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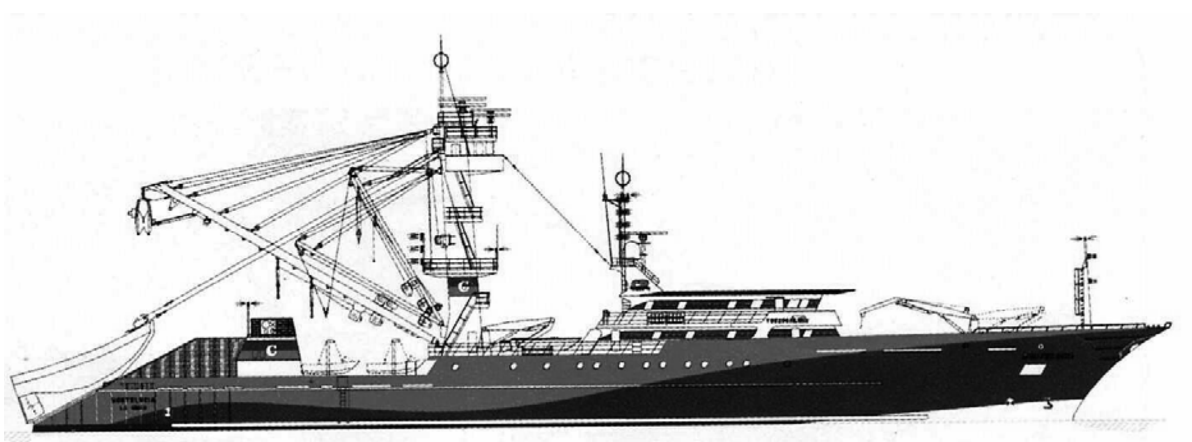
The European Union Research Project
« Efficiency of Tuna Purse-Seiners and Effective Effort »
(ESTHER)

Scientific Report of Project

(English translation of selected sections of the Scientific Report[1])



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Programme Européen N° 98/061

IRD (Institut de Recherche pour le Développement) – IEO (Instituto Español de Oceanografìa

'Efficiency of Tuna Purse-Seiners and Effective Effort'

« Efficacité des Senneurs Thoniers et Efforts Réels »

(ESTHER)

Scientific report

Daniel Gaertner[4] et Pilar Pallares[5]

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The European Union Research Project
"Efficiency of Tuna Purse-Seiners and Effective Effort" (ESTHER)

Scientific Report of Project

(English translation of selected sections of the Scientific Report)

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Scientific Summary

The French and Spanish purse-seine fleets, which target tropical tunas in the Atlantic and Indian Oceans, have been modernised over the past 20 years. This technological upgrading comes from the introduction of new and better-equipped purse-seiners and also to the installation of new fishing equipment on older boats. These developments have produced an overall increase in these fleets' fishing efficiency. Accounting for this increase when estimating fishing mortality is one of the main concerns of international tuna stock management commissions (ICCAT, IOTC, etc.). When a stock comes close to being overfished, any uncertainty over effective fishing effort can lead to very unsuitable regulatory measures. Such measures may be inadequate to prevent the depletion of the resource and the degradation of its ecosystem, when fishing pressure is extensively underestimated, or, on the other hand, lead to economic losses if the precautionary approach is inappropriately applied in a situation of under-exploitation. In order to avoid such extremes, it is essential to have to hand the best possible information on effective fishing effort. To try and address this issue, scientists of the *Institut de recherche pour le développement* (IRD, France) and *Instituto Español de Oceanografia* (IEO, Spain) proposed a project called 'Efficiency of Tuna Purse-seiners and Real Effort' to the European Union's DG XIV.

The main objectives of this study were to review the technological factors that may have contributed to the increase in the 'fishing power' of the European tuna fleet, to observe their use patterns on board purse-seiners and a support vessel and then to quantify their impact on catch per unit of effort (CPUE). During its operational phase, this project had to cope with many difficulties. Firstly, the process of collecting information from the on-board equipment was severely hampered by the very patchy co-operation from the professional sector (boat owners, equipment manufacturers). Secondly, only a few boat owners agreed to the presence of a scientific observer on board. To this background, the statistical analysis was difficult to carry out because the data sets were limited in size and came from very unbalanced sampling plans. The individual variability in the dates of introduction of any particular piece of equipment, the overlapping between installation periods for the various technologies concerned and the many interactions between these factors give the impression that these developments occurred as a continuous process. It is therefore difficult to accurately gauge the causes of significant changes in yields and even more hazardous to appraise the proportion thereof that could be due to each separate factor.

