Tuna Resources of the Lesser Antilles: Present State of Fishing and Prospects for Development

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ABSTRACT

Tuna and tuna-like fishes resources in the Lesser Antilles area and the eastern Caribbean Sea off Venezuela have been estimated at 55,000 tons for yellowfin and skipjack, and 30,000 tons for the other small tunas and tuna-like fishes. The present total catches are about 30,000 tons for the first two species and 12,000 tons for the others, and so could be substantially increased. Tuna fishing is only well developed off Venezuela while in the Lesser Antilles catches only account for about 5,000 tons for a potential estimated at about 25,000 tons. After a brief examination of the meteorological and oceanographic conditions that characterize the Lesser Antilles, the principal tuna resources and fisheries of the region are reviewed, and the potential for capture and appropriate fishing techniques that could be introduced to develop and exploit this potential are discussed.

INTRODUCTION

There are about ten commercially important species of tuna in the Caribbean. These include: yellowfin (*Thunnus albacares*) and albacore (*T. alalunga*), which are mostly caught by longlining; and skipjack (*Katsuwonus pelamis*) and blackfin tuna (*T. atlanticus*), which are caught by trolling, driftlining, or by pole and line fishing with live bait.

The region's yellowfin and skipjack fisheries have expanded considerably with the introduction of industrial purse seining, particularly active recently in Venezuela. Swordfish and marlin are also abundant in the Caribbean where they are a by-catch of the Asiatic longline fleets as well as being actively sought by recreational fishermen.

After briefly reviewing the meteorological and oceanographic conditions characterizing the Lesser Antilles, we will turn to the region's main tuna resources and fisheries. Even a rough estimate of catch potential should enable us to establish which fishing techniques could be most usefully introduced or developed in order to exploit this potential.

The Lesser Antilles is a difficult area to define accurately, whether from an oceanographic viewpoint or from a tuna biology one. This is because it is very closely linked to the whole of the Caribbean region which includes, in the north, the Gulf of Mexico, and in the east, the northern zone of the South American coast. Consequently, a review of the area's resources will, for some species at least, mean taking into account a rather larger portion of the Atlantic.

ENVIRONMENTAL CONDITIONS

Two parameters are usually employed to fix the distribution area of tropical tuna and the depth of their habitat: temperature and dissolved oxygen. However, often this is not enough since the areas to which these parameters apply are extremely large. It is, therefore, necessary to try and determine the preferential concentration zones within these areas:

- zones of convergence with concentrations of forage organisms;
- sectors where enrichment is a more or less permanent feature, either because of upwelling linked to currents and winds, or because of island effects;
- frontal zones capable of constituting traps and thermal walls.

Surface Temperature, Oxygen and Deep Hydrological Structure

Although surface temperature in sub-tropical areas has a deciding role in the distribution of species such as skipjack and yellowfin, its influence is not nearly so clear in the tropics where it is relatively uniform and almost always warm enough for the species. For skipjack, the preferential zone is between 20° and 29°C, whilst for yellowfin the range is slightly narrower owing to the fact that this species is rarely found at temperatures below 23°C.

Caribbean surface temperatures tend to be around 27°C, with fluctuations not exceeding ± 3°C. The highest temperatures occur in August-September (≥ 28°C) and the lowest ones between January and March (25°-27°C). No frontal zones capable of forming traps or thermal walls have been observed. There is a deep homogeneous temperature layer with water temperature at 100 m still being 21-22°C in the south of the region and 24-25°C in the north. The 18°C isotherm is deeper than 200 m in the north of the archipelago, and around 150 m in the south. This deep indistinct thermocline is not, *a priori*, conducive to purse seining, except to the north of Venezuela where the permanent coastal upwelling causes a marked rise in the isotherms in the vertical structure (Fig. 1).

Variations in environmental dissolved oxygen content are only relevant for skipjack which tend to swim faster where the content is lower, though only for short periods at a time. It is generally accepted that the minimum dissolved oxygen concentration required by skipjack is around 2.5 to 3.5 ml/1. In the eastern Atlantic where the homogeneous surface layer is relatively shallow, the oxycline often coincides with the thermocline, constituting an effective barrier which prevents tuna from diving further downwards. In the western Atlantic, however, the barrier is not a factor, since the oxycline and thermocline are much deeper and the homogeneous surface layer is

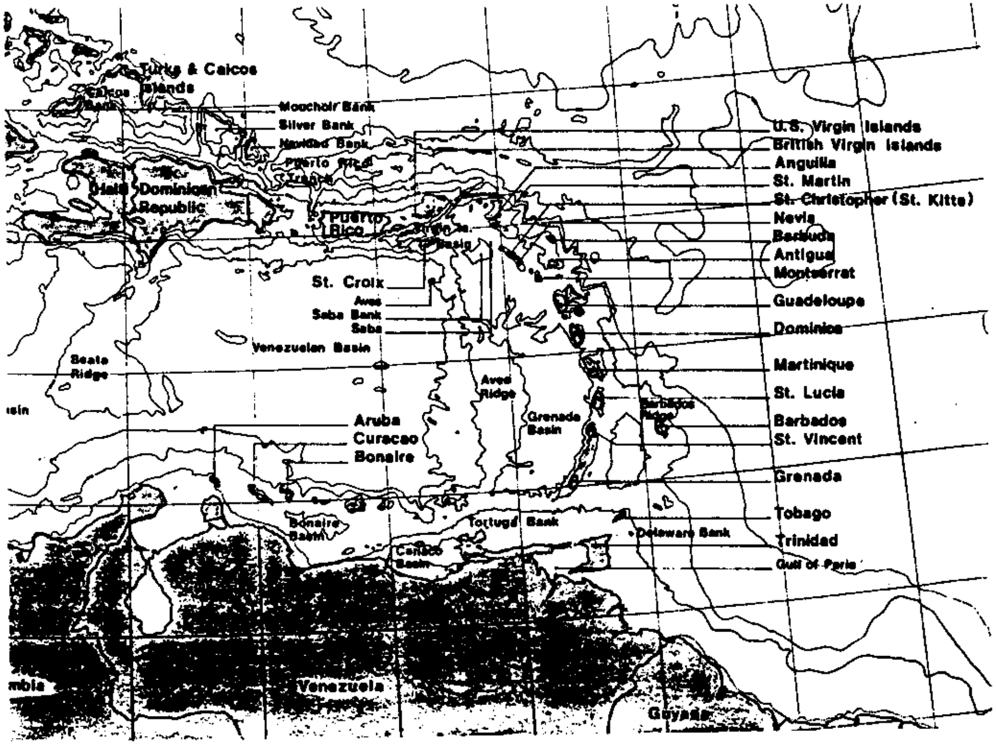

Figure 1. The Lesser Antilles region (from IUCN Data Atlas, Caribbean Region, 1979).

usually oxygen-saturated.

The situation is much more complex in the Caribbean. In the north of the region, where waters with dissolved oxygen concentrations greater than 3.5 ml/1 can be as deep as 200-300 m, whilst they may only go down as far as 100 m off Venezuela and the Guianas in the south. The depth of the layer favoring concentrations of skipjack therefore declines from north to south, and the fish become more vulnerable due to the increasing likelihood of schools being found near the surface the further south they travel.

Yellowfin has lower dissolved oxygen requirements and both northern and southern waters provide enough for its needs.

Wind and Operational Conditions

Conditions at sea are determined to a great extent by wind strength, which is the main meteorological factor, with a direct bearing on tuna fishing operations whether these involve purse seiners, pole and line vessels or artisanal craft. Winds above 15 knots make it more difficult to locate schools and to set a seine. The best places, or times, for fishing tend to be in those areas where winds of below 15 knots predominate.

In the Lesser Antilles, winds from December to March are north-easterly and easterly, with east winds predominating for the rest of the year. This means that the waters lying to the south and west of the islands are relatively calm.

In the sector south of Puerto Rico between 65^{o} and 70^{o}W and 15^{o} to 20^{o}N, winds of force 3 or above on the Beaufort scale occur throughout the year except in September-October which are characterized by calms and light breezes. Off the north coast of Venezuela, weather conditions are usually clement between September and November with calm or force 1-2 seas 50-55% of the time. However, from April to July, the north-east and east winds are strong and regular with calms and light breezes only 20-25% of the time. The south-east sector of the Lesser Antilles is slightly more clement, especially from August to November, whilst the north-east sector enjoys two periods when operational conditions are easier - one in September-October and the other in February-April. Calm seas are most frequent to the west of the Lesser Antilles, with winds of force 1-2 60% of the time between August and November, and more than 40% of the time in February and between April and July.

The most favorable operational conditions are therefore found between August and November and during the second quarter in the western sector of the Antilles Arc and north-east of the Lesser Antilles (Table 1).

Currents

Circulation in the Caribbean is characterized by an east-west movement of water masses, with a current inflow near Trinidad and Tobago and an outflow through the Yucatan Straits.

