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# Rebuilding our marine ecosystems, protecting our future

**Key findings of the International Symposium on Marine Fisheries, Ecosystems and Societies in West Africa – Half a century of change**

## Dakar, Senegal, 24-28 June 2002

GENERAL INFORMATION

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# TABLE OF CONTENTS

# *Ecosystem Overfishing: A Namibian Case Study*

*— Article —*

# La surpêche d'un écosystème : Cas de la Namibie

— Article —

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### *ABSTRACT*

*BASED on reconstructed time series of catch data for the fish and invertebrates caught off Namibia from 1950 to 2000, the demonstration is made that, since 1970, the fisheries in Namibian waters are 'fishing down marine food webs', i.e., their landings are increasingly composed of smaller, shorter-lived species with low trophic levels (TL). This implies that large, long-lived fishes are becoming scarce in the waters off Namibia, and hence in the catches as well. Such changes are often accepted as the price that countries, particularly developing countries, may have to pay to develop their fisheries. Indeed, this downward trend of TL is usually expected to be compensated for by larger catches overall, given that fishes with low TL levels are generally more abundant, and more productive than those with high TL, and that the latter usually prey on the former.*

*However, we show here that 'fishing down marine food webs' in Namibia went along with catch increases that were far less than could have been expected, given reasonable assumptions about the rate of biomass transfer between TL, as shown here through the FiB index of* PAULY et al. *(2000, J. Ciem. 57: pp. 697-706). Subsequent to that, catches declined in absolute terms. These results are discussed with some emphasis on a transition toward a form of ecosystem-based management.*



### *Key words*

*Ecosystem-Based Management — Fishing Down — Food Webs Overfishing*



### RÉSUMÉ

NOUS démontrons, sur la base d'une reconstruction des prises de poissons et d'invertébrés au large de la Namibie de 1950 à 2000, un déclin du niveau trophique moyen des prises depuis 1970. Ceci implique l'occurrence d'un effet de « fishing down », signifiant que les prises et les écosystèmes sous-jacents sont de plus en plus dominés par de petites espèces à vie courte, et de bas niveaux trophiques.

Ces changements paraissent souvent acceptables, surtout dans les pays en voie de développement qui désirent voir l'essor de leurs pêcheries. De plus, les prises brutes totales devraient augmenter quand leur niveau trophique moyen diminue, considérant que les poissons de bas niveaux trophiques sont, dans tous les écosystèmes marins, plus abondants et productifs que les poissons de niveaux trophiques élevés, qui en plus, sont leurs prédateurs.

En Namibie cependant, le déclin du niveau trophique moyen n'a produit aucune augmentation des prises brutes telle que l'on aurait pu le prédire sur la base des connaissances acquises sur les taux d'efficacité de transfert entre niveaux trophiques dans les écosystèmes marins, et l'indice « FiB » de PAULY *et al.* (2000, J. Ciem, 57 : pp. 697-706). En fait, les prises totales ont diminué, un fait dont nous discutons les implications pour la gestion écosystémique.



### Mots clés

Gestion écosystémique — Réseaux trophiques — Surpêche

## INTRODUCTION

MULTIPLE changes have been documented since 1950 in the fisheries along the coast of West Africa, notably in the political and environmental regimes, in the size and structure of local and distant water fleets, and in their catches. However, few attempts have been made thus far to consider these changes simultaneously and to analyse their ecosystem impact. Moreover, there has been a lack of attention to earlier resource states by fisheries scientists working in West Africa, leading to a phenomenon known as the 'shifting baseline syndrome' (PAULY, 1995). This problem is exacerbated by the lack of formal approaches for dealing with early accounts of large extractions of presently depleted or near depleted resources.
Instead, each generation of fisheries scientists accepts the stock size and species composition at the beginning of their career as a baseline to evaluate changes. When the following generation commence its career, the stocks have declined, and the species composition has changed further, but it is still their state at that time that serves as baseline for assessment and management. The consequence is that past exploitation patterns and trends are often ignored when formulating management advice, which therefore does not consider the initial wealth of the system prior to excessive fishing. The result of this shifting baseline is a gradual accommodation to the slow disappearance of fish stocks, and reference points inappropriate for evaluating losses from overfishing, or for setting targets for recovery measures.

