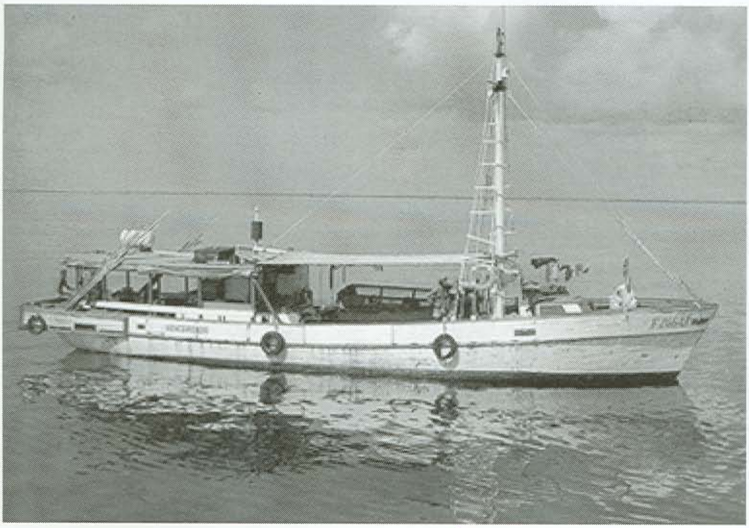
Chronicle of Cuban marine fisheries (1935-1995)

Trend analysis and fisheries potential



ISSN 0429-9345

FAO FISHERIES TECHNICAL PAPER

394

Food and Agriculture Organization of the United Nations

Cover photo: Vessel for pole and line tuna fishing.

Chronicle of Cuban marine fisheries (1935-1995)

Trend analysis and fisheries potential

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Food and Agriculture Organization of the United Nations

Rome, 2000

ISBN 92-5-104410-4

Abstract

This technical paper presents an analysis of trends in the Cuban marine fishery resources as described by a data set that covers the 1935 to 1995 period. Despite the biases that undoubtedly exist in national fishery statistics and the low level of disaggregation for some groups of species, the extended data set offers a comprehensive picture of Cuban fisheries over 60 years and makes it possible to trace down the phase of development as well as the phase of greatest expansion of Cuban fisheries.

The data set shows the sustained increase of catches from the mid-1950s to the 1970s, the decrease in the growth rate during the 1980s and, starting in the 1990s, the senescence of some important fisheries. In 1995, about 38.9 percent of the resources were in a senescent phase (with consequent declining catches), 48.7 percent were in a mature phase at a high exploitation level and only 12.4 percent were still in a developing phase with some possibility of increased catches; none of the fisheries remained undeveloped. Hence, 87.6 percent of the fishery resources are in a critical stage from the point of view of fishery management and, therefore, there is an urgent need to control and reduce the fishing effort.

Adetailed analysis of fishery resources and catch peaks reveals that there is a historical loss of 20 000 tonnes, probably resulting from the combined action of overfishing and changes in the marine ecosystem. Although better management could control losses of some of these resources, in other cases environmental changes might be irreversible.

The theory that the exploitation of fishery resources changes the relative abundance of the different species and, thus, can threaten the stability of marine communities and ecosystems has been confirmed by this study, which shows that the mean trophic level of the species caught, as well as the average maximum size of the catches, have been reduced over time. The mean trophic level and the average maximum catch of the 21 species and groups that have been analysed were negatively and significantly correlated with the period at which they were exploited. The effects produced by reduced nutrient supplies to the insular shelf are also discussed as another factor affecting fishery resources.

Acknowledgements

This document provides an analysis of the 1935-1995 time series of Cuban capture fishery production. The paper was inspired by Chronicles of marine fishery landings (1950-1994) *by Grainger and Garcia, published in 1996 as FAO Fisheries Technical Paper No. 359, and followed the methodology proposed in that paper for analysing long-term series of capture fishery production.*

The author would like to thank John Caddy for calling his attention to the influence of nutrient runoff on Cuban fishery yield and Richard Grainger and Serge Garcia for their encouragement, valuable suggestions and comments. The help of Luca Garibaldi with the English version is very much appreciated.

Baisre, J.A. *Chronicles of Cuban marine fisheries (1935-1995). Trend analysis and fisheries potential.* FAO Fisheries Technical Paper. No. 394. Rome, FAO. 2000. 26 p.

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Introduction

This paper presents an analysis of trends in Cuban marine fishery resources covering the period of development as well as the period of greatest expansion of national marine fisheries. It is based on the national landing statistics by species or species groups. The fisheries statistical data from 1959 to 1980 were analysed for the first time by Baisre (1981). In another paper (FAO, 1993), the analysis was carried further back to cover the 1935 to 1959 period. With the information obtained from the official landing statistics of the Ministry of Fishing Industry (MFI, 1979 and 1981), the Ministry of Economy and Planning and the Cuban Statistical Yearbook (Government of Cuba, 1953), an extended time series has been devised for the most important species or species groups in Cuban fisheries, covering the last 60 years. This time series includes landings of edible fishes, crustaceans and molluscs. The by-catches of shrimp fisheries and the landings of sponges were not considered here because they are not used for human consumption. The landings of marine turtles were also not included in this analysis because their fishing has been prohibited for the last ten years. In total, the landings of 21 species or groups of species have been analysed, representing 63.5 percent of all Cuban landings and 79.5 percent of the landings used for human consumption.