Off Barbados, currents flow in a west-north-west direction for most of the year. Because of the island effect, gyres form on the western side of the coast - anticyclonic in the south-east and cyclonic in the north-west. The gyres gradually weaken on their way westwards into the Caribbean. According to Mazeika (1973), these gyres are caused by water accumulating along the barrier formed by the Lesser Antilles. During the summer months, these systems are characterized by areas of low-salinity water up to 200-300 miles across and of Amazonian origin; as they approach the Antilles Arc they tend to break up causing upwelling at their periphery.

Table 1. Frequency of calm or force 1-2 seas in the Lesser Antilles regions (%) (Seas and Swell Charts, North Atlantic Ocean, Hydrographic Office, United States Navy, 1943)

- Sector 1: 15°N-20°N, 65°W-70°W
- Sector 2: 10°N-15°N, 65°W-70°W
- Sector 3: Caribbean Sea and west of the Lesser Antilles, 10°N-18°N, 61°W-65°W
- Sector 4: North of the Lesser Antilles, 15°N-20°N, 55°W-61°W
- Sector 5: South east and east of the Lesser Antilles, 10°N-15°N, 55°W-61°W

Sectors	Months											
	J	F	M	A	M	J	J	A	S	O	N	D
1	30	37	34	36	34	25	27	39	<u>51</u>	<u>55</u>	<u>41</u>	31
2	31	34	31	24	30	20	23	37	<u>50</u>	<u>55</u>	<u>53</u>	34
3	34	<u>46</u>	37	39	<u>43</u>	<u>40</u>	<u>42</u>	<u>61</u>	<u>71</u>	<u>77</u>	<u>57</u>	34
4	30	<u>41</u>	<u>44</u>	<u>43</u>	33	33	26	31	<u>46</u>	<u>55</u>	35	32
5	30	25	27	28	29	30	31	<u>59</u>	<u>62</u>	<u>63</u>	<u>40</u>	28

Surface currents east of the Windward Islands are generally considered to flow westwards and north-westwards. They can, however, vary considerably in direction and speed; a north-flowing current between St. Lucia and Dominica has been identified by Brucks (1971) from drift bottle analysis. The direction and speed of this current, estimated by direct observation, fits in well with calculations of the geostrophic current (Fig. 2).

In the Caribbean Sea, the current flows strongly westwards in the central zone whilst some anticyclonic circulation has been

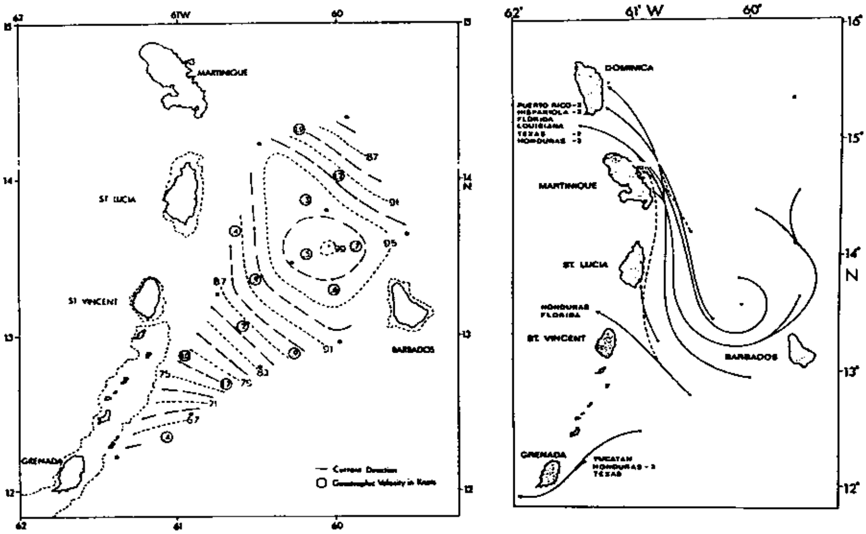

Figure 2. Currents observed from drift bottle studies and deduced from the dynamic topography of the eastern Lesser Antilles (from Brucks, 1971).

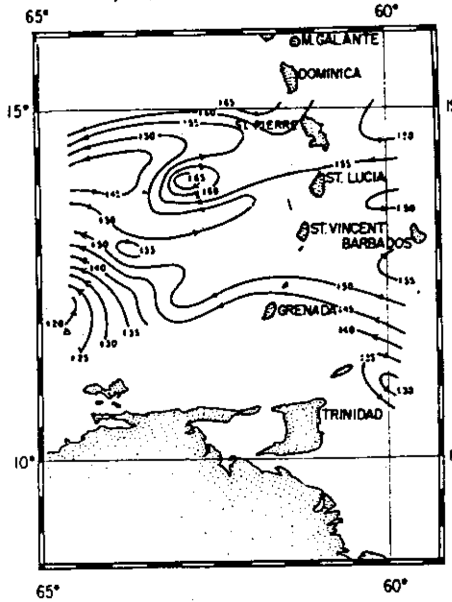

Figure 3. Currents deduced from the dynamic topography of the southern Lesser Antilles (from Febres-Ortega and Herrera, 1976).

noted in the north in small gyres (Nelepo et al., 1978). The southern Caribbean Sea is characterized by an intense cyclonic circulation whose north-east branch is formed by the Caribbean Current and the southern branch by the easterly Venezuela Current.

This structure has also been observed by Febres-Ortega and Herrera (1976) who note a westerly flow penetrating the Caribbean between the islands of Dominica and St. Vincent and composed of two main currents, one coming from the south-east between Barbados and Tobago and the other coming round from the north-west to the south of Dominica (Fig. 3). The cyclonic circulation observed east of Tobago redistributes a large part of the water volume brought by the Guyana Current eastwards towards the West Indies. In the Caribbean Sea, the westwards circulation has two main axes towards 13^{o}N and 15^{o}N with, between them, two counter-currents flowing eastwards, one coastal along the Venezuelan coast, and the other located around 14^{o}N.

The circulation of surface water masses in the West Indies and east of the Antilles Arc is therefore a lot more complex than a simple east-west circulation (Molinari et al., 1980). Gyres and counter-currents cause upwelling or convergences which especially enrich the Lesser Antilles area south of 15^{o}N.

Productivity of the Region

The productivity of a fishing ground, particularly a tuna one, depends largely on its oceanographic conditions. The standard technique for measuring directly a zone's productivity involves trying to make direct measurements of primary production or of the zooplankton biomass. Figure 4, which is taken from the IUCN (*) clearly shows two zones of high primary productivity with one corresponding to the Guyana upwelling and the other to the Venezuela upwelling. In comparison to the waters which wash the Antilles Arc and Barbados, the Guyanan waters are extremely rich ($>$500 mg C/m^2/day). This enrichment can be attributed mostly to river water but also to the effects of the upwelling along the Guyana coast and to remineralization of waste matter in the offshore waters. The fixation rate for these nutrients is very high with the result that when the waters reach the Barbados region, they are low in nutrients, these having been transferred to the higher trophic levels in the food chain (van Bennekam and Tijssen, 1978).

* International Union for the Conservation of Nature and Natural Resources; Data Atlas - Draft Strategy for Marine Conservation in the Antilles Region.

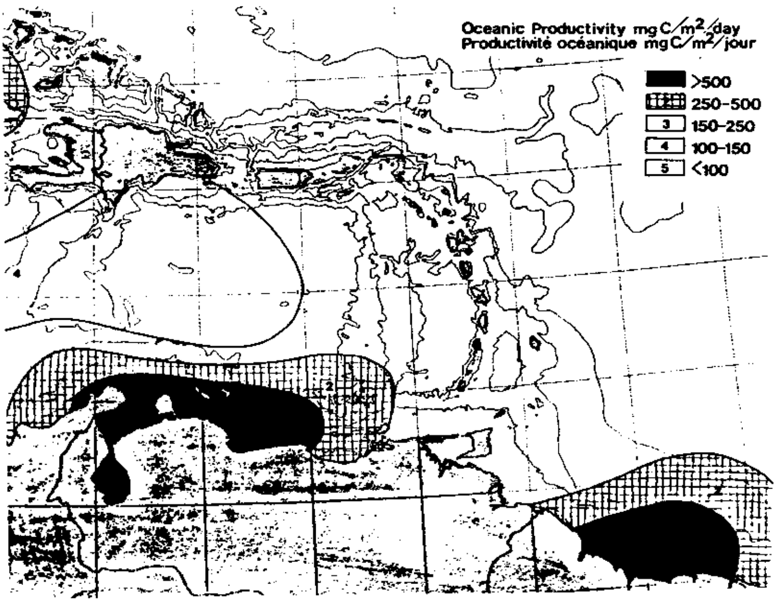

Figure 4. Primary productivity in the Caribbean and off the Guyanas (from IUCN Data Atlas, Caribbean Region, 1979).

