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THE IMPORTANCE OF NON-COMMERCIAL FISH

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Contents

Glossary

Artisanal fishery: A fishery whose catches are predominantly sold.
Bycatch: Catches of untargeted fish in a specialized fishery.
Gleaning: Walking along the intertidal zone at low tide and collecting edible invertebrates and fish.
Juvenile: Sexually immature fish between larval stage and adult stage.
Larva: Immature free-living fish with a developed or residual yolk sac.
Non-commercial: Not involved in a monetary exchange.
Ontogenic (= ontogenetic): Of or relating to the origin and development of individual organisms.
Subsistence fishery: A fishery whose catches are consumed by fisherfolks and their relatives only.
Taxa: Taxonomic groups such as families, genera, species.

Summary

This article deals with the importance of finfish that are not sold on any market. We detail two major points of view: the ecological significance of larvae and juveniles for future harvests, and the importance of subsistence fisheries as a food supply, particularly in the tropics. In the first case, we show that larvae and juveniles of many commercially important species are linked to estuarine and coastal environments and to their quality; they are also dependent on other species of no commercial interest. Although they do not target juvenile fishes, trawl fisheries may exert a significant negative role on their survival and therefore on future catches. However, in all cases, the relationship between juveniles and adults is difficult to quantify. In the latter case, available data show that gleaning, family fishing, and other usually neglected types of fish catch can result in surprisingly high yields not far from those of artisanal fisheries. Both these concerns require an ecosystem approach to ensure the sustainability of the resource.

1. Introduction

This article aims to overview fish resources that are not subject to trade and thus are not accounted for in economical statistics. This comprises fish harvested by subsistence fisheries (e.g.; gleaning or spear fishing, excluding artisanal fisheries) but also ontogenic stages of no commercial interest. We only consider finfish resources (other marine products being treated in other articles), and their importance is understood in terms of effective or potential food supply.

In addition to surveying adult fish of interest to commercial fisheries, a comprehensive approach to the resource must also integrate larval and juvenile fishes as an indissociable part of it. The first section of this article addresses the importance of this often cryptic component. Larvae and juveniles usually grow in coastal and estuarine waters, making these zones particularly important for the sustainability of the resource. Ichthyoplanktonic studies show that unfished taxa account for the majority of fish larvae and play an important role in trophic food webs. Although the relationship between proportions of young and adult fish has been poorly quantified, fish trawlers discard huge amounts of young fish, which might adversely affect the sustainability of commercial fish stocks.

In the second part of this article, the importance of non-commercial fish for human consumption is pointed out. In developing countries, population expansion combined with poor economic conditions and limited employment opportunities lead to a development of low-cost subsistence fisheries. The extent of this sector has scarcely been assessed, although available information shows that it is significant. An excerpt from Blaber (1997) summarizes the importance of subsistence fisheries in certain tropical countries, the gender and inter-generational issues involved, and the unevaluated importance of their yields: the hilsa fishery in the Bay of Bengal “has subsistence, artisanal and commercial sectors, although there is considerable overlap between all three, and very large numbers of people are dependent on the fishery [which produces more than 100 000 t. per year^{-1}]. The subsistence sector comprises mainly the fishing activities of women and children who catch juveniles in the estuaries and rivers [...]. There are conflicts of interest between the sectors, with the commercial fishers believing that the catching of juveniles by the subsistence sector adversely affects adult stocks [...].”

These two aspects of non-commercial fish highlight the necessity of a comprehensive approach of the fish resource at the ecosystem level.

2. Importance of Non-commercial Fish in Terms of Global Harvests

Larval and juvenile fish are usually of no commercial interest, but they provide the recruits for future harvests.

Although several species of commercial interest spawn and grow at sea, the majority of fish species harvested on continental shelves have larval and juvenile phases in estuarine and littoral areas. Dozens of studies demonstrate the nursery role played by these zones. Three combined environmental factors explain this phenomenon: a particularly abundant and diversified food supply, shallow waters, and turbidity, which all induce a reduced predation rate on juveniles.

In the Gulf of Mexico for instance, between 1961 and 1971, 90 per cent of the commercial catch was made of estuarine-dependent species. At a larger spatial scale, estuarine-dependent resources made up to 50 per cent of the total U.S. commercial landings in 1990. In Southeast Asia, estuarine and mangrove capture fisheries are estimated to contribute approximately 1.4 million tons, or 21 per cent of the region’s total marine capture fisheries. The relationship between estuarine/coastal concentrations of juvenile fish and commercial fisheries has also been confirmed in Australia and in South Africa. However, in spite of these clear trends, some controversy remains about the absolute or relative dependence of marine harvested fish species on estuarine zones.