This explains why politicians can still be found in West African countries who speak of 'developing' national fisheries at the same time these slowly collapse under the weight of excess fishing effort, why are only the last 5-10 years are commonly used to serve as baseline when stocks are evaluated, and why is conservation still considered a rich countries' alternative to exploitation. Countering the 'shifting baseline syndrome' requires the reconstruction of past series of abundance, for which reliable time series of catches are essential.

Long time series of fisheries catches can also be used to test for the occurrence of the 'fishing down marine food webs' phenomenon, which occurs when there is, in fisheries landings, a transition from large, long-lived, high-trophic level fish to smaller, short-lived, low-trophic level fish and invertebrates, reflecting similar changes in the underlying ecosystem (PAULY *et al.*, 1998). Though they found this 'fishing down' to occur in most parts of the world, PAULY *et al.* (1998) found no distinct trend in mean trophic level in the FAO catch data for FAO area 47 (South-eastern Atlantic), i.e., the west coast of southern Africa. This may have been due to the underlying national catch data sets, originating from Angola, Namibia and South Africa. The first objective of this study was therefore to investigate whether 'fishing down' occurred in the region, based on more reliable data set, i.e., that reconstructed by WILLEMSE (2002), covering all catches taken from 1950 to 2000 in Namibian waters.

However, we must also consider the possibility that 'fishing down' is a deliberate policy choice, aiming to increase bulk catches, irrespective of their species composition, a policy which some have suggested may be appropriate for developing countries (CADDY *et al*., 1998; MANNING, 1998). Indeed, biological production is much higher in the lower, than in the upper parts of a food web, given observed transfer efficiencies ranging from 3 to 20 per cent (mean 10 per cent) between trophic levels (PAULY & CHRISTENSEN, 1995). The problem is that catches do not necessarily increase as much as these transfer efficiencies would imply as one moves down the food web. Nor do, in fact, catches always increase as TL decrease.

PAULY *et al*. (2000) have developed an indicator, the fishing-in-balance (FiB) index, whose value remains constant when changes in tropic levels are fully matched by corresponding changes in catches (in terms of the transfer efficiency prevailing in the ecosystem in question). The second goal of this study is thus to evaluate, using the FiB index, whether the trophic level changes in the landings from Namibian water resulted in corresponding changes in catches. Or more precisely: did Namibia gain by allowing 'fishing down' to occur?

## MATERIAL & METHODS

### *Reconstruction of Catches for Namibian Marine Waters, 1950-2000*

THE landings data (in metric tons, or 'tonnes') from Namibian waters used here were extracted by WILLEMSE (2002) mainly from Statistical Bulletins and other documents of the Madrid-based International Commission for the South Eastern Atlantic Fisheries (Icseaf), which reported from 1971 on the activities of distant water fleets (DWF) operating off Namibia. Other data, notably early catch figures from 'South West Africa,' then under the administration of South Africa, were obtained from the Food and Agriculture Organization of the United Nations (FAO) and South African fisheries statistics. Also, reports of the National Marine Information and Research Centre (NatMirc; Ministry of Fisheries and Marine Resources, Namibia) and articles in scientific journals were searched for information. For example, CRAWFORD *et al.* (1987) published landing data extracted from Icseaf Statistical Bulletins, which also formed the basis of many subsequent studies (including by NatMirc staff). The fish species whose catch was considered here largely overlap with the species listed in statistical reports of the Ministry of Fisheries and Marine Resources (MFMR), Namibia, and include all groups that can be expected to affect, either as prey or as predator, the structure and functioning of the Namibian marine ecosystem. Landings for the two *Merluccius* species caught off Namibia, *Merluccius capensis* and *M. paradoxus*, were combined, and treated as a single entity ('Cape hakes'), because the two species are not distinguished in catch records. The various species of tuna caught in Namibian waters were also aggregated.