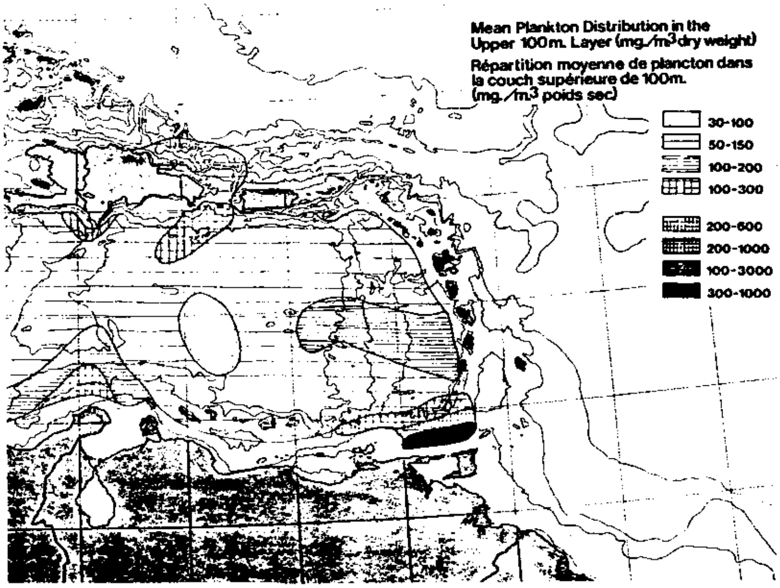

Figure 5. Mean plankton distribution in the upper 100 m layer (from IUCN Data Atlas, Caribbean Region, 1979).

Although the relationship between the oceanography of the South American coast and the Antilles is not at present very well understood, it seems that the Amazon and Orinoco discharges have a profound effect on productivity in the Barbados region and in the Lesser Antilles (Kidd and Sander, 1979). Quantitative differences have been observed in most physiochemical and biological variables between tha Amazon's periods of maximum influence (June-September) and least influence (December-April) and it is reasonable to deduce that year-to-year variations in this discharge play an important role in the region's productivity.

Finally, it is highly likely that the Antilles islands and the nearshore shallow waters create "island effects" bringing about a local enrichment mainly in the area to leeward of the islands. However, the real importance of the island effect on the productivity of these waters has yet to be ascertained.

In the Caribbean Sea, the high primary productivity of the Venezuelan coast, due to the coastal upwelling, is the main source of enrichment; because of the westward drift of the surface currents it is probably the reason for the large concentrations of zooplankton met with further west, to the north of the Bay of Maracaibo and off the Colombian coast (Fig. 5). Furthermore, the high secondary productivity noted west of St. Lucia could be explained either by the island effect or by the contribution of the counter-current observed towards 14°N (Febres-Ortega and Herrera, 1976).

The northern zone of the Caribbean appears to be relatively low in nutrients, because there is no upwelling or other important source of enrichment.

TUNA FISHERIES

Artisanal Fisheries

Artisanal and small-scale tuna and marlin fisheries are still relatively underdeveloped in the Lesser Antilles. Although there are no accurate statistics, the total catch can be roughly estimated at around 5,000 tonnes a year out of a total marine production of about 40,000 tonnes in the region (FAO Yearbooks of Fishery Statistics).

In Martinique and the Iles des Saintes, skiffs and rowboats may venture as far as 60 miles from the coasts to fish for skipjack, yellowfin, dolphin fish and flying fish which gather round drifting wreckage in the sector between the 14th and 16th parallels, east of the Martinique coast (Sacchi et al., 1981). This offshore fishery, called "miquelon" fishing, is carried out in the "northward current" described by Brucks (1971), and is at its most active between February and May. Trolling lines are used for the large pelagic fish and drift nets for flying fish. Deep sea fishing is not yet well-developed with only a few driftline boats operating west of the Grenadine Islands, off Venezuela, and north-east of the Guianas. Yields are around 10-15 tonnes for 15 fishing days at a rate of 3-4 fish per 100 hooks (Sacchi et al., 1981). Tuna (bigeye, yellowfin and albacore), swordfish and sharks dominate the catch. The Martinique catch of large pelagic species amounts to around 1700 tonnes; that of Guadeloupe to 1200 tonnes. These figures include tuna (yellowfin and blackfin), bonitos (skipjack and others) as well as dolphin fish, kingfish and barracuda.

Trolling is active in Barbados and is carried out around drifting wreckage in the flying fish sectors and when running between the coast and these sectors. Dolphin fish, sailfish (Istiophorus platypterus) and blue marlin (Makaira nigricans) are frequently caught as well as tuna (especially yellowfin, blackfin) and skipjack. Tuna, sharks and marlin represent around 10% of the Barbadian pelagic catch, i.e., about 200-300 tonnes. They are mostly caught between January and June when fishing effort is at its highest. Yellowfin is plentiful from December to July whilst there does not appear to be any particular season for marlin which are fished throughout the year (CIDA, 1981).

In St. Lucia, trolling is carried out around drifting wreckage between January and June, during the flying fish season. Tuna appear to be relatively underfished, with dolphin fish representing about a quarter of pelagic fish landings - 240 tonnes in 1981 and 380 tonnes in 1982.

In Grenada, fishing is mostly done in coastal waters where small pelagic species are caught with beach seines and gillnets. Large pelagic species are caught by trolling and handlining between January and June, with a peak for skipjack in April and May. Out of a total production of 3600 tonnes in 1981, yellowfin accounted for 500 tonnes, skipjack for 150 tonnes, blackfin for 80 tonnes and the various types of marlin for 30-40 tonnes.

In many islands, but especially in the Virgin Islands in the north of the Lesser Antilles, recreational and sport fishing is an important activity closely linked to tourist development; tuna and marlin are the most highly prized species according to season.

Industrial Surface Fishing

Pole and Line Fishing

Tuna fishing by live bait and pole and line methods has considerably expanded in the western Atlantic. ICCAT statistics (Table 2) show that the total catch rose from 2000 tonnes in 1973 to more than 22,000 tonnes in 1983, with skipjack accounting for around 85%. Up until 1979, the fishery was dominated by the Cuban pole and line vessels; total catches were stable at around 2000-2500 tonnes a year (mostly skipjack and blackfin). The most spectacular increase has come from the Brasilian coast and does not, therefore, concern the Caribbean area.

In the Caribbean Sea, only the Venezuelan fishery is especially active, with a catch of around 4000-5000 tonnes a year (Table 3), consisting of yellowfin and skipjack in more or less equal quantities (Table 4). Skipjack are mainly fished in the Caribbean during the first and fourth quarters, with yellowfin the most important species during the second and third quarters and still significant in the fourth quarter. In the Atlantic area, catches and fishing effort are low except in the the first quarter and consist mainly of skipjack (Table 4). The fishing grounds are located along the Venezuelan coast although they can extend as far east as Guiana (Fig. 6).

Table 2. Pole and line tuna catches (in tonnes) in the western Atlantic (Source: ICCAT Statistical Bulletin)

Year	Yellowfin	Skipjack*	Blackfin*	Total	Country
1973	26	1921	-	1947	Cuba, Japan
1974	1278	2926	-	4204	Cuba, Japan
1975	312	2738	-	3050	Cuba, Japan
1976	-	2800	-	2800	Cuba
1977	-	2400	-	2400	Cuba
1978	1012	2812	-	3824	Cuba, Spain
1979	519	4279	-	4798	Cuba, Brazil Spain
1980	392	9396	-	9788	Brazil, Cuba Panama
1981	1928	18064	700	20692	Brazil, Cuba Venezuela
1982	2970	22002	631	25603	Brazil, Cuba Venezuela
1983	3134	19179	569	22882	Brazil, Cuba Venezuela

* Until 1980, the Cuban blackfin and skipjack catches are listed together under "skipjack"

Purse Seining

The Spanish seiner "Albacora dos" in 1972 seems to have been the first vessel to experiment with tuna seining in the western Atlantic and, more particularly, off the Venezuelan coast. However, between 1973 and 1980 USA seiners were the only ones to survey and exploit this region (Table 5). Subsequently, the Venezuelan fishery took off sharply as shown by the catch figures which rose from 6,600 tonnes in 1980 to more than 30,000 tonnes in 1983 (Table 3).

Little data is available on yields obtained by American ocean-going seiners in the Caribbean. Even where it exists, such data should be treated with caution since these vessels initially only fished incidentally in the western Atlantic on their way from the eastern Pacific coast to the fishing grounds of the eastern tropical Atlantic. A study of ICCAT statistics shows high yields for yellowfin and skipjack in the Caribbean Sea in September-October 1978 (29 tonnes and 12 tonnes/day respectively); the catch obtained between March and June the same year was extremely low. In 1981, surveys and fishing trials took place between January and August with very irregular yields: 7 tonnes/day in January, 26 tonnes/day and 9 tonnes/day in June and August, and an insignificant quantity between February and May. From these rather sketchy statistics it begins to look as if the best period for purse seining is between June and December and this has been confirmed by more recent data from the Venezuelan fishery (Salazar, 1984).

Table 3. Assessment of the Venezuelan tuna, small tuna-like species and marlin catch (in tonnes) in the Atlantic, Caribbean, by type of gear: 1973-1984 (ICCAT, 1984)

Year	TYPE OF GEAR				
	Longline	Pole and line	Non-specified surface gear	Purse-Seine	Total
1973	2324		5976	-	8300
1974	1508		6750	-	8258
1975	981		6899	-	7880
1976	1791		6297	-	8088
1977	1649		5997	-	7646
1978	2277		4720	-	6997
1979	1819		7401	-	9220
1980	2036		6967	6648	15651
1981	3138	4000	6586	4600	18324
1982	765	5074	5441	21563	32843
1983	940	*4231	6495	*30277	41843
1984*	-	*4015	-	*28500	-

* Estimates (P. Miyake, pers. comm.)