This analysis follows the ideas and methodologies developed by Grainger and Garcia (FAO, 1996), in particular those regarding assessment of trends and evaluation of the fisheries potential of world marine resources. The Cuban resources have been grouped according to the pattern of their landings and in relation to the different phases of fishery development as described in a generalized fishery model (FAO, 1984). The fisheries potential was then estimated on the basis of the relative rate of growth in landings. In addition to the works already mentioned, an extended data set such as the one examined here and despite the biases that undoubtedly exist in national statistics, was also found to contain coherent and useful information on

Cuban fisheries, which can assist not only in the appraisal of fishery potential but also in the planning and management of fisheries.

Analysis of production peaks

The sequence of production peaks reached by each species or species group can be used to identify the different phases of the development of each fishery (FAO, 1996). The results of this analysis for Cuban fisheries are summarized in Table 1. This table shows the sequence of attainment of peak landings in a smoothed time series by five-year running-means. The procedure for smoothing the original time series has the effect of reducing, but not completely eliminating, the potential impact of interannual environmental changes on natural populations.

The sequence of peaks is generally as would be expected, based on knowledge of fisheries development in Cuba. With the exception of small tunas (skipjack and blackfin tuna mainly), whose peaks occurred at the end of the 1950s, most of the peaks occurred in the 1970s and 1980s with only one group, the mojarras, reaching a peak in the 1990s. The last column of Table 1 lists the ratio between recent landings (1995) and maximum landings. Only the turkey wing clam and the mojarras (two species that have been exploited only relatively recently) show recent landings that are above the peak landings on a five-year running mean. Grunts, spiny lobster, porgies and thread herring landings have fallen by less than 25 percent, but shrimps, mullets, gray snappers and Nassau grouper have fallen by around 75 percent, or even more, in the last two decades. All the other species or species groups, such as small tunas, yellowtail snapper, lane snapper, mutton snapper, Spanish mackerels, scaled sardines, sharks and jacks, have fallen by between 40 and 70 percent. The overall fall is 40 percent, considerably higher than the 22 percent calculated by Grainger and Garcia (FAO, 1996) for world demersal resources.

Although the differences between peak and current landings must be interpreted with caution, as pointed out by Grainger and Garcia (FAO, 1996), peaks in smoothed time series probably give an indication of the average long-term yield that the species assemblage in a given area may be able to

TABLE 1

Development of fisheries by species or species group

Species or species group	Scientific name	1995 landings *(tonnes)*	Maximum landings (5-yearmeans) *(tonnes)*	Period of maximum landings	Ratio of 1995 to maximum landings
Small tunas	*Thunnini*	1 091	2 267	1959-1963	0.48
Nassau grouper	*Epinephelus striatus*	81	1 509	1962-1966	0.05
Yellowtail snapper	*Ocyurus chrysurus*	578	1 064	1962-1966	0.54
Spanish mackerels	*Scomberomorus spp.*	538	844	1963-1967	0.64
Lane snapper	*Lutjanus synagris*	1 943	3 776	1971-1975	0.51
Mangrove oyster	*Crassostrea rhizophorae*	1 885	3 194	1971-1975	0.59
Mullets	*Mugilidae*	108	916	1972-1976	0.12
Scaled sardines	*Harengula spp.*	1 045	1 599	1975-1979	0.65
Grunts	*Haemulidae*	2 128	2 264	1976-1980	0.94
Shrimps	*Penaeus spp.*	1 651	6 281	1976-1980	0.26
Land crab(*)	*Cardisoma guanhumi*	284	1 203	1977-1981	0.24
Gray snappers	*Lutjanus spp.*	155	1 150	1979-1983	0.13
Sharks	*Elasmobranchii*	1 365	2 628	1983-1987	0.52
Spiny lobster	*Panulirus argus*	9 406	12 349	1985-1989	0.76
Porgies	*Calamus spp.*	372	459	1986-1990	0.81
Blue crab	*Callinectes sapidus*	744	1 238	1987-1991	0.60
Turkey wing clam	*Arca zebra*	1 906	1 813	1987-1991	1.05
Mutton snapper	*Lutjanus analis*	609	1 507	1987-1991	0.40
Jacks	*Caranx spp.*	344	501	1988-1992	0.69
Thread herring	*Opisthonema oglinum*	2 005	2 256	1989-1993	0.89
Mojarras	*Gerreidae*	2 221	2 012	1993-1997	1.10
All species		**30 459**	**50 830**		**0.60**

* Although the land crab is a terrestrial species, its fishery is based completely on its annual migration to the sea during the reproductive season.

sustain in the future if properly managed and if there are no significant causes of disturbance for the fisheries. The sum of the differences between the observed historical peak landings of each species or species group, smoothed by a five-year running-mean, and recent landings, amounts to about 20 000 tonnes. This observation implies that, if these individual species or species groups were all restored to their historical maximum levels, a gain of some 20 000 tonnes of landings could be expected. However, some declines may reflect potentially irreversible situations created by habitat losses in the coastal zone caused, in turn, by the impact of human activities or by other environmental changes.

Generalized fishery model

Although any analysis of a time series of landings usually shows large variations along the time axis, some trend patterns have been identified and described. Caddy (FAO, 1984) presented a generalized model of a fishery (Figure 1) which, in the course of its development, can be considered to pass through four phases: I) undeveloped, II) developing, III) mature, and IV) senescent. Implicit in this model, and underlying it, is the concept that fishing capacity and fishing effort (or extraction rate) increase over time and drive the fishery from one phase to the next (FAO, 1996).