Another constraint on analysis is linked to the problem of scale of observation. When the impact of a particular piece of equipment can only be measured at a specific phase of the school capture process (detection of aggregations, location of school, deployment of purse-seine, etc.), the analysis is carried out on overall CPUE figures, which can make interpretations of results inaccurate. In order to take these considerations into account more reliably, and despite the low number of observations at sea, we tried to determine the fishing phase during which each piece of equipment is used.

As with many examples of the numerical analysis of data, the existence of interactions between the various factors can lead to the development of complex statistical models that may be accurate in terms of fit but are difficult to interpret because they appear to be over-parameterised. An insight into these difficulties is given in the analysis made to standardise the CPUEs, where, despite a deliberately limited number of explanatory variables, we obtain significant interactions between the age of the purse-seiner, the country category to which it belongs and the time period over which observations were recorded. It would therefore seem that, depending on the period analysed and the nationality and size class of the purse-seiner, the ageing effect will show varying degrees of intensity (it can even be positive for some size groups, which permits supposition that technological progress has been introduced on board).

In practice, the combined effects of certain innovations (eg sonar and echo-sounder when fishing around FADs) do not make it possible to differentiate the individual effects of any piece of equipment or what might be due to synergy between them. In some cases, synergy is not automatically developed between the various technological innovations, because one replaces another. It is possible, for example, that a helicopter may have been replaced by bird radar in the aggregation detection phase and as the aid to decision-making in the pursuit of a school. Similarly, the dual use of certain pieces of equipment (eg sonar, bird radar), more frequently indicating the preference of the captain or first officer rather than simultaneous use, would not necessarily lead to a doubling in the boat's efficiency (even if this could reduce the risk of failure of one of the pieces of equipment).

Lastly, in some cases, the positive impact of a form of technological progress can be negated by a change in the fisher's behaviour resulting from its use (for example, the bending of FAD antennae, so as to avoid thefts). In another area, the efficiency gain resulting from the deepening of purse-seines (reduction of nil set returns) would have been greater if this development had not prompted fishers to explore new fishing grounds further offshore, releasing them from some of the constraints imposed by the thermocline. These considerations illustrate quite clearly the complexity of the interactions that exist between all these technological and behavioural factors.

Despite the need to conduct more thorough research, this research programme enabled the identification of major factors in the development of purse-seiner fishing efficiency. The switch by the French boats to an 'opening ring' system in the second half of the 1980's made it possible to virtually double in 20 years the time spent on searching for aggregations and locating schools. However, this gain is only really substantial in a situation of great school density.

The intensification of FAD fishing since the late 1980's is a major factor in the increase in purse-seiners' fishing efficiency; this trend is recognised by both scientists and professionals. The adoption of FAD fishing made it possible to minimise the risk of having totally unproductive fishing days (direct effect on increases in CPUE), but also to exploit new fishing grounds (indirect effect). However, real progress only occurred when fishers were able to instrument their FADs in such a way as to find them easily from a long distance. The use of GPS buoys, the Ariane type in particular, can be considered as a significant step forward in the development of purse-seiners' fishing power. In such cases the efficiency gain mostly concerns skipjack and juveniles of the other two target species (yellowfin and bigeye), as fish caught on FADs are usually small in size. The time spent on this fishing method reduces by the same amount the time spent seeking free-swimming schools, so the effect would be the opposite one for large yellowfin taken from unassociated schools. Together with FAD use, the assistance provided by fishery support vessels is also an illustration of the increase in the efficiency of the purse-seiners receiving such assistance. The Esther project made it possible to acquire precious information on the operating methods of this kind of boat and to appraise the impact of such support on Spanish purse-seine yields.

The importance of bird radars during fishing was unanimously recognised by all fishers to whom the question was put. This device would appear mostly to be used to detect aggregations, then to select potentially promising indications. It enables the purse-seiner to avoid having to sail the place of detection every time to check if an indication is worth pursuing and thus to avoid unproductive use of time.