The quantities for each species landed at Cumana in 1982, 1983 and during the first three quarters of 1984 are given in Table 6, together with their origin. The figures in the table do not correspond to the total estimated Venezuelan catch for the Caribbean and Atlantic zones (21,000 tonnes in 1982 and 30,000 tonnes in 1983) but they do show an increasing proportion of the catch as coming from the Caribbean, the Pacific catch having been very low in 1984 (P. Miyake, pers. comm.), as it had been in 1983 when it was a third of the 1982 total. Catches are mainly yellowfin and skipjack but also include bigeye, albacore, and various small tuna-like species.

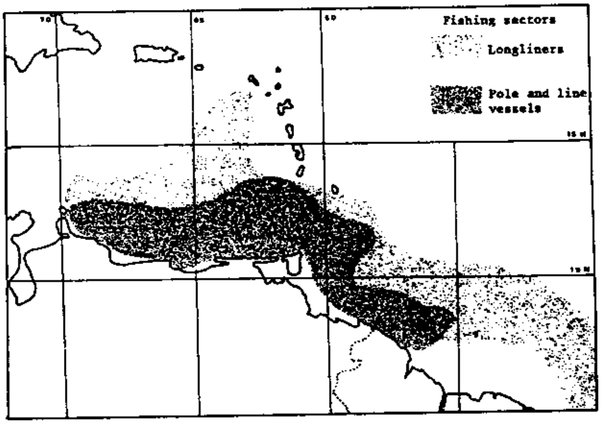

Figure 6. Venezuelan longline and pole and line fishing sectors - 1981 (from Calderon de Vizcaino and Salazar, 1984).

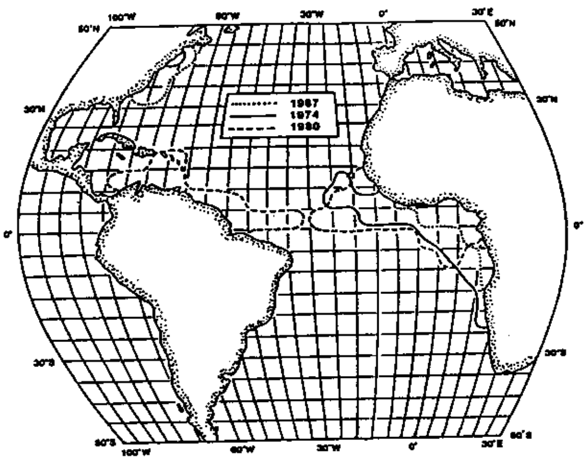

Figure 7. Distribution of U.S. tuna purse seine fishing effort in the Atlantic Ocean in 1967, 1974 and 1980.

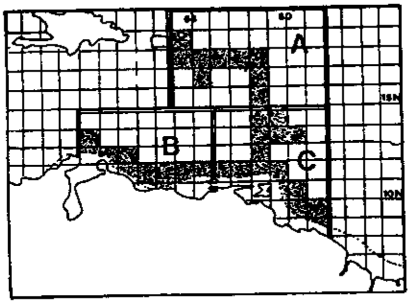

Figure 8. Zones A, B and C, with shaded areas showing sectors considered to be coastal or influenced by island effects.

Table 4. Venezuelan pole and line tuna catch (in tonnes) in 1982, by quarter and by species (Salazar, 1984)

Species	Caribbean					Atlantic				
	Quarters									
	I	II	III	IV	Total	I	II	III	IV	Total
Skipjack	632	301	235	440	1608	270	1	-	93	364
Yellowfin	26	543	636	492	1697	6	-	7	17	29
Albecore	-	44	5	5	-	49	28	-	-	28
Other tuna	12	203	250	387	852	1	20	9	18	46
Total	670	1091	1126	1319	4206	305	21	15	126	467

Table 5. Yellowfin and skipjack seine catches (in tonnes) in the western tropical Atlantic (Source: ICCAT Statistical Bulletins)

Year	Yellowfin	Skipjack	Total	Country
1973	2850	332	2582	USA, France
1974	-	-	-	-
1975	1137	299	1936	USA, Spain
1976	634	700	1334	USA, Canada
1977	1073	638	1711	USA, Spain
1978	2656	2699	5355	"
1979	1035	1489	2524	"
1980	5735	2728	7863	Venezuela, USA Ghana
1981	2785	2363	5148	Venezuela, USA
1982	12112	9543	21655	"
1983	14037	11526	25563	Venezuela

Not much is known yet about the western Atlantic sectors. In 1980, American seiners concentrated their surveys mainly in the Caribbean south of 15°N and in the equatorial region north-east of Brazil (Fig. 7). A few trials were made in the northern region of the Lesser Antilles without, however, much success.

Since 1981-1982, Venezuelan seiners have tended to concentrate their fishing effort in the south, between 60° and 65°W, where the pole and line vessels operate. The reason for this is that pole and line vessels and seiners almost always work in association: the former baiting the school to concentrate the fish before the latter strike with the seine net. This technique tends to limit the potential zone of action of the seiners to that of the pole and line vessels (which is more restricted).

Making sets on flotsam is also common practice and is mainly carried out during the day (P. Miyake pers. comm.).

Longlining by Foreign Vessels

Longlining for tuna in the Atlantic Ocean developed spectacularly between 1956 and 1965 following the rapid expansion of the Japanese fleet. Since 1966, Korean and Chinese (Taiwanese) longliners have gradually been replacing the Japanese fleet. The total tuna and marlin catch of these fleets reached a record level of nearly 140,000 tonnes in 1965 before sharply dropping back to level out at around 100,000 tonnes a year for the whole of the Atlantic, all species combined.

Table 6. Tuna landings (in tonnes) of Venezuelan seiners at Cumana, and origin of catch

Fishing Zone		SPECIES					Total	%
		Yellowfin	Skipjack	Albacore	Bigeye	Other Tuna		
Year 1982	Caribbean	4681	3612	276	-	1560	10129	67
	Atlantic	15	366	261	-	62	704	5
	Pacific	2165	1197	-	-	825	4187	28
Year 1983	Caribbean	11488	9269	98	1053	2830	24739	86
	Atlantic	825	842	62	-	92	1820	6
	Pacific	821	761	-	-	631	2213	8
1984 Jan. to Sep.	Caribbean	7354	6770	21	148	1606	15899	
	Atlantic	704	713	15	-	125	1557	
	Pacific	no data						

The mobility of the longline fleets causes problems when it comes to estimating stocks of the different species in an area as small as the Caribbean and the Antilles Arc. Fishing effort varies considerably from one year to another with boats changing their sector of operations in accordance with the yields obtained and the target species.

The target species of the Japanese fleet, for example, have changed radically: to begin with, the target species was yellowfin, then yellowfin and albacore, and finally yellowfin and bigeye as well as bluefin. The target species also vary in accordance with the size of the vessel and its home port in Japan or abroad. In the eastern Caribbean and the Lesser Antilles, the Japanese longline fleet is nowadays not very active. Indeed, in the sector between 10°N and 20°N and 55°W and 65°W fishing effort was non-existent in 1981 and extremely low in 1982 (Table 7).

Korean longliners, whose target species are yellowfin and bigeye, only fished the sector on a highly seasonal basis in 1981 and 1982, concentrating fishing effort in February, July and August in 1981, and in June and July in 1982. The Taiwanese feet fishes mainly for yellowfin and albacore and operates in the Lesser Antilles from May to September.

Table 7. Estimate of longline fishing effort (10^3 hooks) in the Lesser Antilles sector in 1981 and 1982 (Sector: 10°-20°N, 55°-65°W)

Year	Korea	Japan	China	Cuba	Venezuela	Total
1981	1.500	3	720	-	226	2.449
1982	530	219	1.206	158	261	2.374

The quarterly distribution of fishing effort of these three fleets is shown by 5° square in Table 8. It can be seen that fishing effort is mainly concentrated north of 15°N, and between 55° and 65°W during the second and third quarters.

The Venezuelan longline fishery is centred south of 15°N along the northern coast of Venezuela and off the Guianas (Fig. 6). Fishing effort and yields (number of fish per 100 hooks) of the Cumana based boats are shown in Table 9. Yellowfin is the main species caught and yields appear to vary not only from one year to another, but seasonally as well with the second and third quarters proving the most productive in the Caribbean.

Shiohama (1971) calculated indices for measuring the degree of interest shown by fishermen for each of three species - yellowfin, albacore and bigeye - by 5° geographical sector. The results, for the Lesser Antilles region, broken down into quarters, show that yellowfin may be sought on a year-round basis in the south using longlines, but only during the third and fourth quarters in the north. Albacore is sought north-east of the Lesser Antilles and in the northern Caribbean Sea during the second quarter, whilst there is no fishery concentrating exclusively on bigeye except towards the end of the year in the south-east sector (Table 10).