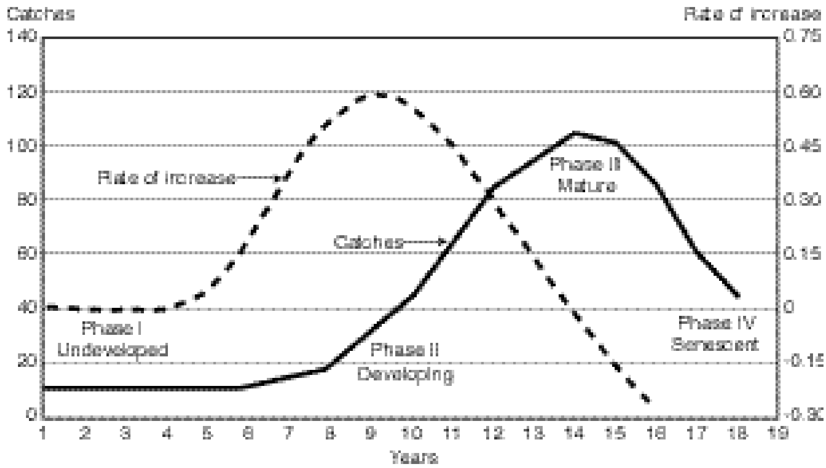
The undeveloped phase is characterized by the exploitation of fishery resources at well below their maximum potential, usually with less efficient (e.g. artisanal) fishing gears. In the development phase there is rapid growth of catches concomitant with increased numbers of fishers and boats together with the modernization of fishing gears and methods. The revenues obtained during this phase are often reinvested to increase fishing effort.

Although during the mature phase there is still an increase in catches, in most cases they are already very close to the maximum sustainable yield (MSY) and the rate of increase, which starts to decrease during the developing phase, now drops very rapidly. However, the momentum of the investment process means that the fishing effort continues to grow, and the fishery soon enters into the senescent phase as catches begin to diminish. This process can be accelerated by unfavourable changes in environmental conditions.

The duration and slope of the different phases are results of both the rate of increase of fishing intensity (and mortality) and the biological carrying capacity of the resource (FAO, 1996).

Figure 1 showns the theoretical change in yield (C) and the rate of increase

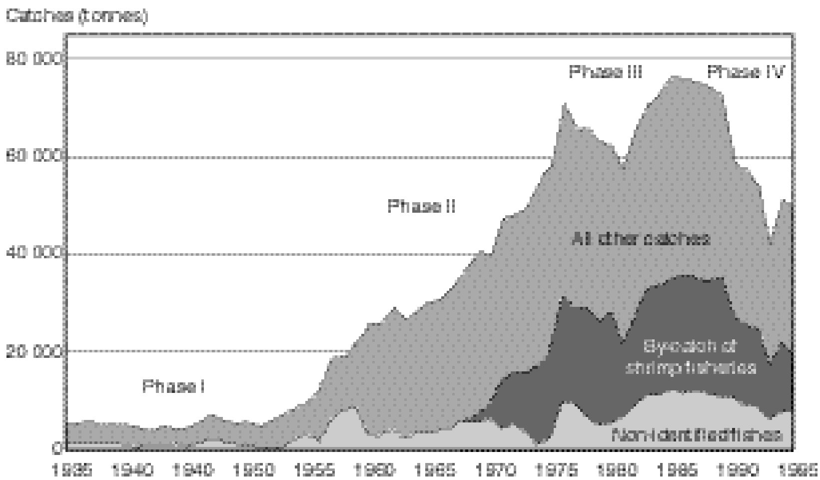
FIGURE 1
Generalized model showing the different phases of a fishery



of yield $(C_{t+1} - C_t)/C_t$, where t is the time in years, of the development process. The rate of increase, which varies significantly as the maximum long-term yield is approached, reached and surpassed, is of particular interest and has been used to provide a rough assessment of the state of Cuban marine fishery resources. The rate is nil for a stable non-developing fishery (Phase I) and increases rapidly (Phases I to II) as the fishery starts to develop. It then decreases during the phase of steady growth of the fishery (Phase II) and drops to zero when the fishery reaches its maximum production (Phase III). Following Phase III, fishing capacity may also develop, further aggravating depletion, and the relative rate of increase may become negative as overfishing progresses.

Figure 2 shows the development sequence of Cuban fisheries, considered as a whole, from 1935 to 1995; the four phases of the generalized fishery model can be clearly distinguished. According to Baisre (1987a), the undeveloped phase lasted from 1935 to 1954. In the mid-1950s, the developing phase began with landings continuing to grow up until the mid-1970s,

FIGURE 2
The phases of Cuban total landings, shrimp fisheries by-catches and non-identified fishes



when fisheries reached the mature phase. In the 1980s, most of the fishery resources were fully exploited and some cases of overfishing were already evident (Baisre, 1987b). A more detailed analysis of each fishery resource is presented in the following sections.

State of marine fishery resources

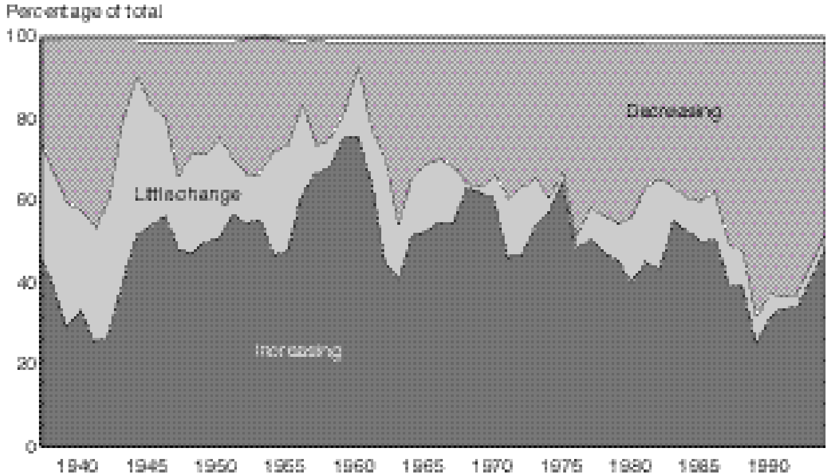
As pointed out by Grainger and Garcia (FAO, 1996), when a sufficiently long time series is available and marked changes in landings have occurred, the model described above may allow the present state of the fishery to be diagnosed, based on the development phase that it has reached.