### *Derivation of Time Indices of Ecosystem States*

Trophic levels (TL) express the number of steps a consumer organism is removed from the primary producers at the base of a food web, and can be defined by the equation:

$$TLi = 1 + \sum_{j=1}^{n} DC_{ij} \cdot TL_j \qquad 1)$$

where $i$ is the predator, $j$ the $n$th prey, and $D.C._{ij}$ is fraction of $j$ in the diet of $i$. T.L. assignment starts with detritus and plants, both with definitional T.L. value of 1.

The T.L. estimates for the finfish species and invertebrate species considered here were adapted from FishBase (FROESE & PAULY, 2000), from data in BIANCHI *et al.* (1993) and from the study of HEYMANS & BAIRD (2000), and are fully documented in Willemse and Pauly (*in press*). Note that assigning trophic levels is not straightforward, as many marine species tend to be opportunistic feeders. Many marine fish species change their diets as they grow larger, *i.e.*, the size of their prey increases, which changes their trophic levels (CADDY *et al.* 1998; PAULY *et al.*, 2001). Diets can also change over time, depending on the availability and distribution of food due to environmental change. However, small, pelagic, zooplanktivorous fishes maintain a more or less constant diet composition throughout their life cycle, and thus have a near constant trophic level. There is a broad predictability of trophic levels in demersal fishes as well, especially when species are aggregated (PAULY *et al.*, 2001).

The mean trophic levels of the catch from Namibian waters was computed for each year from 1950 to 2000 landings, using

$$\overline{TL_k} = \sum_{i=1}^{m} TL_i \times Y_{ik} \Big/ \sum_{i=1}^{m} Y_{ik} \qquad 2)$$

where $Y_{ik}$ is the landings of species $i$ in year $k$ and $T.L._i$ is its trophic level. Trophic levels for taxa higher than species were estimated as the mean T.L. of component species.

Then, the FiB index was computed from:

$$FiB = \log\left[\left(\sum_i Y_{ik} \cdot 10^{TL_i}\right) / \left(\sum_i Y_{i0} \cdot 10^{TL_i}\right)\right] \qquad 3)$$

where $i$ and $k$ are defined above, and where the subscript '0' refers to the year at the start of a series, which serves as anchor (PAULY *et al*., 2000). The FiB index changes its value only when a decrease in T.L. is not matched by a corresponding increase in catch, and conversely for increasing T.L. Here, 'corresponding' is defined as a tenfold increase for a decline of one trophic level, as implied by a 10 per cent transfer rates between trophic levels mentioned above.

## RESULTS & DISCUSSION

Figure 1 presents a slightly aggregated version of the catch time series reconstructed by WILLEMSE (2002), illustrating the build up and subsequent decrease of overall catches, and massive changes in their composition.

Figure 2 shows that the 'fishing down marine food webs' phenomenon began in 1970, following on the build-up of the fishery (1950-1969).

The mean trophic levels in the series oscillate strongly; WILLEMSE & PAULY (*in press*) show that these oscillations closely correlate with changes in the ratio of piscivorous to planktivorous fishes (CADDY & GARIBALDI, 2000) in the Namibian upwelling system, and hence with environmental factors impacting on short-lived zooplanktivores such as anchovies and sardines, a theme not pursued here.

