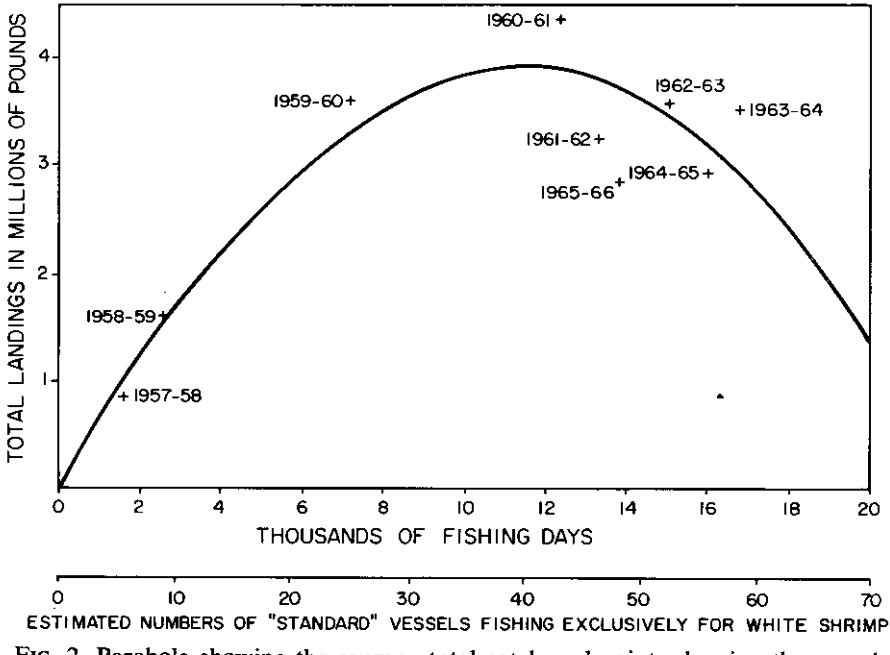

FIG. 2. Parabola showing the average total catch and points showing the actual catches of white shrimp at different levels of fishing intensity, 1957-66.

short-lived, fast growing animals such as shrimp the deviation is not likely to be sufficient to render the model useless.

Even if the model is completely applicable to shrimp, the rate of increase of the population is likely to be affected by environmental factors as well as by the size of the population. If these effects are slight or moderate, they will only lessen the accuracy with which the catch and catch per unit of effort can be predicted; but if they are great, they will probably render the model useless for the management of the fishery, even if it is valid.

WHITE SHRIMP: *(Penaeus occidentalis, P. vannamei* and *P. stylirostris)*

Probably more than 80% of the fishing effort of the shrimp trawlers of El Salvador is directed towards the capture of white shrimp. Other types of shrimp and fish are taken incidentally in the white shrimp fishing operations or in special hauls or cruises when white shrimp are scarce. The initial recommendation for a fleet limitation was based almost exclusively on an evaluation of the trends in the landings of white shrimp.

Figure 1 shows the catches per day of white shrimp and the fishing effort devoted to their capture between 1957 and 1966. Since these appeared to follow a straight line fairly closely, the regression line was calculated and is also shown. Since the individual points lie close to this line and it is in a negative direction, it is probable that the two factors are inversely related. This strongly suggests that the increase in fishing effort has been a major cause of the decline in the catch per day.

Figure 2 shows the average total catches of white shrimp for different levels of fishing intensity. This was calculated by multiplying the various numbers of fishing days by the average catch per day, calculated from the regression coefficient of Figure 1. These data provide an estimate of the average level of the maximum sustainable yield of the stock of white shrimp. The 3.9 million lb maximum is achieved with 11,156 days fishing which implies an average catch per day of 349 lb. The 11,156 fishing days are equated to 38 "standard vessels" fishing for 290 days exclusively for white shrimp or 47 vessels which fish mostly for white shrimp but also spend an average of 44 days per year fishing for red shrimp.

The observed yields of white shrimp and effort for the years 1957 through 1966 are also shown in Figure 2. Some of the actual landings lie fairly close to the curve of the average while others diverge. The greatest divergences from the averages were minus 22% in 1965-66 and plus 16% in 1960-61. These were presumably caused by natural factors which may have caused differences in levels of recruitment to the stocks. Since it is not yet possible to identify the natural factors which influence the landings nor to measure their likely future effect, it is clearly not possible to make precise predictions of landings which might be expected in the future with different levels of fishing intensity.

The explanation for the trends observed during the history of the fishery would seem to be the following:

When fewer vessels were fishing, each vessel had access to a larger share of the relatively stable annual crop of shrimp. At that time it was not possible for the small fleet to catch all of the available shrimp; good catches were taken close to the home port and large stretches of the coast presently yielding shrimp were never visited by the trawlers. By about 1961 the pressure of declining catches on the former fishing grounds had forced the vessels to exploit the entire coastline. The fishing intensity continued to increase and each vessel's share

of the total landings declined proportionally. The average size of shrimp landed also started to decline, reducing the catches and earnings of the vessels.