In accordance with Grainger and Garcia (FAO, 1996), to compare each of the different time series, the data were first standardized by rescaling each time series so that the averages equalled zero and standard deviation (SD) equalled 1. Then, by comparing the data available in every two consecutive years of each time series, each resource-year element in the data was placed in one of three categories – increasing, little change or decreasing landings – depending on whether the slope of the series between the two years considered was more than 0.05, between + 0.05 and - 0.05, or less than - 0.05, respectively.

The results of this classification are illustrated in Figure 3, which shows the percentages of the 21 species or species groups that fall into each of the three categories in a particular year. In spite of the oscillations observed, it can be noted that the percentage of the resources in the increasing category, which was about 35 percent at the beginning of the series, surpassed 70 percent at the end of the 1950s and oscillated around the 50 percent level until the mid-1980s. In the last ten years of the series, the percentage of resources in this category returned to its original level. The percentage of the resources showing little change diminished considerably over the entire period (from about 30 to only 2 to 3 percent). This category of stable landings corresponds to a latent undeveloped phase of a fishery before it starts to grow (Phase I), to stabilization at mature exploitation (Phase III) or, in a few cases, to a lower level after a fishery has collapsed (Phase IV). In any

FIGURE 3

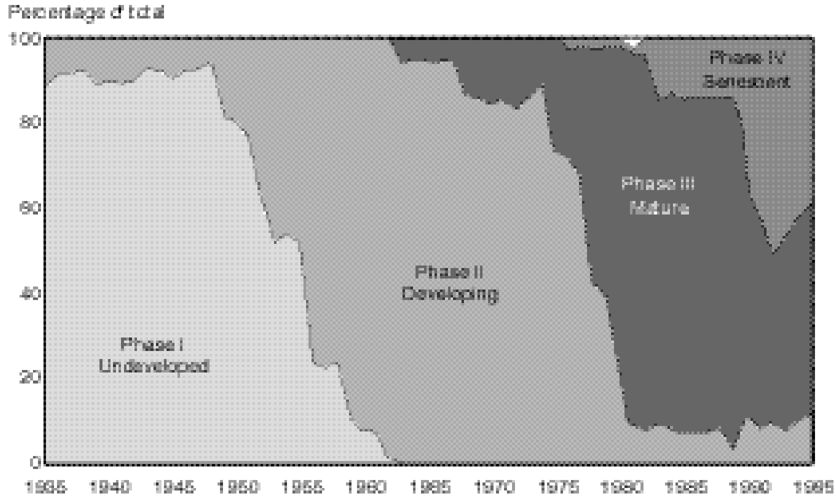
Percentage of major marine resources showing increases, little change and decreases in landings



case, the decreased percentage of resources showing little change indicates that there has been a reduction in the number of developing or mature fisheries (Phase II or III) and confirms the tendency (similar to that of world fisheries) for the majority of fisheries to fall into one of two main categories: in expansion or in decline.

The standardized landings of each of the series were then fitted with a third-degree polynomial function calculating the slope of the fitted line for every successive pair of years, and the curves were sliced into segments corresponding to the phases of increasing, little change or decreasing. It was assumed that the phases of increase or decrease correspond to the developing (Phase II) or senescent (Phase IV) stages of fishery development, respectively. The phase of little change was subdivided into high-exploitation mature (Phase III) or undeveloped (Phase I) phases, depending on whether the observed period of little change was followed by a period of increase or not. Once the resources matching each profile had been identi-

FIGURE 4
Percentage of major marine resources in various phases of fishery development