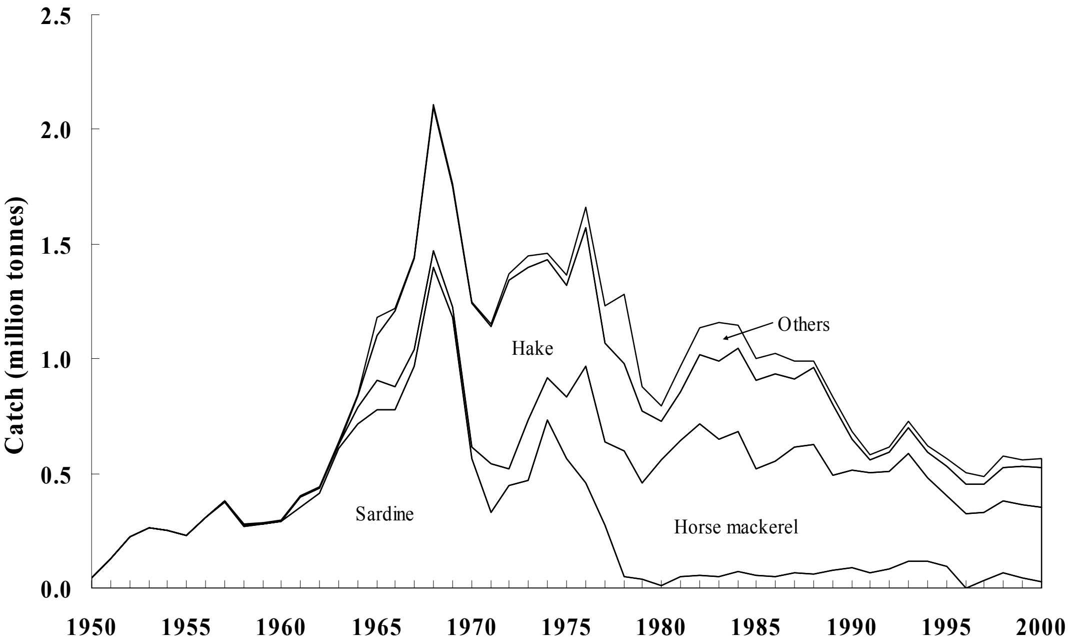


FIG. 1. — Catches of fisheries operating in Namibian waters, 1950 to 2000, by major groups. Note decline since the mid-1980s, not attributable to fluctuation in the sardine stock, which collapsed in the late 1960s.

*Prises totales des pêcheries au large de la Namibie, 1950-2000, par principaux groupes (Horse mackerel = chinchard ; hake = merlu ; others = autres espèces). Noter le déclin de l'ensemble des prises depuis les années 1980, non attribuable à la sardine dont le stock s'est effondré depuis la fin des années soixante-dix.*

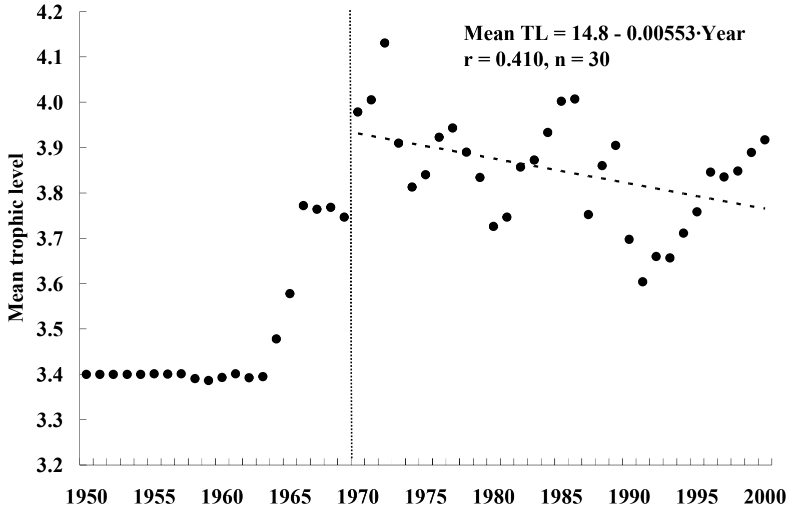


FIG. 2. — Trend in the mean trophic level of fish and invertebrates caught in Namibian waters, 1950 to 2000. Note general decline since 1970, and interannual oscillations (see text).