In reef systems, knowledge of larval stages, of their dispersal by oceanographic advection patterns, and of larval settlement events allows a better assessment of the sustainability of a local fishery. These also are key factors to identify relevant zones of reef reserves, which have been considered as a solution to ensure a consistent recruitment in adjacent harvested zones.

In arctic zones, eggs and larvae are a critical ontogenic stage. Ultraviolet radiation damages their DNA and it has been suggested that increased solar UVB resulting from ozone depletion may reduce recruitment and adversely affect the whole trophic web. The egg stage is particularly exposed as most marine fish eggs are buoyant and drift in the upper layers of the sea. Furthermore, along productive littoral zones, the thin air-water interface layer often exhibits extremely high concentrations of hydrocarbons, heavy metals and pesticides. The quality of coastal waters is of importance not only for coastal species, but also for typically oceanic and commercially dominant species such as tunas, whose larvae concentrate around islands where they find better feeding conditions.

From an ecological perspective, the importance of certain non-commercial species in the functioning of coastal and reef systems should be stressed. Table 1 provides an example of the dominance of larvae of unharvested species in the marine environment:

Table 1: Comparison of the importance of shore fish in the fishery with larval abundance in Hawaii (after Bohelert 1996).

	% in fishery	**% of shore fish larvae**
6 fished families	100	5.3
9 unfished families	0	84.2

At a given ontogenic stage, fish of the six families harvested by the fishery necessarily interact, compete with, feed on, or escape predation from other unfished families. The latter make up the majority of the fish assemblage. Some particular taxa can have a prominent place in the biotic system: in this table 73.7 per cent of unfished taxa larvae consist of Gobiidae. The quantitative dominance of Gobiidae, Blenniidae, or Eleotridae larvae has been confirmed all over the world in various environments ranging from mangroves to continental shelves. Thus they should play a consistent role in the diet of several commercial species. In return, adults of these taxa (of limited size, reduced catchability, and difficult identification) are often quite abundant and may feed on larvae and juveniles of other species. The contribution of these taxa to trophic webs leading to harvestable fish resources has probably been notably underestimated.

Although the relationship between non-commercial larval or juvenile stages and commercial adult fish is clear in ecological and qualitative terms, it would be more convincing if also expressed in quantitative terms. However, the lack of efficient tools for such quantification remains a problem. Stock-recruitment relationships and their variability are poorly known in spite of considerable scientific efforts. Up to now most theoretical models using estimated values of recruitment have not been useful for the management of tropical fisheries. The complexity of multispecific trophic networks involving larval and juvenile phases and subsequent feedback phenomena is an impediment to management models. An underestimation of total fishing effort, due to neglected subsistence fisheries in tropical zones, could be another factor affecting the failure of current models. In reef fisheries, settlement variability is a supplementary critical factor influencing the year-to-year harvest.

The importance of larval and juvenile stages to commercial fisheries could be better assessed if the proportion of larvae entering into the fishery as adults was appraised. The "equivalent adult analysis" method is an attempt to do so. This method aims at calculating the number of adults able to reproduce which will survive from an initial number of juveniles in a given age class. However several parameters necessary to run the model (e.g. probability of survival from spawning to time *t*, average fecundity of mature females of a given age class etc.) remain unknown for most tropical species.

Larval and juvenile stages experience a very high natural mortality, which is increased by a sizeable fishing mortality due to trawl fishing. It has been estimated that on average 27 million tons of fish are discarded each year in global commercial fisheries (this represents more than half of all marine fish harvested annually for direct human consumption). Trawlers, particularly shrimp trawlers, operate in shallow coastal waters with small-sized mesh nets and discard high quantities of small fish caught together with prawns. The ratio often amounts ten kilos of unwanted fish for one kilo of prawns in tropical waters. Juvenile finfish can account for 80 per cent of yields. For instance, in the New South Wales Australian prawn fishery, the by-catch ratio amounted to 10.4 kg of fish for one kilogram of prawn. Eighteen per cent of this bycatch was retained for sale whereas 82 per cent was discarded as commercially worthless. A variable but small proportion of these discarded fish survive; small because of direct mortality or of increased vulnerability to predation. These fish consist mostly of immature individuals of commercially valuable species, and of non-commercial species that are a food source for targeted ones. These juvenile fish could contribute to replenish stocks if allowed to mature; however a detailed impact assessment of bycatch requires more information on natural mortality, growth rates and proportions of juveniles discarded relative to adult stocks.