In the Caribbean and the Lesser Antilles zone, longline tuna and marlin catches are very low amounting to 500-1000 tonnes per year for all the Asiatic fleets, all species combined. The Venezuelan catch in the Caribbean and off Guyana is also around 1000 tonnes a year.

Experimental Fisheries

Experimental pole and line fishing using live bait has been tried several times in the Lesser Antilles zone: between 1966 and 1970 by the UNDP/FAO project; between 1976 and 1978 by the pole and line vessel "Cdt. Levasseur;" and in March-April 1980 by another pole and line vessel, the "Rhonda Sue," under an international skipjack program.

Table 8. Quarterly distribution of fishing effort in 10^3 hooks and by 5^o square in the Lesser Antilles sector in 1981 and 1982. The main fleets active in the area are indicated by the letters K (Korea), J (Japan), T (Taiwan) and C (Cuba)

Quarter	Latitude	1981 70°W–65°W	1981 65°W–60°W	1981 60°W–55°W	1982 70°W–65°W	1982 65°W–60°W	1982 60°W–55°W
I	20°N–15°N	-	-	-	-	-	-
I	15°N–10°N	-	-	520.5 K	-	2.2 K	47.2 KJC
II	20°N–15°N	37.2 T	323.4 T	77.7 T	153.8 T	341.3 KT	517.1 TK
II	15°N–10°N	68.1 K	24.3 K	63.9 K	-	136.2 C	60.1 JK
III	20°N–15°N	259.4 TK	101.9 TK	176.1 T	34.1 KT	236.2 TK	545.7 TK
III	15°N–10°N	170.3 KT	29.8 K	694.3 KJ	173.3 KT	16.8 K	150.1 JK
IV	20°N–15°N	19.3 K	63.0 K	27.8 KT	52.0 KT	11.3 K	-
IV	15°N–10°N	17.6 K	-	17.5 K	54.0 T	9.0 K	28.8 J

Baiting fishing results have been available: in Guadeloupe and Martinique, the "Cdt Levasseur" did not encounter any major problems and was able to take on board a full stock of bait at almost every trip in the bay of St Pierre, and the Bay of St. Lucia, and off Le Prêcheur, with lower quantities being taken in the bights of Arlet and Schoerlcher (Sacchi et al., 1981).

During trials carried out under the FAO/UNDP project, the bait fishing results were positive in the south, around Trinidad and Tobago, but also at St. Lucia in Roseau and Soufrière Bays and, at Grenada, in Beauséjour Bay and in the Port of St. Georges where nightly "boke ami" yields attained 25-33 3 kg buckets for each night of fishing (Wagner, 1974). The "Rhonda Sue" carried out night and day trials with lampara nets and obtained good day time results at Barbados (an average of 94 buckets per trial), and good night results at Grenada, St. Lucia and Guadeloupe, with average catches of 41, 38 and 27 buckets respectively (Rinaldo et al., 1982). These yields would probably have been ever greater if submerged lamps had been used instead of a simple surface projector.

Table 9. Venezuelan mean quarterly longline catch (number of fish/100 hooks) in 1981 and 1982 (Calderon de Vizcaine and Salazar, 1984; Salazar, 1984)

	Caribbean				Atlantic			
1981/Quarters		2	3	4		2	3	4
Effort x 1000 h		28.8	137.5	162.4		26.8	98.1	
No. of yellowfin/100h		1.9	0.8	0.4		1.9	1.5	
No. of albacore/100h		-	0.4	0.6		-	-	
Total		1.9	1.2	1.0		1.9	1.5	
1982/Quarters	1	2	3	4	1	2	3	4
Effort x 1000 h	50.0	125.5	40.3	86.8	60.3	41.0	85.8	31.6
No. of yellowfin /100h	0.9	1.5	1.2	0.4	0.9	8.2	0.8	0.9
No. of albacore /100h	-	0.6	-	0.1	-	0.1	0.4	-
Total	0.9	2.1	1.2	0.5	0.9	2.3	1.2	0.9

During the course of these surveys, the tuna catches (especially of skipjack, yellowfin and blackfin) were rather irregular, due, it would appear, to the schools not responding well to the bait. Positive results were obtained most frequently with yellowfin schools (40%) and skipjack schools (26%) with only a 15% response rate for blackfin. Results tended to vary according to time of day, with a first peak between 07.00 and 10.00 hr, and a second, greater, one between 15.00 and 18.00 hr.

Generally speaking, experimental live bait and pole and line fishing has not been very successful in the Lesser Antilles although there are active commercial fisheries both to the north off the Cuban coast and to the south off the coasts of Venezuela and Trinidad and Tobago. However, too much should not be made of these trials since they were carried out with vessels that either were not suited to this type of fishing or were too big and used bait fishing techniques that were inappropriate to an area with extremely limited resources.

Table 10. Main yellowfin, albacore and bigeye fishing sectors by quarter and 5° square (from Shiohama, 1971). A = albacore; YF = yellowfin; BE = bigeye

I

	70°W–65°W	65°W–60°W	60°W–55°W
20°N–15°N	YF	-	A
15°N–10°N	YF	YF	YF

II

	70°W–65°W	65°W–60°W	60°W–55°W
20°N–15°N	YF A	A	A
15°N–10°N	YF	YF	YF

III

	70°W–65°W	65°W–60°W	60°W–55°W
20°N–15°N	YF	YF	A
15°N–10°N	YF	YF	YF BE

IV

	70°W–65°W	65°W–60°W	60°W–55°W
20°N–15°N	YF	YF	YF
15°N–10°N	YF	YF -	YF BE

Trials should, therefore, be continued in order to establish just how fishing can be made successful, what techniques need to be developed, and what boat should be used. It will certainly have to be small, adapted to the region and capable of making daily bait and tuna fishing trips.

REVIEW OF THE BIOLOGY AND PRESENT STATE OF STOCKS OF THE MAIN SPECIES

Skipjack (Katsuwomus pelamis

Together with blackfin tuna, this is the most abundant of all the tunas in the Antilles. Skipjack are found along the Atlantic coasts of the Lesser Antilles early on in the year, in fast-moving schools, hunting along the edges of reefs. From April-May onwards they start moving in towards the coasts to hunt around the coral reefs and shallows. At this time of year they are found together with shoals of blackfin in the Caribbean and they may come very close to the coast in summer (Sacchi et al., 1981). They appear to be less abundant at the beginning of autumn when they leave the coastal zone to establish themselves off the continental shelf at channel outlets. According to Morice and Cadenat (1952) some very large schools may be found near shallow water off the Windward Islands and in the region around the Isla de Aves.

The Atlantic skipjack fisheries are almost all based on seining or pole and line methods; in the eastern Atlantic the catch amounted to 130,000 tonnes in 1983 with two thirds being taken by seiners.

Between 1969 and 1977, the western Atlantic catch amounted to just a few hundred tonnes, but it has since increased considerably, rising to 30,000 and 32,000 tonnes in 1982 and 1983 respectively. The increase is due to an expansion in the Brazilian fishing effort (pole and line) and the Venezuelan effort (mainly seiners).

Stocks in the eastern and western Atlantic are normally considered to be completely independent of each other and the western stock's current low level of exploitation suggests scope for a substantial increase in the future catch.

Blackfin Tuna (Thunnus atlanticus)

Blackfin tuna are common throughout the western central Atlantic. They are present all year round in the Lesser Antilles, but more particularly in the Caribbean around the banks off the Isla de Aves and at the outlets of the channels separating the islands (Sacchi et al., 1981). The species is regularly caught northwest of Tobago near Barbados, in Grenada, and in St. Lucia but the largest concentrations are to be found to the north of the Lesser Antilles east of Puerto Rico. The observations of schools, which are usually of average size and highly mobile, are almost always made easier by their surface activity and by the presence of birds; the fish tend to stay in the vicinity of shallow water and they make a valuable contribution to the troll catch until the beginning of summer. They can also sometimes be caught with beach seines at St. Lucia and in the Virgin Islands (Morice and Cadenat, 1952) According to Maghan and Rivas (1971), the largest concentrations have been observed in waters between 20 m and 700 m deep, and especially around 40-50 m.

The blackfin catch amounts to about 1500-1800 tonnes a year (ICCAT, 1984) if one includes the Cuban fishery (500-700 tonnes a year) where the species is caught at the same time as skipjack using live bait and pole and line techniques. The blackfin tuna is not much fished in the Lesser Antilles and the potential catch is certainly far greater than that made at present.

Little Tuna (Euthynnus alleteratus) and Frigate Mackerel (Auxis sp.)

Little tuna are caught in coastal waters in the Lesser Antilles, where they congregate in small schools above the continental shelf. In the Iles des Saintes and in the south of Martinique they are caught with beach seines from March and April onwards. There appear to be more and bigger schools in the south of the Lesser Antilles (Sacchi et al., 1981).

Little tuna are caught with purse seines in Monserrat between April and July and in August-September in Dominica (Morice and Cadenat, 1952). The species is often caught near Trinidad and Tobago. As it is a continental species, little tuna should be found in abundance on the South American continental shelf near the mouths of estuaries. The little tuna and frigate mackerel catch amounts to 2,400 tonnes a year in Venezuela. However, no figure is available for the Lesser Antilles. The potential of the resource has not yet been assessed but it is thought that stocks there are underfished.