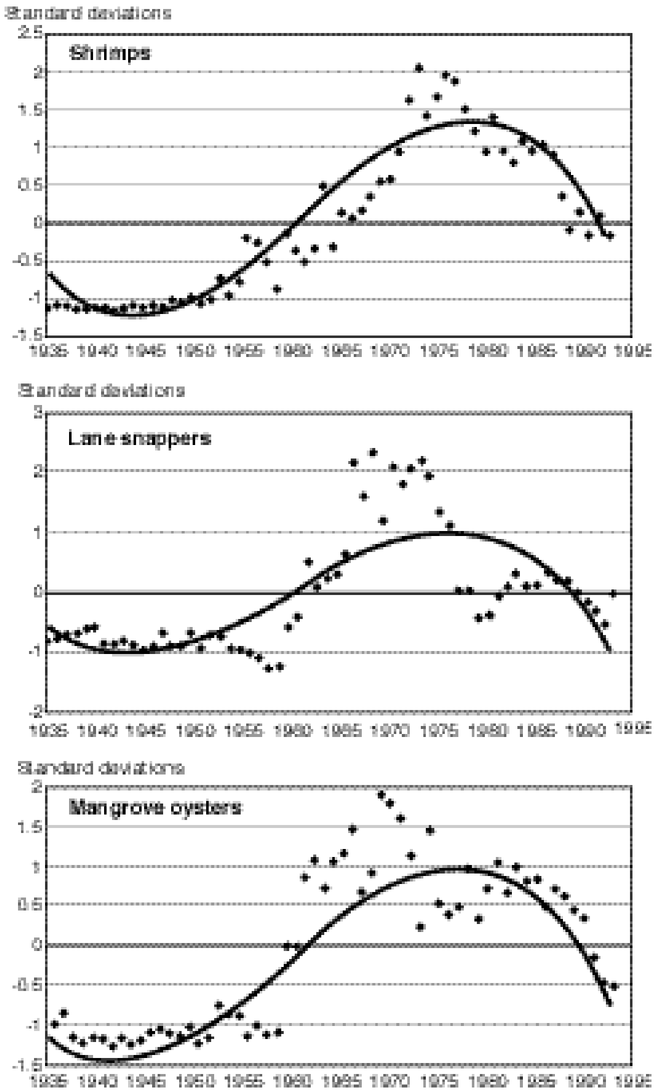


fied, the percentage of resources in each phase was calculated for each year separately and for the whole data set. The overall pattern is illustrated in Figure 4. It clearly shows that in the mid-1950s most of the fisheries were undeveloped (Phase I) while, in the mid-1960s, they were nearly all in the developing phase (Phase II). From the mid-1970s, most of the species or species groups were in the mature phase (Phase III) and the first cases of overfishing in the Cuban fishery sector were beginning to appear. The figure also shows that, in 1995, about 38.9 percent of the fisheries were in the senescent phase, 48.7 percent were in the mature phase with a high level of exploitation, and only 12.4 percent were in the developing phase with some possibility for growth.

Landings trend profiles and fitted polynomials for several selected species or species groups are presented in Figures 5, 6 and 7. Although some of the most important fisheries (i.e. those in Figure 5) exhibited the general trend predicted by the generalized fishery model (Figure 1, on page 6), marked

FIGURE 5

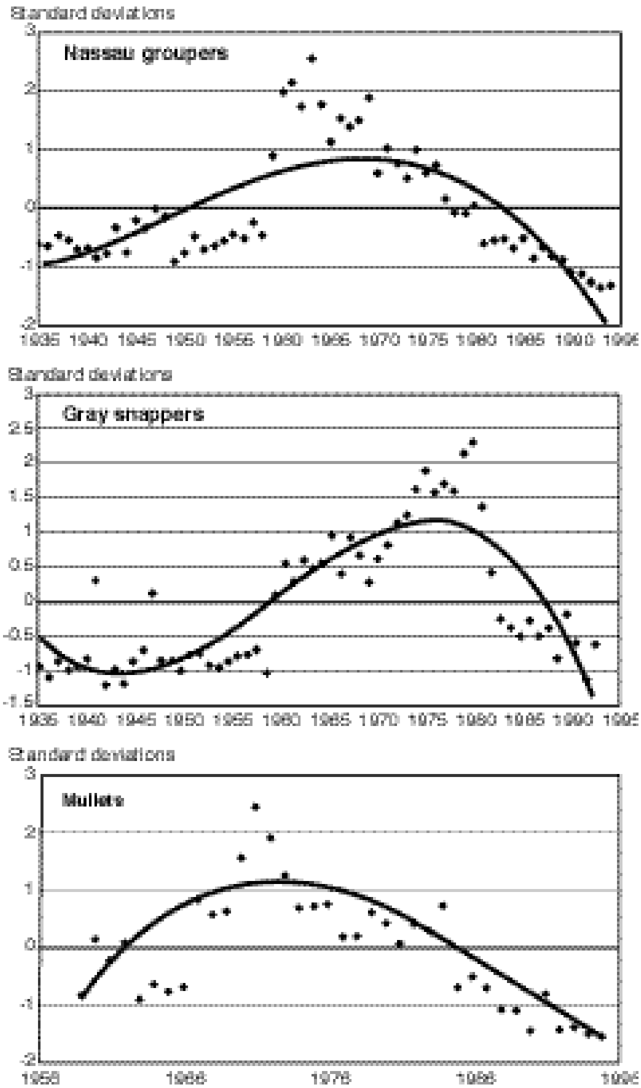
Average standardized landings of shrimps, lane snapper and mangrove oyster[1]



[1] The curve represents the fitted third-degree polynomial.

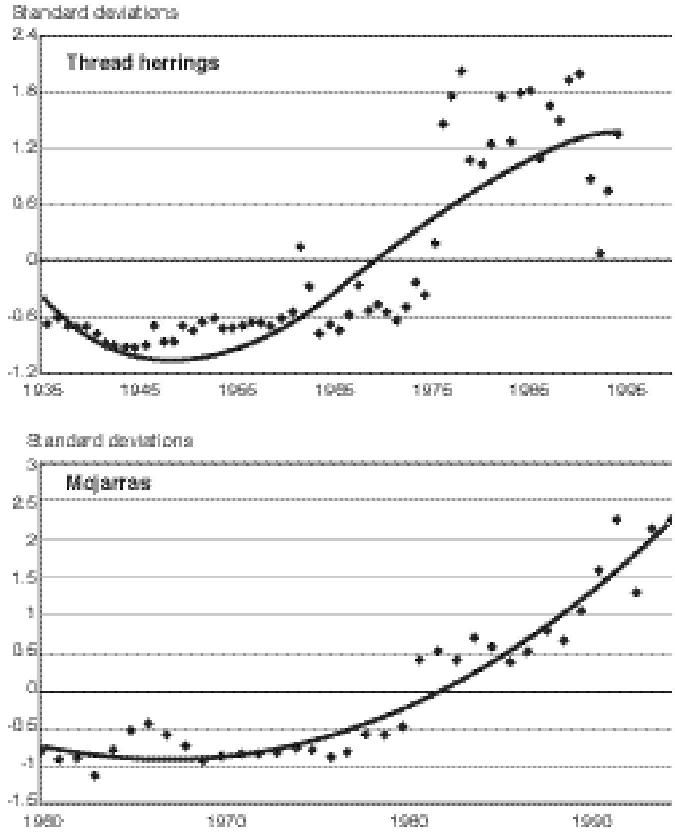
FIGURE 6

Average standardized landings of Nassau grouper, gray snappers and mullets[1]



[1] The curve represents the fitted third-degree polynomial.