In conclusion, larval and juvenile fish, although they have no direct commercial value, are a key component of harvested marine systems. A sustainable management of the fish resource must take these phases into consideration. In terms of research strategies, scientific studies of ichthyoplankton and juveniles should be favored.

3. Importance of Non-commercial Fish for Humans

Given the abundance of islands in the Pacific, the density of littoral populations in Asia and the limited financial resources and employment opportunities in developing countries, fish gathering can be expected to be an important activity at the family level in these countries. Several studies have pointed out the importance of human predation on rocky shores and on invertebrates, but studies of fish harvests of such non-commercial fisheries are scarce, and most of them deal with the Pacific or the Indian Ocean reef systems.

One of the most detailed studies available was done in the American Samoa islands. Gleaning accounted for 32 per cent of annual fishing effort and provided 9.7 per cent of annual finfish catches (and 78 per cent of invertebrates catches); this activity dominantly involved women and children. The production of this subsistence fishery was amounted to 18 $t.km^{-2}.year^{-1}$ for finfish only.

In Viti Levu Island (Fiji) in 1996 the annual catch of subsistence fisheries was amounted to 3500 tons (35.8 $kg.person.year^{-1}$), when the artisanal catch reached 6200 $t.year^{-1}$.

In the Philippines, on Pamilacan Island in 1986 fish production by gleaning reached 7.2 $t.km^{-2}.year^{-1}$, accounting for 40 per cent of the total reef yield, while on Bolinao reef flat in 1989 the fish capture by traps and spear fishing amounted to 6.4 $t.km^{-2}.year^{-1}$. Regarding spear fishing, a summary of 10 studies conducted in South Pacific reefs shows that catch per unit effort (CPUE) varies from 0.4 to 8.5 $kg.h^{-1}$ per fisher (average value = 2.2).

In south-western Madagascar, subsistence fisheries provide 3 to 4 kg of fish per day per family, and total gathering was assessed to reach 15 to 16 $t.km^{-2}.year^{-1}$.

In comparison, artisanal reef fisheries productivity usually ranges between 0.2 and 36 $t.km^{-2}.year^{-1}$ (average 7.2 $t.km^{-2}.year^{-1}$) and fish productivity of freshwaters world-wide ranges between 0.0003 and 0.028 $t.km^{-2}.year^{-1}$ (average 0.0027 $t.km^{-2}.year^{-1}$).

Therefore the productivity of subsistence fisheries in coral reef regions can be similar to the productivity of artisanal fisheries, although the latter has been considerably more studied. Incidentally, a major environmental consequence of intensive gleaning on coral flats is trampling, the destructive consequences of which have been well documented.

When dealing with freshwater non-commercial fish resources, the trends are similar: paucity of quantitative data in general and surprising amounts in the few available figures, particularly in Asia. In Cambodia, subsistence fisheries production amounts to 115–140 000 tons a year (one third of the total fish catch); this is supplemented by rice field fisheries producing 45–110 000 tons a year (productivity of about 100 $kg.ha^{-1}.year^{-1}$). Other studies on rice field fisheries have estimated their production at 50–100 $kg.ha^{-1}.year^{-1}$ in India, 57-201 $kg.ha^{-1}.year^{-1}$ in Malaysia, and 25 $kg.ha^{-1}.year^{-1}$ in Thailand on average. These rice field fish might be considered a commercial resource as they are often sold and significantly contribute to the household income (their value amounting 40–80 per cent of that of the rice production in Cambodia); however this mostly happens after the family food requirements are satisfied.

In developed countries, studies on subsistence fisheries are not abundant and very few of them have quantified fish captures; however in southern Alaska the yearly capture of salmon for self-consumption amounted to 134 $kg.year^{-1}$ per household.

Very few studies document the nutritional importance of subsistence fisheries. In Vanuatu in 1983–1984, “small-scale unstructured village fishing” provided an average of 3750 tons of fish, when artisanal fishery provided only 90 tons. This subsistence fishery provided between 16 and 18 per cent of the population’s yearly protein requirement.

In the Mekong river basin, proteins of aquatic origin make up 50–75 per cent of the diet of rural populations, and the consumption of aquatic animals (mostly fish) ranges between 20 and 64 $kg.person^{-1}.year^{-1}$.

This protein input is also of major importance along African coasts and rivers. Historians have related human settlements to local fishery resources, anthropologists often mention subsistence fishing as a part-time activity, but we are not aware of quantified evaluations of the nutritional contribution of these fish.