Yellowfin Tuna (Thunnus albacares)

Adult yellowfin are fished in the Atlantic in an extremely wide belt between 40°N and 40°S. The longline catch is highest in the Equatorial Current, at the Equator, and just to the south of it although concentrations may also be found in the Equatorial Countercurrent, the North Equatorial Current, and the southern Gulf Stream. Generally speaking, fish caught in more temperate waters tend to be larger than those caught in equatorial waters (Hayasi et al., 1970; Honma and Hisada, 1971).

There are marked seasonal variations in most high-concentration equatorial zones. During the northern winter, high catch rates are obtained in two distinct areas: the Gulf of Guinea, and the waters between the Gulf of Mexico and northeast Brazil. In the spring and summer the western Atlantic concentrations seem to move towards the central Atlantic and the Cape Hatteras and Caribbean regions. In autumn, adult concentrations in the central Atlantic head eastwards towards the Gulf of Guinea and westwards towards the Caribbean and the Gulf of Mexico. On the basis of these seasonal movements, it would appear as if the longliners are exploiting two groups of adults - the eastern and western Atlantic groups - which are clearly separated during the northern winter but mixed together to a fairly large extent in the summer.

In his analysis of monthly variations in longline yellowfin catch-per-unit of effort (cpue) in the western Atlantic, Yanez and Barbieri (1980) notes that north of Brazil (south of 15°N and between 40° and 60°W), seasonal variations are not marked and there is little dispersion; major concentrations of big fish are found at the beginning of the year and during the third quarter, with a slight drop during the second quarter and a rather larger one at the end of the year. In the Caribbean, cpue is minimal at the start of the year, but progressively increases and is quite large by the end. According to Yanez and Barbieri (1980), the considerable seasonal variations in cpue observed in this area might be explained by a change in vulnerability arising from vertical migration of large fish at spawning time.

The Caribbean Sea and the Lesser Antilles unquestionably constitute an active spawning area for the western Atlantic stock. Indeed, it is possible to find there throughout the year young yellowfin associated with schools of skipjack and blackfin tuna, and it is the tendency to concentrate in schools or in surface waters, especially during the breeding season, that has been responsible for the recent development of the purse seine fishery.

Little is known about the catch potential of the western Atlantic stock, but the recent increase in number of surface fish would seem to indicate a production potential of some substance.

The surface fishery, and purse seining in particular, has only recently got underway in the Caribbean region; consequently, there are no catch and fishing effort series to help in estimating the "surface potential." Could we not estimate this potential on the basis of "longline potential" instead?

The first thing to remember is that the apparent maximum sustainable yield of a yellowfin stock exploited by longliners alone is not comparable with a situation where the same stock is being exploited by a different kind of fishery (with a different age at first capture and a different age mortality vector). In the particular case of a surface fishery being introduced, the potential is always greater. In the eastern Atlantic, average MSY for yellowfin used to be between 15,000-20,000 tonnes before the introduction of purse seining; nowadays, however, the figure is 110,000 tonnes or five times greater for the combined longline and purse seine fisheries. The record longline catch was 40,000 tonnes in 1960, just one third of the maximum surface catch of 120,000 tonnes obtained in 1981. In the eastern Pacific, the longline yellowfin catch seems never to have exceeded 30,000 tonnes a year, although surface MSY is now 150,000-160,000 tonnes or five times greater. In the western Pacific, the longline catch is stable at 50,000-60,000 tonnes, although the surface catch amounted to 90,000 tonnes in 1983. It is too early to say if this latter figure represents the MSY, since the surface fleet has only recently been introduced.

In the western Atlantic, longline catches corresponding to the MSY for this type of gear have remained steady at between 10,000 and 12,000 tonnes (Table 11). By analogy with the situation in the eastern Atlantic, the total MSY could be between three and five times greater than this, i.e., between 30,000 and 60,000 tonnes. On this basis, the surface catch, which amounted to

17,000 tonnes in 1983, could certainly be doubled at least, although such an increase would probably be accompanied by a sharp fall in longline yields.

Table 11. Eastern and western Atlantic surface and longline yellowfin catch (in tonnes) (ICCAT Statistical Bulletin, 1984)

Year	Eastern Atlantic		Western Atlantic		Total Atlantic		
	Longline	Surface	Longline	Surface	Total Catch	% Longline	% Surface
1965	27.1	26.7	10.5	-	64.3	58	42
1966	12.2	30.7	12.1	-	55.0	44	56
1967	14.7	34.5	3.5	1.1	53.8	36	64
1968	20.6	52.7	6.2	2.2	81.7	33	67
1969	19.5	60.1	9.3	2.3	91.2	32	68
1970	15.7	42.4	11.5	2.4	72.0	38	62
1971	13.6	42.4	13.5	1.5	71.0	38	62
1972	18.0	60.6	11.6	3.7	93.9	32	68
1973	19.2	60.4	12.3	2.6	94.5	33	67
1974	16.9	75.4	12.6	1.9	106.8	28	72
1975	13.6	94.6	14.2	2.3	124.7	22	78
1976	12.8	99.1	12.6	1.1	125.6	20	80
1977	15.6	99.0	11.3	2.0	127.9	21	79
1978	11.3	107.3	9.5	5.4	133.5	16	84
1979	6.8	105.8	9.0	5.0	126.6	12	88
1980	12.5	94.7	6.6	6.1	119.9	16	84
1981	7.9	118.9	11.2	5.6	143.6	13	87
1982	9.9	109.1	9.7	15.7	144.4	14	86
1983	6.1	102.0	5.8	17.1	131.0	9	91

Bigeye Tuna (*Thunnus obesus*)

The Caribbean is not particularly rich in bigeye which tends to concentrate more to the east of 45°W, between 5°N and 20°N, and in the South Atlantic between 10°S and 30°S, east of 10°W. However, bigeye can be caught in the eastern and southeastern zone of the Lesser Antilles during the winter months. In the Caribbean zone, small-sized individuals form a relatively high proportion of the longline catch. The entire Atlantic bigeye catch amounted to 65,000 tonnes of which 30,000-40,000 tonnes was accounted for by the longline fishery and the rest by the surface fisheries, especially those active in the eastern Atlantic. Overall fishing effort has tended to rise, reaching a high level during the period 1980-82. The recent increase in the bigeye catch is partly due to the Japanese vessels making greater use of deep longlines, particularly in the equatorial zone. Current catch levels are in the region of the maximum sustainable yield, estimated at between 60,000 and 120,000 tonnes.

Albacore (Thunnus alalunga)

It is generally agreed that the Atlantic albacore is split between two main stocks, a northern one and a southern one, which are conventionally separated by the 5°N parallel. The northern stock is exploited principally by three types of fishery: two surface ones (handlining and pole and line vessels) and a longline fishery. The overall catch reached 60,000 tonnes during the first half of the sixties, then fluctuated around 50,000 tonnes until 1979 at which point there was a considerable fall - down to a low of 33,000 tonnes in 1981. The catch picked up again in 1982 and reached 50,000 tonnes once more in 1983. After the period of intense exploitation which lasted until 1977, it now seems as if effort has stabilized at a more moderate level (ICCAT, 1985) so that any increase in effort might well result in a larger catch. Surface albacore catches, particularly in the eastern Atlantic, have fluctuated between 34,000 tonnes and 57,000 tonnes a year. The longline catch, which in the summer (April-September) is mostly concentrated in the west, between 15° and 40°N, and in the winter further eastwards (Hayasi et al., 1970; Yang and Sun, 1984), has fluctuated between 10,000 and 20,000 tonnes a year. In the Caribbean region, which is situated to the south of the albacore distribution areas, the species is more abundant to the north of 15°N and to the east of 70°W during the summer. The season appears to start in April, northeast of Puerto Rico, with concentrations moving first southwest and then southeast along the Atlantic coast of the Lesser Antilles between July and October.

Swordfish and Marlin

The eastern coast of the United States and the Gulf of Mexico are known to have a sizable population of swordfish and marlin. Studies carried out on most species show that adults migrate to spawn in the southern region of the Gulf of Mexico and in the Caribbean. They are mainly caught incidentally by longliners and so the commercial value of these species for the fishery is relatively low. As they are highly prized by sport fishermen, marlin and swordfish resources are extremely important for recreational fishing. Bullis and Klima (1972) estimated the total stock of the whole eastern coast of the United States, the Gulf of Mexico and the Caribbean at 14,000 tonnes (half of this in the Caribbean).

The Lesser Antilles zone and, more especially the northern part of it, is known to be an important swordfish (Xiphias gladius) reproduction area and Berkeley (1982) believes there is scope for developing the fishery for this species. The Cubans catch 1,200 tonnes a year by longlining at night.

White marlin (Tetrapterus albidus) and blue marlin (Makaira nigricans) are actively sought after by sport fishermen in the north of the Virgin Islands and off the coast of Venezuela in the Gaira region. In the south, white marlin is abundant mainly in late summer and autumn, whilst blue marlin is more abundant in winter and in spring. In the Virgin Islands, the blue marlin is more abundant than the white marlin with spring and summer being the season for large individuals although it lasts until autumn for smaller ones (Mather et al., 1972; Olsen and Wood, 1982).