FIGURE 7
Average standardized landings of thread herring and mojarras[1]



[1] The curve represents the fitted third-degree polynomial.

decreases in landings of Nassau grouper, gray snappers and mullets are noticeable during the last 20 years (Figure 6). Only the landings of thread herring, mojarras (Figure 7) and turkey wing clam show a positive trend.

Trend analysis

To calculate the trend of each time series of landings and of total landings, the following simple linear regression model was used:

$$Y = aX + b$$

where Y = rate of increase, X = number of years and a and b are the slope and the intercept of the regression line. The rate of increase (Y) is calculated from the equation:

$$(C_{t+1} + C_t)/C_t = at + b$$

where C_t is the catch in the year t. Before the calculations were made, the trends of each of the time series of landings were standardized and smoothed by three-year running means. The theoretical maximum production was then calculated when the rate of increase statistically reaches zero (the mean of the standarized series). Taking into account the fact that most of the Cuban fisheries developed during the 1960s, the trends of all time series of landings were calculated for the last 21 years (1975 to 1995). The results of these calculations, as well as the coefficients of determination (r^2), are shown in Table 2. When the value of the slope (b) is positive, the general trend is of increasing catches while, when it is negative, the catch trend is decreasing. As can be appreciated from the last row of Table 2, the trend of total landings is negative but not significantly so. The significantly negative correlation for Nassau grouper, mullets, gray snappers, land crab and stone crab landings is particularly noteworthy. Less important, but also significant, are the negative trends in the landings of sharks, grunts and mangrove oysters.

The potential maximum production according to the generalized fishery

TABLE 2

Parameters of the regression lines fitted to relative rates of landing increases (1975 to 1995)

Species or species group	a	b	r^2	Potential maximum production[1]	Yearof full exploitation *(tonnes)*
Nassau grouper	+0.3709	-0.0907	0.9510*	630	1979
Stone crab	+0.8011	-0.1213	0.8269*	119	1982
Mullets	+0.9795	-0.1286	0.9030*	519	1983
Scaled sardines	+0.4222	-0.0556	0.1418 ns	877	1983
Gray snappers	+2.2721	-0.1820	0.8413*	674	1987
Land crab	+1.4714	-0.1092	0.6586*	876	1988
Lane snapper	+0.5889	-0.0417	0.2998*	1 981	1989
Sharks	+1.2861	-0.0871	0.5412*	2 079	1990
Shrimps	+0.2741	-0.0177	0.0242 ns	4 295	1991
Spanish mackerel	+0.9620	-0.0621	0.2985*	520	1991
Small tunas	+1.2532	-0.0779	0.6991*	1 890	1991
Mangrove oyster	+1.0094	-0.0445	0.4556*	2 439	1993
Grunts	+0.7854	-0.0434	0.4723*	1 951	1993
Yellowtail snapper	+0.6264	-0.0226	0.0513 ns	740	2003
Mutton snapper	+0.9948	-0.0239	0.0222 ns	1 007	2017
Jacks	+1.0860	+0.0494	0.1196 ns	381	[2]
Mojarras	-0.9478	+0.1483	0.9428*	930	[2]
Turkey wing clam	-0.6587	+0.0927	0.2680*	1 414	[2]
Porgies	-0.1805	+0.0762	0.3363*	340	[2]
Spiny lobster	+1.0513	-0.0043	0.0077 ns	10 769	[?]
Thread herring	+1.3743	-0.0048	0.0045 ns	1 919	[?]
All species	**+1.5716**	**-0.0196**	**0.1212 ns**	**56 961**	**[?]**

Notes: * = statistically significant (P< 0.05);
ns = not significant (P> 0.05);
[1] calculated when the rate of increase statistically reaches 0 (the mean of the standardized series);
[2] positive slope, catch trend still growing;
[?] very low value of the slope, statistically not significant, it indicates a very slow decrease and, therefore, the estimate of the potential is not reliable.

model would be about 57 000 tonnes, a value that is 87 percent higher than the 1995 landings of the same species and groups of species.

Ecological analysis

TROPHIC LEVELS AND AVERAGE MAXIMUM SIZES

It has been suggested (Froese, Torres and Pauly, 1998) that the exploitation of multispecies communities has the effect of changing the relative abundance of the different functional groups in the ecosystem that supports these communities. The most common effect expected is that large, long-lived species with high trophic levels would be replaced in the catches by smaller, short-lived species with lower trophic levels. Pauly *et al*. (1998) have analysed the FAO capture database, which covers 45 years of global capture production, and found a so-called "fishing down marine food webs" trend. The same methodology has been applied here (for the first time to a single country) in studying the trends of the mean trophic level and the