Continuous recruitment of small shrimp into the fishery implies that a closed season to protect young fast growing shrimp is not practical. Closed areas are impractical because small white shrimp appear to be distributed throughout the fishing area. Mesh regulations are not easily enforced and therefore are not useful here. The most appropriate management measure would seem to be that of applying control on the fishing intensity.

The fleet limitation, imposed by the government of El Salvador in 1962, has been beneficial. Export data from Panama and Ecuador and U. S. import statistics showed that 40,000 lb to 41,000 lb of shrimp per vessel were exported from these countries in 1959. With catches at this level many vessels were losing money and withdrew from the fleet. Since 1959 in El Salvador, the quantity of shrimp exported per vessel has consistently been greater than 100,000 lb. In contrast to Panama and Ecuador, the El Salvador shrimp fishery is much more profitable even though operating costs of the El Salvador fleet are higher due to the larger size of the vessels. Requests for new permits were submitted even after the fleet limit was imposed so it is certain that, if the limit had not been imposed, the fleet would have continued to increase. Hence, as in Panama and Ecuador, the fleet would have increased to the stage where the fishery would have become unprofitable for many of the vessels.

Although the fleet limitation at least partially fulfills the management policy favored by the Government, the data discussed earlier strongly suggest that the fishing intensity had already passed the optimum level for white shrimp before the restriction was imposed. This optimum level was calculated to be 11,156 days. Yet, during the 12 months prior to the imposition of restriction of permits, the fishing fleet devoted 13,000 days to the capture of white shrimp. During each subsequent year until 1963-64, fishing effort continued to increase, not through an increase in the number of vessels but through better utilization of those in use. From the available evidence, there seems to be no reason to doubt that the increase in fishing intensity was largely responsible for the decline in total catches and catches per unit of effort after the effort passed the optimum level.

The appropriate level of fishing intensity for the type of vessel and gear currently in use is calculated, on biological grounds, to be 11,156 days per year. It is believed that at that level of fishing intensity maximum total landings of white shrimp will be obtained. Since this theoretically appropriate level of fishing effort has been exceeded every year since 1961, it seems likely that higher total landings of white shrimp would be achieved if the fishing effort applied to white shrimp were reduced. Thereby the gross value of the exports might be increased by about a half million dollars per year. Three methods of reducing intensity can be considered. The first, a forced retirement of some vessels from the El Salvador white shrimp fleet would probably lead to the vessels in the fleet fishing almost exclusively for white shrimp and hence cause a decline in the landings of other shrimp and fishes. The second is restricting the fishing time per vessel. This would have a minimal effect on the landings of the other products if the restriction were applied only at the beginning and at the end of the year, when the vessels fish almost exclusively for white shrimp. The third and most desirable alternative would seem to be that of diverting a portion of the total fishing effort to the exploitation of products other than white shrimp.

RED AND BROWN SHRIMP: *(Penaeus brevirostris* and *P. californiensis)*

It appears that trends in the landings of red shrimp cannot be explained by changes in fishing effort devoted to their capture. A more likely explanation is that captains make special efforts to catch red shrimp only when white shrimp are scarce. Thus, this effort is irregular and bears little or no relationship to periods of red shrimp abundance.

No special effort appears to be made to catch brown shrimp which are associated with red shrimp in deeper water and with whites in shallower water.

The shrimp vessels of El Salvador usually fish in depths less than 35 fathoms, while in the neighboring country of Guatemala it has been reported that vessels regularly fish up to 55 fathoms and catch proportionally more red shrimp. The fleet limitation has almost certainly been an important indirect cause of this apparent lack of initiative on the part of the vessels in El Salvador. It has more or less "guaranteed" a "reasonable" return of investment from the fishing operations close to shore, chiefly for white shrimp.

At least a moderate increase in the landings of red shrimp and perhaps brown shrimp might be obtained if the fishing operations based in El Salvador were extended into deeper water.

It may also be true that, at the deepest part of their operations, the Guatemalan vessels may be fishing close to the limit of efficiency of their equipment and that commercial quantities of different species of shrimp may exist in yet deeper water. In the Gulf of Mexico, for example, United States vessels have found commercial quantities of royal red shrimp in depths of 170 to 250 fathoms. It is possible that commercial quantities of shrimp also occur off the coast of El Salvador, and exploratory fishing is presently being initiated to investigate this.

SEA BOBS

The processing of sea bobs for export is marginally economical because of their low value in the United States market and the relatively high export tax*. Large, but unknown, quantities of these were formerly discarded at sea. The relatively steady increase in the landings of sea bobs, especially since 1964, was probably caused by a decline in the quantity discarded. Increased demand, and the installation of peeling and deveining machinery presumably enabled the sea bobs to be processed at a profit. A further cause of the increased landings of sea bobs was that during periods of scarcity of white shrimp, especially during 1965 and 1967, some vessels made special hauls, or cruises to try to catch them, while in previous years they were taken incidentally to white shrimp. The production could probably be further increased if more special trips were dedicated to their capture.