Sonar has been used on board tuna boats for a long time now but its productive use, especially to take a decision on net setting and to guide the captain during the encircling of the school, would appear to come with gradually increasing familiarity over the analysis period. Here again, skippers responding to questions on this point recognise the fundamental role that this device plays, particularly when fishing on free schools. Even if the deeper the net is closed, the greater the risk of a zero catch, as demonstrated by this project, the deepening of nets over time has made it possible to catch deeper schools and has probably contributed to the redistribution of fishing effort in offshore grounds, which were unfavourable in the past due to the depth of the thermocline. Many other factors such as top speed (competition between boats on the same aggregation), the modernisation of winches and of the power block (less downtime when setting), etc have also contributed to increasing individual fishing power of community purse-seiners. It must however be borne in mind that the on-board use of a technological innovation can be justified both by a reduction in operating costs for the vessel and by an observable positive effect on changes in CPUEs.

1.2.4 - Participants

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Conclusions

The main goals of this study were (1) to develop an inventory of the technological factors which have a potential to influence increases in fishing power of the European Union tuna purse seiners, and (2) a tentative assessment of these effects. The usefulness of such a study can be perceived at two complementary levels: accounting for the increasing trend in the efficiency of the purse seine fishery in stock assessment studies, and searching for a compromise between the effective fishing effort and the quantity of resource available during the same period of time.

Numerous difficulties have been found during the development of the operational stage of this research program. First, acquiring information on equipment on board has been thwarted by the low levels of assistance and cooperation provided by the industrial tuna sector. We met a partial or total refusal from tuna company owners (consequently there were important delays in the transmission of the data) and providers of fishing devices were reluctant to provide information, even in the case of outdated fishing devices. Secondly, in spite of explanations given to tuna vessel associations about the objectives and on the great utility of a scientific observer program, only few tuna companies agreed to cooperate (sometimes under the condition that the observer trip be conducted outside the general framework of the Esther project).

In addition to these practical impediments, the statistical analysis of data obtained from a non-equilibrate sampling situation is not easy. For instance, new and innovative equipment have not been introduced continuously (i.e., one by one) but rather in waves of improvements during specific periods of time. However, the introduction dates of equipment among vessels were heterogeneous and there were partial overlaps between the periods of introduction of the new fishing devices. There were also complex interactions between these devices (bearing in mind, that the use of a new technology could modify the fisherman' behaviour at sea). Thus, for all of these reasons, one can believe that this evolutionary process has developed in a continuous manner. This explains why it was very difficult to detect which factor was responsible for a significant change in the catch per unit of effort, and, *a fortiori*, which part of this change was caused by each factor.

Another constraint in this type of analysis is related with the relative scale of the observations. Because data depict global CPUEs, there is a risk that the effect of a particular factor would be diluted by a global improvement in efficiency. This might occur even if, *a priori*, we suspect that a new fishing device influences only a specific stage of the fishing process (e.g., the detection of clusters of tuna schools, the sighting of the school, the duration of the set, etc.). To overcome this difficulty, we attempted to identify the time period of the fishing process in which each fishing device was used. Furthermore, in this scientific report we highlighted the fact that maintaining a new technology on board may be justified as well for reducing the overall fishing costs of a purse seiner as increasing the success of fishing, which can be directly measurable on CPUEs changes.

As commonly found in numerical analysis involving a large number of variables, the presence of numerous interactions may lead one to select complex and sophisticated statistical models. Such models produce improved fits but are difficult to analyse because of the large number of parameters involved. This type of problem was found when we attempted to standardise the CPUE data. Although we decided to reduce arbitrarily the number of explicative factors, we observed the presence of significant interactions between the age of the vessel, the category-country of the vessel and the period of the time series. In this simple case, it appeared that the

influence of the age of the vessel on the CPUE depended on the period of the time series and on the category-country of the vessel (the fact that for some class of vessels an increase of the age of the vessel led to a corresponding increase in CPUE suggests that modern equipment has been introduced on board).
The synergies between several equipment types (e.g., the combined effects of the sonar and the depth sounder for FAD fishing, the direct impact of drifting FADs on the increase in CPUEs but also their indirect effect resulting from the discovery of new fishing grounds during the searching process and the recovery of the buoys, etc.) don't allow us to easily discriminate the influence of each fishing device from the effect caused by combined or indirect effects. The combined usage of some fishing devices (e.g., sonar, bird radar), represents more commonly a skipper's preference than a simultaneous utilization of both devices. As consequence this may not indicate that the fishing efficiency increased automatically by a factor of two (even if the risk of defection due to the breakdown of one of the two devices was logically reduced). In other cases, there is not a systematic synergy between new technological factors but rather a substitution of equipment for the same task. For example ,, there is a possibility that bird radar replaced the use of the helicopter (very effective but with high maintenance costs) for detecting clusters of tuna schools and for providing assistance to the skipper in the decision to pursue a school.