Sailfish (Istiophorus platypterus) are caught on a seasonal basis in the American Virgin Islands with most being caught between November and March (Olsen and Wood, 1982). In winter, they are also found off the Venezuelan coast, whilst in April to June they appear to migrate towards the western Caribbean (Wise and Davis, 1975).

In 1982, the swordfish and marlin catch for the whole of the Atlantic amounted to 22,000 tonnes, of which swordfish accounted for 16,000 tonnes (Table 12). The Japanese share of the catch has remained relatively stable over the last decade, although in the northwestern sector (north of 5°N and west of 40°W) this index fell steadily between 1977 and 1980. However, this may not constitute solid proof of a real change in the size of the stock since, a) the Japanese longline swordfish catch is small and largely incidental, and b) the fall might be due to the increasing use of deep longlines which are less effective for this species (Suzuki et al., 1977).

Table 12. 1982, Atlantic Ocean swordfish, sailfish and marlin catch (in tonnes) (ICCAT Stat. Bull.)

	Total Atlantic catch	Eastern Atlantic	Western Atlantic	Unspecified region
Sailfish	1975	876	738	361
	Total Atlantic catch	**South Atlantic**	**North Atlantic**	**Unspecified region**
Blue marlin	2568	829	1458	281
White marlin	1081	429	652	
Swordfish	16791	5236	11555	

Sailfish stocks appear to be exploited only moderately and the Japanese longline hook rate for the western Atlantic does not provide evidence of any particular trend.

Blue and white marlin landings fell steadily between 1975 and 1979, from 5,000 to 2,300 tonnes. Since then, they have been increasing again - 3,500 tonnes in 1982 and 3,000 tonnes in 1983. Longline yields have shown a marked downward tendency over the last few years, although there has been considerable fluctuation on a year-to-year basis. Fishing pressure on these two stocks, which was heavy in the past, has been diminishing recently due to the increasing use of deep longlines which are only half as effective, for the blue marlin at least, as surface longlines.

CATCH POTENTIALS

Potential Yellowfin and Skipjack Catches

Potential yellowfin and skipjack catch estimates are usually made by examining what effect increasing fishing effort would have on the overall catch. This so-called "global" method has been used successfully to assess yellowfin stocks in the eastern Atlantic and in the eastern Pacific, but it cannot be applied to the western Atlantic surface fishery which has only developed very recently. Potential will therefore be estimated rather more approximately by assessing average tuna productivity in an intensely exploited zone.

The reference productivity figure chosen for a rich, intensely exploited oceanic zone is the average productivity of surface fisheries in the rich sectors of the eastern Atlantic as calculated by Fonteneau (pers. comm.); this comes to 660 tonnes per 1° square per year. The same author reckons 100 tonnes to be the minimum annual productivity figure for a 1° square.

The reference productivity of 660 tonnes has been applied to two southern zones, B and C (Fig. 8), thought to be the richest because of the effects on zone B of the Venezuela upwelling in the west, and the joint effect of the Guyana upwelling and the enriched waters of the Orinoco and the Amazon on zone C. The lower reference productivity figure of 100 tonnes was applied to zone A, considered a priori to be the poorest. It is difficult to apply productivity figures calculated for oceanic environments to the Venezuelan island and coastal sectors because of island and coastal effects on tuna biology and productivity. As an extremely rough approximation, we have used the productivity calculated by Fonteneau for the coastal zone of Senegal, i.e., 1,200 tonnes a year per 1° square.

In the northern zone of the Lesser Antilles (sector A, Figure 8), we consider that the island effect would be felt in nine 1° squares, the low productivity oceanic sector covering the remaining thirtyone 1° squares. The coastal productivity of zone A would, therefore, amount to 14,000 tonnes/year - considerably in excess of current production levels. The same calculation was made for zones B and C, taking account of the fact that sectors in these zones would have a productivity of 660 tonnes per 1° square. Total annual productivity was put at 20,000 tonnes for zone B and 26,000 tonnes for zone C (Table 13).

This maximum catch should be treated carefully as it is a very rough estimate and could only be achieved when fishing effort was at a very high level and with each boat consequently obtaining only moderate yields. A reasonable initial objective would be to aim for three quarters of the total potential, or around 35,000 tonnes, a figure which corresponds to the catch currently made in sectors B and C. Only careful monitoring of changes in vessels yields, as fishing effort increases with the introduction of new units will allow us to decide whether this deliberately conservative estimate of potential can be raised.

Table 13. Estimated potential yellowfin and skipjack catch in the Lesser Antilles and off the Venezuela coast (see Figure 8 for sector boundaries)

Zone	Sectors	No. of 1° squares	Productivity by 1° squares in tonnes	Estimated production potential per sector	Total production potential per zone
A	Coastal	9	1.200	10.800	13.900
	Oceanic	31	100	3.100	
B	Coastal	7	1.200	8.400	19.600
	Oceanic	17	660	11.200	
C	Coastal	13	1.200	15.600	25.500
	Oceanic	15	660	9.900	
					59.000

Potential Catch of Small Tuna-like Species

The potential catch of small tuna-like species is especially difficult to estimate because there are no reliable statistics for the various species in this category.

The main ones are: blackfin tuna (Thunnus altanticus); Atlantic little tuna (Euthynnus alleteratus); frigate mackerel (Auxis thazard and A. rochei); wahoo and king mackerels (Acanthocybium solandri and Scomberomorus cavalla); and the spotted Spanish mackerel (S. maculatus). In the Lesser Antilles zone and off the Venezuelan coast the first two of these species probably offer the best chance of increasing the catch.

The total catch of small tuna-like species amounts to 4,000 tonnes a year in the Lesser Antilles and 6,000 tonnes in Venezuela, according to ICCAT, but the figures probably do not show the full picture since there are no statistics for some countries with an active fishing sector. Catches per kilometer of coast are put at 1.8 tonnes/year in the Lesser Antilles on the basis of the available statistics (Table 14; Wise, 1986) and 3.1 tonnes/year in Venezuela. If one only takes account of the six countries which have provided statistics, this gives an average catch of 2.7 tonnes/year/km for the Lesser Antilles region. Extrapolating this value to the rest of the zone, we arrive at a "real" catch figure of 5,800 tonnes instead of 4,000 tonnes, i.e., a total catch of around 12,000 tonnes for the whole of the region, including Venezuela.

Table 14. Annual Lesser Antilles catch (in tonnes) of small tuna-like species, length of coast and average catch per km of coast (Wise, 1986)

Country	Average catch 1981-1983	Length of coast (km)	Catch per km in tonnes
Virgin Islands (UK)	0	100	0
Virgin Islands (USA)	0	100	0
Anguilla	0	#	0
St. Christopher & Nevis	0	100	0
Antigua et Barbuda	0	100	0
Monserrat	0	#	0
Guadeloupe	500	300	1.7
Dominique	0	10	0
Martinique	1300	200	6.5
St. Lucia	0	100	0
St. Vincent	0	100	0
Barbados	200	100	2.0
Grenada	200	500	2.0
Trinidad and Tobago	1500	500	3.0
Netherlands Antilles	300	300	1.0
Total Lesser Antilles	4000	2200	1.8
Venezuela	6100	2000	3.1
Total Lesser Antilles and Venezuela	10.100	4.200	2.4

These yield/km figures can be compared with those from other countries bordering the Atlantic with active fisheries for small tuna-like species: in Senegal and Ghana, two countries with inshore waters enriched by coastal upwelling, annual yields average between 10.5 and 13.0 tonnes/km without the limits of the potential appearing to have been reached. Productivity of between 8 and 10 tonnes could, therefore, probably be applied fairly reasonably to the Venezuelan coast, including the Dutch Antilles and Trinidad and Tobago, giving a total production of 20,000 to 30,000 tonnes a year from 2,800 km of coast. The productivity figure estimated for Martinique of 6.5 tonnes/km/year is probably a slight over-estimate in that it includes yellowfin and skipjack as well. An average of between 4 and 5 tonnes/km/year for small tuna-like species would seem to be more realistic and would give a potential of 6,000 to 7,000 tonnes a year for the Lesser Antilles (Table 15).

Table 15. Potential catches and present catches of small tuna-like species in the Lesser Antilles area and off Venezuela

	Length of coast (km)	Productivity by km/year in tonnes	Estimated annual potential (tonnes)	Present catches (tonnes)
Venezuela, Trinidad and Tobago Dutch Antilles	2,800	8 to 10	22,240 to 28,000	8,000
Lesser Antilles	1,400	4 to 5	5,600 to 7,000	2,000 to 4,000
Total	4,200		28,000 to 35,000	10,000 to 12,000

Observations on Catch Potentials

The catch potentials discussed above are on the conservative side because they are based only on the production of surface fisheries. Skipjack might well have a higher potential and so, to a lesser extent, could the large deepwater species such as yellowfin, bigeye or albacore. The potential marlin and swordfish catch is rather uncertain although fishing pressure on these species does appear to be diminishing as the longline vessels, which used to catch them, have been increasingly turning in recent years to deep longlines.