FIGURE 8

Linear regression of the mean trophic levels of Cuban fishery landings

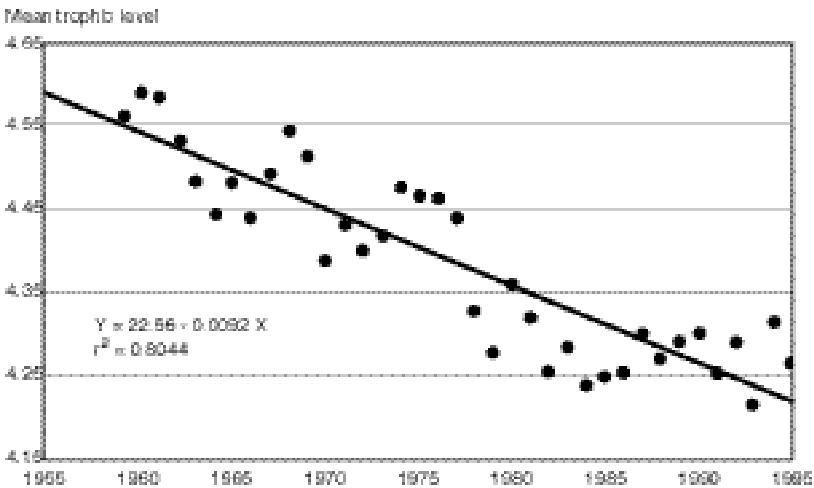
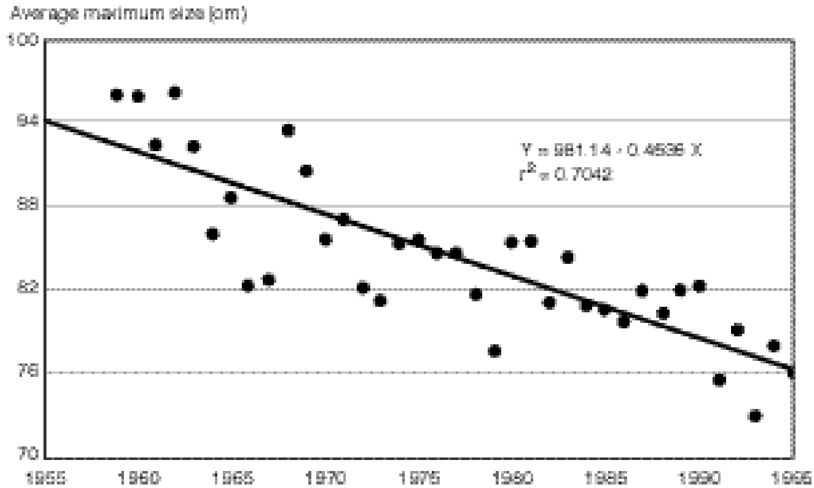


FIGURE 9
Linear regression of the average maximum size of Cuban fishery landings



average maximum size of landings for the 21 most important species or species groups in Cuban fisheries.

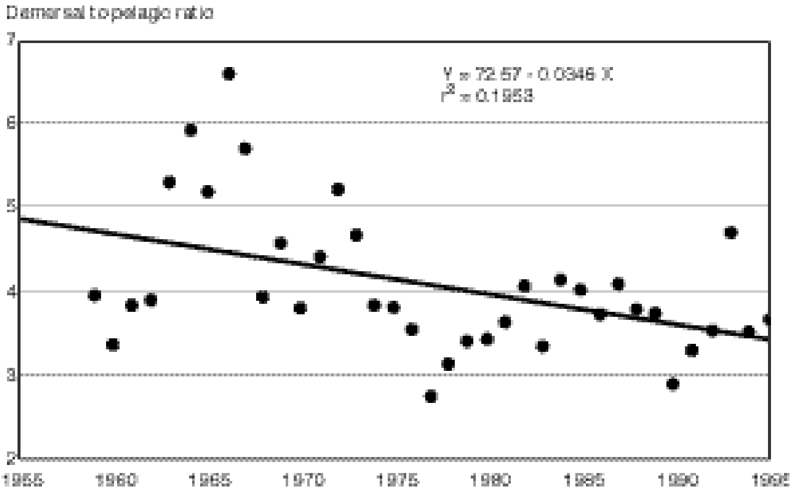
The data of the mean trophic level and of the average maximum size for each species or species group were obtained from FishBase (ICLARM, 1998). To calculate the trophic level of a species, both the diet composition and the trophic levels of their food items were taken into account applying the formula:

trophic level = 1 + mean trophic level of the food items

where the mean is weighted by the contribution of the different food items (Pauly and Christensen, 1998).

Figures 8 and 9 show the linear regressions (highly significant, $P< 0.001$) of the mean trophic level and of the average maximum size for the 1955 to 1995 period. The negative trends are clearly visible and indicate a gradual transition from landings of large piscivorous fishes to small fishes and inver-

FIGURE 10
Ratio of demersal to pelagic landings



tebrates feeding on smaller organisms (plankton and bottom invertebrates). These results are in line with those obtained by Pauly *et al* (1998) on the global scale.

DEMERSAL VERSUS PELAGIC FISHERY RESOURCES

Each species or group of species was classified as pelagic or demersal and the proportion of total landings to fall into each of the two categories was calculated. The pelagic fish species include: small tunas, sharks, sardines, thread herring, jacks and Spanish mackerels. The demersal species include: spiny lobster, shrimps, lane snapper, yellowtail snapper, mutton snapper, gray snappers, mangrove oyster, Nassau grouper, turkey wing clam, grunts, mullets, mojarras, porgies, blue crab and land crab. Figure 10 shows the linear regression of the ratio between the landings of demersal and pelagic resources over the last 40 years. As can be noted, the demersal species have far higher landings than the pelagic species, but this trend is decreasing ($r^2 = 0.195$, $P < 0.001$) along the time series. Although some of the pelagic species are not intensively exploited because there are no advanced fishing technologies available (e.g. the small tunas fishery) or because they are not suitable for industrial processing (e.g. scaled sardines), the coefficient of variation of pelagic species landings (27.7) is higher than that of demersal species (19.2).

Discussion and conclusions

The extended data set that has been analysed offers, for the first time, a coherent picture of Cuban fisheries over the last 60 years. The landing statistics show sustained growth from the mid-1950s until the end of the 1970s, a diminution of the rate of increase during the 1980s and a decrease, coinciding with the decline of some important fisheries, from the beginning of the 1990s.