Non-commercial fisheries are not only important in terms of fish production, but also from a social point of view. In the Philippines, the global fishing and gathering activity related to Bolinao reef flat provided about 230 jobs per km^2. Such activity is also important to women and children. In Oceania, the contribution of women and children to total fish catches ranges from 16 to 50 per cent. In Africa, several studies demonstrated the importance of invertebrates gathering, but apparently no study quantified family finfishing, although mosquito net fishing and harvests were often supposed to be far from negligible. Actually, underestimation of harvests may also reflect the underestimation of the role of women in developing countries' rural economies. Statistical monitoring of fisheries has been conceived in terms of landings, and designed at a large scale; family subsistence fishing escapes this valuation just like small fish through a large mesh net.

Lastly, and beyond the scope of this article, these non-commercial fisheries are also more than just fish harvesting. They refer to global patterns of production, distribution, exchange, and consumption, and are part of a complex web of social relationships and sometimes of cultural identities.

4. Importance of an Ecosystem Approach for the Sustainability of the Resource

The first sections of this article focused on the importance of larvae and juveniles growing in estuarine and coastal zones, and the importance of gathering fish on reef flats. An overview of the extent of such zones and of the dependence of their functioning on adjacent ecosystems will show the importance of an ecosystem approach for a sustainable management of the resource.

The considerable extent of zones of estuarine nature in the world has been substantially documented. In Southeast Asia, the sea between Thailand, Hong Kong, the Philippines, and Indonesia exhibits physico-chemical and faunal characteristics of estuarine nature; this is due mostly to the outflows of the Mekong and the Chao Phraya rivers. In the Bay of Bengal, such waters extend 100 km from the mouth of the Ganges. Estuarine characteristics are also present up to 20 km away from shores in West and Central Africa. Most of the Gulf of Mexico waters, fed by the Mississippi, have similar characteristics. In South America the effects of the discharge of the Amazon River are felt up to 400 km from the mouth, up to Guyana where estuarine waters extend 40 km from the shore. In fact, several authors agree about the relative estuarization of the continental shelf in much of the tropics.

The total area of coral reefs was more precisely evaluated at 617 000 km^2; this is probably an underestimate but subsistence fishing, as defined above, is restricted to reef flats that comprise only a part of total reef shelves.

Non-commercial fish resources are important not only in terms of biodiversity but also in terms of quantities harvested and even more in terms of future commercial harvests. They are impacted by human activities occurring at a scale much larger than that of the resource biotope. As a matter of fact, all estuarine and coastal zones have a particular biological function depending on freshwater and terrestrial inputs. Riverine inputs are equally critical to coral reefs, but as a negative factor linked with siltation. In both cases, these inputs result from processes occurring at the drainage basin scale, such as deforestation and river flow modification. Multiple studies all over the world have shown a positive correlation between river discharges and marine catches. A dramatic example is the collapse of the coastal sardine fishery in the eastern Mediterranean Sea resulting from the hydrological management of the Nile River.

At a slightly lower scale, human settlements in coastal areas directly impact these systems through pollution and environmental modifications (about 3 billion people live at less than 60 km from a shoreline, and two-thirds of cities exceeding 2.5 million habitants are located along estuaries). In tropical America as well as in Asia, several studies exhibited positive correlations between marine fish catches and areas of coastal vegetation, and this environmental dimension in fishery management cannot be ignored.

Similar observations were made decades ago, and recent analyses keep on insisting on the necessity of a global system functioning approach, overtaking sectorial management. To date, comprehensive management integrating fisheries and biotope needs for the different ontogenic stages of the resource has hardly been applied at all. One impediment lies in the frequent division of responsibilities between inland and marine/coastal management bodies. But above all, managers and decision-makers need, over the conceptual approach of the resource, practical guidelines to implement a sustainable management, at least at a regional scale. Considering the current decline of many fish resources, providing these guidelines is a major challenge for the scientific community at the beginning of the twenty-first century.

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Biographical Sketch

Eric Baran is a fish biologist specialized in tropical communities and statistics. His Ph.D. in Biological Oceanography (University of West Brittany and ORSTOM, France) dealt with estuarine and mangrove fish assemblages in West Africa. He deepened the multivariate statistical approach of fish communities at Lyon-1 University (France). He worked as a biology lecturer in that University, then as a consultant for the IUCN, the UNEP, the WHO, etc. He is currently a Project leader at ICLARM-The World Fish Center, and focuses on global management of the Mekong River fish resource. His publications cover tropical fish biology, coastal ecology, resource management and statistical analysis.