It should also be borne in mind that there are several factors capable of seriously restricting full exploitation of these catch potentials: the first factor has to do with the drop in yields that occurs in most stocks once fishing effort is increased considerably, thus limiting the economic viability of the fishery being developed; other factors are connected to the technical difficulties caused, for example, by unfavorable weather conditions in some seasons, or by local or seasonal variations in species catchability.

SMALL-SCALE AND INDUSTRIAL FISHERIES DEVELOPMENT TECHNIQUES

The catch of tuna and small tuna-like species can be increased in a variety of ways:

- by increasing the number of small artisanal fishing units using pole and line, trolling, handlining, gillnetting or seining techniques;

- by developing the industrial pole and line, longline or seine fisheries.

Each technique has its advantages and disadvantages; several have already been developed in the Lesser Antilles and the Caribbean whilst others which have proved successful in other countries could be tried out in the region with a view to their later introduction (Marcille et al., 1984).

We shall now turn to the various ways of increasing the catch, ending with a section on sport fishing whose economic possibilities in some regions are far greater than might be supposed by the number of fish presently caught.

Handlining

Handlining for large tuna is usually done near underwater peaks and "drop-offs" and in the vicinity of drifting wreckage. In some countries the technique is highly developed, e.g., in Indonesia, the Philippines, Hawaii and a number of other Pacific islands where Fish Aggregating Devices (FADs) have been introduced. In the Philippines, fishing is carried out with small 2 GRT canoes producing yields of two or three 40 kg fish (yellowfin) a day. The two lines used are baited with horse mackerel, small tuna or squid. In the Philippines, fishing is normally by day although it can take place at night as in Hawaii. The cost of introducing FADs in the Antilles would not be excessive to the extent that anchor depths do not exceed 1000-1500 m. Considerable progress has been made in the last four or five years in FAD manufacture with losses, particularly those due to currents, declining all the time. The devices could be positioned on the leeward side of the islands where the currents are not so strong and navigation is easier. Yellowfin fishing could take place all the year round in the southern-most part of the Lesser Antilles, south of St. Lucia, and from July to November in the north. In all likelihood, bigeye could also be caught by this method, particularly in the south between August and November.

Deep Trolling

Trolling, whether in Martinique, Grenada or St. Lucia, etc., is carried out in the standard way - on the surface around drifting wreckage - and the season lasts from February to June. During the rest of the year concentrations appear too low for the activity to be profitable. Here again, FADs could help extend the fishing season. Deep rather than surface trolling could be carried out around these structures leading to an increase in the catch of large yellowfin. The technique is popular in the Philippines where small boats use a troll line with six squid baited hooks and a 10 kg sinker; yields may amount to ten 25-50 kg fish per day. The technique could be tried out around a FAD from July to December, or on drifting wreckage between February and May.

Gillnetting

Small-scale tuna fishing using gillnets has been developed in a number of countries, especially Sri Lanka, Indonesia and the Philippines. In Indonesia, the catch consists mostly of skipjack and yellowfin with incidental, though sometimes significant, catches of shark, ray, marlin and sailfish. Ten to twelve m boats are used, with a 40 h.p. outboard motor; ten to twenty 100 m x 20 m nets with a 15 cm mesh are used on each trip, and yields are 80-100 kg a day. In the Philippies, the nets used are deeper, about 60 m. Recently, gillnets were tested in Western Samoa in the vicinity of an FAD with simultaneous live baiting and the results were satisfactory.

Gillnetting for skipjack and marlin has also been extensively developed off Japan and in the Northern Pacific using industrial-type boats (refitted ex-longliners) with 300-400 x 50 m nets are set during each trip.

In tropical regions, though, it is not altogether certain whether the technique could be easily employed on an industrial scale due to the damage that sharks can cause to the nets, at least in shallows and near the coast. Small-scale fishermen in the Philippines get round this danger by patrolling along the fishing nets and only lifting the part of the net where the floats are sinking, which is a sign of fish. In Samoa, the net is only placed near the FAD for a very brief time, an hour before daybreak.

Longlining

Although longlining for large pelagic fish, as it is performed by the Japanese or Korean fleets, requires large vessels and a considerable degree of automation, the longline fisheries off the southeast coast of Florida and the northwest coast of Cuba consist of small boats using surface longlines. Any region with reefs lying close to the coast can be suitable for this type of activity. Amongst the fish caught, there may be a significant number of swordfish, marlin and sharks when fishing is done at night, as in Cuba, or with phosphorescent lures, as in Florida.

Longlining by day can be carried out in the more oceanic regions, but in the Caribbean and north of Guiana seasonal tuna yields are rather variable from year to year, a factor which limits development of this technique.

Pole and Line Fishing with Live Bait

This is a widely-used technique for catching skipjack and young yellowfin as well as blackfin in Cuba. Pole and line fishing has considerable potential in regions where bait can easily be obtained - in Venezuela and in the southern Lesser Antilles at Trinidad, Tobago and Grenada. However, the technique will be more difficult to develop in the north because of the shortage of bait and the more seasonal habits of surface tuna. Nonetheless, small 12-30 GRT boats could have some success in the region catching skipjack and blackfin tuna; they would only need around 100 kg of bait a day which they could either catch themselves at night with submerged light and "boke-ami," or obtain from coastal fishermen in areas where beach seines are in use.

Seining

Seining for tuna and small tuna-like species can be looked at from two totally different angles: small artisanal units, or large scale oceanic seiners.

Small seining vessels could probably operate in the northern Lesser Antilles catching skipjack, blackfin and little tuna on grounds between 50 and 700 m deep and on banks; however, because schools are highly mobile they need to be fixed by baiting or by the use of a FAD. In the Philippines, more than 300 small 20 GRT seiners use 400-500 m x 100 m ring nets, operating at night with the aid of a FAD and having first concentrated the fish by using light. The method does not seem to have been tested on blackfin but the attempt could be made in the more sheltered Caribbean sectors.

As has already been mentioned, industrial seine fishing has been developing rapidly since 1982 and there are now about 15 large oceanic seiners operating along the Venezuelan coast and in the southern Lesser Antilles in association with pole and line vessels, or drifting wreckage. This number is likely to increase in the years to come (Miyake, pers. comm.), but a substantial rise in the Caribbean and southern Lesser Antilles catch is not expected.

For most countries in the Lesser Antilles, there does not appear to be much point in employing oceanic seiners since these boats would not enjoy the advantages which have stimulated development of this fishery in Venezuela, e.g., the fact that the pole and line vessels working in association with the seiners are able to easily procure live bait and, even more important, to benefit from extremely low diesel prices.

Sport Fishing

Sport fishing for large pelagic species (not just tuna, but also marlin, sailfish, swordfish and dolphin) could be developed in many countries in the Lesser Antilles, as it has already in the Virgin Islands and in Barbados, amongst others. When sport fishing is introduced, a host of other activities develop in its wake, involving small boat construction (they rarely exceed 10 m), maintenance, insurance, the sale of fishing lines and accessories, and the provision of fuel, ice and bait. By way of example, along the east coast of the United States between New York and Cape Hatteras, sport fishermen spent an estimated 40 million US dollars in 1983 on a sport fleet numbering 2,500 boats and whose total catch did not exceed 1,300 tonnes (Figley, 1984). Without necessarily reaching these levels, sport fishing in the Lesser Antilles, linked to tourist development, could certainly be developed to a much greater extent than at present, capitalizing on the region's favorable climate and the presence of sought-after species.

CONCLUSIONS

The potential tuna catch in the Lesser Antilles region and the Venezuelan coast can be roughly put at 55,000 tonnes/year for yellowfin and skipjack and 30,000 tonnes/year for small tuna-like and other species. Currently the catch is 30,000 tonnes for the first two species and 12,000 tonnes for the others. The potential catch increase for the whole region is, therefore, on the order of 40,000 tonnes/year.

Although there is an active industrial tuna fishery off the coast of Venezuela, the Lesser Antilles catch only amounts to 4,000-5,000 tonnes a year, although the potential is estimated at 25,000 tonnes.

There are active handlining and trolling fisheries in the Lesser Antilles but new techniques could also be tried there with a view to subsequent development, e.g., gillnetting, deep trolling or handlining near FADs. Pole and line fishing with live bait is well developed in Venezuela and could also be tested further north with small artisanal units operating on a daily basis and not requiring large quantities of bait. Depending on the results of these tests and on whether live bait fishing proved seasonal or not, these small boats could also fish with gillnets or seines near FADs.

Small fisheries for swordfish and marlin could also be developed with small boats operating at night using surface longlines and phosphorescent lures.

Not much is currently known about tuna potential in the Lesser Antilles and much work needs to be done in assessing resources and getting to know the distribution of the main species and the quantities actually caught at present. A comprehensive and accurate study of the fishing techniques used, together with an experimental fishing program using small artisanal boats and fish aggregating devices (FAD), would help improve the effectiveness of existing techniques and pave the way for the introduction of new methods that have met with success in other countries.

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