In some cases the expected positive effect caused by a new technology may have been progressively reduced by a simultaneous change in the fishermen's behaviour. We showed that although the implementation of drifting FADs undoubtedly increased the fishing power of seiners, it appears that fishermen fishing on FADs behave in a more independent manner which can be less effective than fishing cooperatively for non-associated schools and sharing information into a "code group". In a similar manner , bending the antenna of the radio beacon in order to avoid having their drifting FADs stolen considerably reduced their efficiency. Another example was seen in the increase in efficiency (i.e., a decrease in the unsuccessful sets) resulting from the adoption of a deeper purse net. This gain may have been more significant if this change in net technology had not been used by fishermen for exploring new offshore areas, where the thermocline is deeper. These few examples give a good illustration of the complexity of the interactions existing between the technological factors involved and the fishermen' behaviour at sea.

Without discarding the need of additional studies for confirming some results, we can draw some conclusions concerning the major impacts observed during the Esther project (without ranking the technological improvements by importance levels). The adoption of the Spanish purse ring system by the French purse seiners in the mid-eighties, cut the setting time in half, and consequently increased the time devoted to searching for tuna schools and school sightings.. Notice however, that this improvement is only higlhy significant in areas of high density of tuna schools.

It is commonly admitted by fishermen and scientists that the intensive implementation of drifting FAD technology since the late 1980s has been one of the main factors responsible for the increase in fishing efficiency of the purse seine fishery. The main advantages of this fishing mode are the strong probability of making a successful set and to capture a large catch per set. As a consequence, FAD fishing meant minimizing the risk of zero catch days with the possibility of exploring new fishing grounds. However, real progress were observed only when fishermen were able to incorporate electronic technology on the drifting FADs in order to detect them over large distances. For this reason, the introduction of GPS buoys, specifically the *Ariane* type, can be considered as a significant technological improvement. It must be stressed that this modern location system influences differently the fishing power exerted on the different tuna species. Because tuna caught under drifting FADs are small fish, the increase in fishing power due to this technology concerned only skipjack and juveniles of the other two tropical tunas (yellowfin and bigeye). It appears likely that a subsequent reduction in searching time devoted to non-associated schools resulted, producing a reduction of fishing effort for large tunas caught in this fishing mode (i.e., large yellowfin).

Simultaneously with the use of drifting FADs,, the assistance provided by supply vessels during fishing operations as well as for logistic support provides a good illustration of how fishing efficiency can be improved. For the first time, the Esther research program provided the possibility of obtaining detailled information about the activities of a supply vessel and to estimate its influence on the CPUE of assisted Spanish purse seiners. The interviewed fishermen agreed with the importance of bird radar during the fishing operations. This fishing device would be used mainly during the location of concentrations of tuna schools, and subsequently during the selection process of the sightings presenting potential sets. It would be used by the fishermen before moving to the area of the sightings to verify whether tuna schools may be present or not, and in this manner avoid unproductive pursuits.

The sonar was introduced on board purse seiners a long time ago. However its effective usage, specifically to guide the skipper in the decision to set the net, then during the encircling phase of the set, appeared to have been a continuous and progressive learning process over the period analysed. The interviewed skippers highlighted the great utility of this electronic device, specifically for catching non-associated schools. Even if increasing the pursing depth of the net increases the probability of an unsuccessful set, as showed in this research project, the general increase of the net depth over the years allowed the capture of deep schools and likely contributed to the development of the fishing effort in new areas which were not fished in the past because of the thermocline depth.. This inventory list is not exhaustive and other factors, such as the maximum pursuit speed of the vessel, the winches, the power-block, the auxiliary side thrusters, etc., contributed also to the improvement of the fishing efficiency of the European Union purse seiners.

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