FISH

Only the medium and large sizes of fish taken with shrimp are landed by the shrimp trawlers. Until 1965, landings showed a steady increase each year, at a rate greater than the increase in fishing effort. The stocks were probably not at a critical state and the trends in the landings are caused by economic and technological rather than biological factors. One of these was probably the gradual improvement in the distribution and marketing system for internal consumption.

Since the captain and crew are only really interested in shrimp, it is likely

*Since the tax is based on the quantity exported, the sizes and types of shrimp of low value pay a higher proportion of their value than the more valuable ones.

that even marketable sizes of fish are discarded early in the trip to leave space in the brine tanks for later catches of shrimp. Because fishing effort in the white shrimp fishery is more or less "frozen" by the fleet limitation, it seems doubtful that the total landings of fish by the shrimp vessels will increase significantly.

Although large quantities of fish are taken in the shrimp trawl, this gear is not the most efficient for their capture. Its low head line, small mesh size and relatively slow towing speed makes it a poor instrument for catching off-bottom or active swimming fish. Areas presently being exploited by the shrimp trawlers probably are not those on which fish are most abundant. Higher fish yields would be possible through the introduction of vessels especially designed and equipped for fish trawling.

CONCLUSIONS

It has been shown that it might be possible to achieve at least a moderate increase in the production of shrimp through the reduction of the fishing effort applied to the white shrimp and the application of greater fishing effort to the capture of other types of shrimp. Ideally, this should be accomplished through the diversion of part of the fishing effort presently devoted to white shrimp to fishing for other types of shrimp. Since white shrimp are more valuable and their times and areas of distribution and density are better known than for the other types of shrimp, this possible diversion of effort is not likely to occur to a significant extent under existing conditions.

The emphasis presently being placed on the capture of white shrimp is further encouraged by the export tax structure. Since the tax is based upon the weight shipped, the higher-value white shrimp pay a lower percentage of their value in taxes. A modification of the tax system, based on value rather than weight, might result in increased landings of sea bobs, brown and red shrimp; at the same time reducing fishing effort for white shrimp and hence achieving a more rational exploitation of all types. Clearly, changes in the tax system could only be contemplated after a detailed study of other economic factors. If changes in tax structure were the chief measure aimed at trying to achieve rational exploitation of the resources, their application would probably result in the utilization of a standard size and type of vessel being used for all activities which may not be the most desirable arrangement from an economical point of view. A possible alternative would be separate licenses for each activity.

Separate activities might include white shrimp fishing, sea bob fishing, deep-water fishing for red or brown shrimp and fish trawling. Of these various possible activities, only the fishery for white shrimp is known to be economically feasible if an appropriate number of vessels is employed. Experimental and exploratory fishing is required to determine the economic feasibility and the most desirable practices for other fisheries. Gathering of this information should precede the separate issue of licenses.

Control measures cannot be established until more data are available on possible alternative resources. The exploitation of shrimp and fish as separate activities may offer the additional advantage that vessels and gears used for each could be designed specifically for that purpose. Thus the operations should show a moderate gain in efficiency and reduction in cost of operations

over current practices. Similarly, higher total production and profits through rational controls might enable Government tax revenues to be increased. In summary, the fleet limitation imposed by the government of El Salvador on its shrimp trawling industry has undoubtedly been beneficial in protecting this investment. With the present number of vessels, the fleet limitation has not achieved the most rational exploitation of the resources of shrimp, fish and other products. Experimental and exploratory fishing, further biological, economic and technological studies will be required before measures can be devised to achieve more rational exploitation of the resources.

APPENDIX

Landings and Fishing Effort of the Shrimp Fleet of El Salvador 1961-67

(All weights heads-off)

	1961	1962	1963	1964	1965	1966	1967
Production thousands of pounds							
White shrimp	3,856	3,485	3,632	3,837	2,338	3,497	2,312
Brown shrimp	960	254	205	228	143	207	174
Red shrimp	1,652	1,212	1,054	834	966	1,090	922
Sea-bobs	2,037	3,310	2,820	2,721	3,503	5,288	4,299
Total, all types	8,505	8,261	7,711	7,620	6,950	10,082	7,707
Fishing effort							
Average number vessels	63	65	64	67	65	68	68
Total effort (days)	15,297	16,304	18,068	19,373	18,937	19,837	19,459
Pounds per day of fishing							
White shrimp	252	214	201	198	123	176	119
White and brown shrimp	315	229	212	210	131	187	128
Red shrimp	108	74	58	43	51	55	47
Sea bobs	133	203	156	140	185	267	221
All shrimp	556	507	427	393	367	508	396
Thousands of pounds of shrimp per vessel per year							
Shrimp of genus *Penaeus*	103	76	76	73	53	70	50
Sea bobs	32	51	44	41	54	78	63
All shrimp	135	127	120	114	107	148	113
Thousands of pounds of fish and other products							
	1,729	2,013	2,594	3,090	3,878	3,940	4,138

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