Analysis of the dynamics of the 21 most important species or species groups also shows that, in 1995, approximately 38.9 percent of the resources were in the senescent phase (with declining catches), 48.7 percent were in the mature phase at a high exploitation level and only 12.4 percent were still in the developing phase with some possibility of increased landings. None of the fisheries was still in the undeveloped phase. This means that 87.6 percent of fisheries resources are in a critical stage and, therefore, there is an urgent need to implement fishery management measures such as the control and reduction of the fishing effort.

The assumption that the exploitation of fish communities has the effect of changing the relative abundance of the different functional groups of the ecosystem (Froese, Torres and Pauly, 1998) can be considered as confirmed for the data examined here. In addition, the "fishing down marine food webs" theory (Pauly *et al*., 1998), as well as the reduction of the average maximum size of catches, have also found correspondence in this study of Cuban fisheries. The mean trophic level and the average maximum size of the 21 species and groups analysed here had both negative and significant trends throughout the period being considered.

According to Baisre (FAO, 1993), most of the Cuban commercial species are at high risk of overexploitation, as they are in other tropical countries. This is the result of one or more of the following factors, some of which are typical of tropical fisheries:

- the high market value of the target species;

- mass migration movements (reproductive runs) during the spawning season, which are well known (in time and place);
- the use of non-selective fishing gears;
- low reproductive potential (e.g. sharks) and/or low growth rate (e.g. many reef fishes);
- habitats that are restricted and easily accessible.

Analysis of the resources and of the sequence of peak landings shows that a historical loss of 20 000 tonnes has occurred. This means that, if the landings of individual species or groups could be re-established, about 20 000 additional tonnes of yield would be obtained. Adding together the landing peaks of all the species examined here, produces a total yield of about 50 800 tonnes (Table 1), which becomes 79 870 tonnes if the total landings of all Cuban marine resources are considered. This figure is very close to previous estimates (80 000 tonnes) of Cuban fisheries potential (Baisre and Páez, 1981; Baisre, 1985). On the other hand, potential maximum production, according to the generalized fishery model, corresponds to about 57 000 tonnes (Table 2), 12.1 percent higher than the sum of landing peaks and 87 percent higher than 1995 landings.

The immediate question is: Are there any real possibilities for recuperating these losses? The decreases in landings of Nassau grouper and mullets, about 95 percent and 88 percent respectively, seem to be particularly dramatic. Although earlier landing statistics of the Nassau grouper might have been overestimated (they included the catches from Bahamian waters until 1976, when that country prohibited fisheries within its territorial waters), the continued decrease of catches is very significant and corresponds with the drop observed for similar species in other regions (FAO, 1997). There are probably several causes that have contributed to this striking decrease. The species is particularly vulnerable because it gathers in spawning aggregations during the reproductive season (Colin, Shapiro and Weiler, 1987; Olsen and La Place, 1979; Tucker, Bush and Slaybaugh, 1993), when it is caught with non-selective methods; it is a hermaphrodite species and this provokes a differential mortality between the sexes; and it has a slow growth rate. The fact that there is also a general decrease in the landings of grouper species in the Caribbean area as a whole might indicate that there are few possibilities for recovery in the short term.

Although overfishing is undoubtedly one of the main causative forces, not all of the observed changes can be attributed to this single factor, and some of them are probably irreversible. In the case of mullets, the indiscriminate use of set nets, even during spawning runs out of the coastal lagoons (Baisre, 1985), and the impact of the construction of dams in the main rivers have probably both helped to provoke the dramatic drop in the catches of this group of species, whose life cycle is fairly dependent on the good health of the estuarine environment. Their recovery depends, therefore, on the restoration of their nursery habitats, but there is strong evidence that the damming of numerous rivers flowing into southeastern Cuba, where the most important fishing grounds for mullets and other estuary-associated species are located, has resulted in both a shortage of nutrients in the coastal waters and a reduction of the nursery habitats, resulting from the filling of many coastal lagoons (González and Aguilar, 1984). Therefore, the recovery of these fisheries does not seem feasible for the next few years.

According to Caddy (1991), there has been little documentation on the effects provoked by various terrestrial inputs on fisheries in open-sea areas. Caddy also discussed how increased nutrient discharges can play a role in semi-enclosed seas, such as the Mediterranean and the Black seas, increasing biological production and fishery yields by cultural eutrophication. In Cuba, the opposite effect seems to be occurring, as a result of intensive river damming, which has produced a considerable shortage in nutrient discharges in open seas, augmented by the drastic reduction of fertilizer imports and production during the last ten years. The magnitude of this reduction as well as its impacts on fishery resources must be a research priority in the next years.

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This paper presents an analysis of trends in Cuban marine fishery resources covering the period of development, as well as the period of greatest expansion, of national marine fisheries. An extended time series offers, for the first time, a comprehensive picture of Cuban fisheries over the last 60 years. A detailed analysis of fishery resources and catch peaks reveals that there is a historical loss of 20 000 tonnes, probably resulting from the combined action of overfishing and changes in the marine ecosystem. Although part of this loss could be recuperated through better management practices, some of the changes brought about might be irreversible. The study confirms the theory that the exploitation of fishery resources changes the relative abundance of the different species within the ecosystem; and shows how both the mean trophic level and the average maximum catch of the 21 principal species and groups of species have been reduced. The mean trophic level and average maximum catch of the species and groups analysed are negatively and significantly correlated with the period at which they were exploited.

ISBN 92-5-104410-4 ISSN 0429-9345

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X4529E/1/4.00/1600