*Tendance du niveau trophique moyen des prises de poissons et d'invertébrés au large de la Namibie, 1950-2000. Noter le déclin général depuis 1970, et les oscillations interannuelles (voir le texte).*

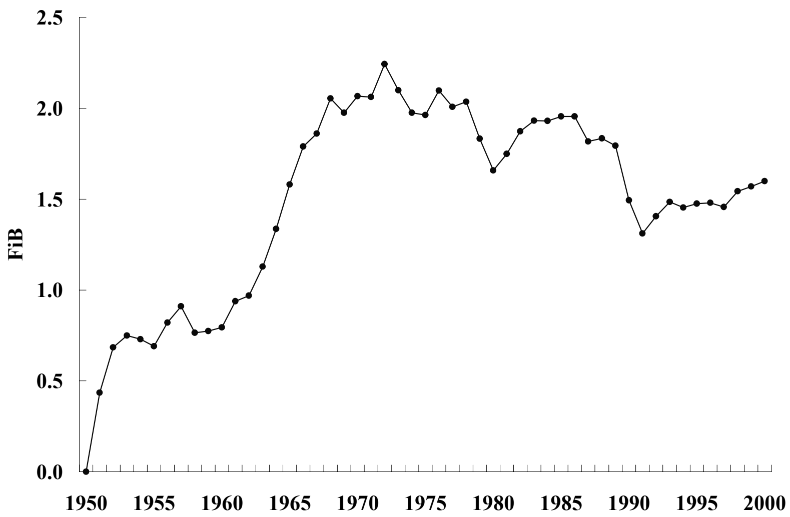


FIG. 3. — Trend of the 'Fishing-in-Balance' (FiB) index for fisheries catches from Namibian waters, 1950-2000. Note decline since the early 1970, indicating that the drop in mean trophic level is not compensated for by increasing catches (see text).

*Tendance de l'index FiB (« Fishing in Balance ») pour les prises au large de la Namibie, 1950-2000. Noter le déclin depuis le début des années 1970, qui indique que les changements du niveau trophique moyen des prises ne sont pas compensés par les changements des prises elles-mêmes (voir le texte).*

Figure 3, our main exhibit, shows that the FiB index for Namibian marine fisheries first increased, reflecting how the fisheries grew to gradually rely onto the productive capacity of the entire ecosystem, then, since the early 1970s, slowly decreased. This implies that since that time, decreases in trophic levels have not been compensated for by ecologically equivalent catch increases. Indeed, total catches, and their underlying biomasses have now declined so much that sophisticated indices of management performance have now become completely superfluous.

BOYER & HAMPTON (2001), BOYER *et al*. (2001) and others in the volume on '*A Decade of Namibian Fisheries Science'* (PAYNE *et al*., 2001) discussed at length the particular features of the stocks and fisheries that contributed to the trends discussed here. The broad ecosystem perspective taken in this contribution does not enable us to contest or even comment on any of their detailed findings. However, it is clear that analyses of the sort presented here can help put catch trends in a broader, ecosystem context, and provide a synthetic view of the joint performance of a set of fisheries exploiting the same ecosystem.

Thus, we conclude with a plea for a form of ecosystem-based management that would consider changes in catch and catch composition such as documented here, and use critical values of indicators quantifying these changes, *i.e.*, ecosystem state indicators, to adjust catch quota.

## NOTE ADDED IN PROOFS

Completing the work presented in WILLEMSE and PAULY (*in press*) provided an opportunity to review the trophic level (TL) estimates used in the present study. This review showed that the decline of mean TL of Namibian marine catches is less pronounced than suggested in Figure 2. On the other hand, the trend in FiB (Figure 3) was largely unaffected, suggesting this to be a more robust indicator of ecosystem status.

The main conclusion of the present contribution (that the Namibian marine ecosystem, through the late 20$^{th}$ century, became increasingly modified by fishing) still stands.

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