Convention on Biological Diversity 2010 Target and the Biodiversity of Marine Fishes

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Abstract

The Convention on Biological Diversity (CBD) ...

1 Introduction

The United Nations has declared 2010 to be the International Year of Biodiversity. This is a direct response to initiatives by the Convention on Biological Diversity (CBD; established 1993) to: (i) conserve biological diversity; (ii) use biological diversity in a sustainable fashion; and (iii) share the benefits of biological diversity fairly and equitably. In April 2002, the Conference of the Parties adopted a strategic plan for the CBD, the mission statement of which articulated what has become known as the "2010 Biodiversity Target": to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth (`http://cbd.int/2010-target/about.shtml`).

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Among the indicators formally identified by the CBD to evaluate the progress achieved in meeting the 2010 Biodiversity Target is one that examines "trends in the abundance and distribution of selected species". The only index formally under consideration by the CBD that pertains to marine fishes is the Marine Living Planet Index (World Wildlife Fund for Nature, 2008). Although it utilizes information on 162 fish species, these trend data have not been segregated from those available on the other 179 species used in the index. Our objective here is to quantify trends in population abundance and biomass to assess the degree to which the CBD's 2010 Biodiversity Target is likely to be met for marine fishes on global and regional scales. Our analysis extends the temporal, spatial, taxonomic, and analytical breadth of the only previous global and regional examination of populations trends in marine fishes (Hutchings and Baum (2005); hereafter, HB2005).

2 Materials and Methods

Data on spawning stock biomass (SSB) were compiled from stock assessments undertaken by scientists associated with national and international fisheries management agencies. This database will soon be made available to interested researchers (`http://www.marinebiodiversity.ca/RAMlegacy/srdb`). The geographical breadth of these data included: Northeast Pacific (Eastern Bering Sea, Gulf of Alaska, British Columbia, California Current); Northwest Atlantic (Northeast Newfoundland Shelf, Gulf of St. Lawrence, Scotian Shelf, Bay of Fundy, Gulf of Maine, Georges Bank, Northeast and Southeast U.S. Shelves, Gulf of Mexico); Northeast Atlantic (Barents Sea, North Sea, Iceland, Irish Sea, Baltic Sea, Faroes); Australia/New Zealand; South America; and South Africa. To reduce variability in data quality, we restricted our analysis to spawner biomass data estimated from age-structured, sequential population analyses reported in fisheries stock assessments.

Given that the 2010 Biodiversity Target is a target based on the rate of change in abundance, we compared the slopes of linear regressions of log-transformed SSB plotted against time for two different time periods. For each population/stock, we compared regression slopes for all available data up to 1991 (the year the CBD was initially agreed upon) with those for all available data from 1992 onwards (usually to 2007). Our analyses were restricted to those stocks with a minimum of 25 years of data dating back to 1978 or earlier.

We estimated the slopes up to 1991 and the change in slopes observed after 1992:

$$log(SSB)_{y+1} = \alpha_{pre1992} + (\eta * \delta_{intercept}) + (slope_{pre1992} + (\eta * \delta_{slope}))y \quad (1)$$

where,

α is the intercept

η is a class variable determining whether year y is before ($\eta = 0$) or after and including ($\eta = 1$) 1992

$\delta_{intercept}$

$slope_{pre1992}$ is the temporal slope up to to 1991

δ_{slope} is the change in slope observed after 1992

Under this model, a reduction in the rate of decline after 1992, reflected by a positive slope difference (i.e., $\delta_{slope} > 0$), would be consistent with the 2010 Biodiversity Target.

Multi-species indices of abundance were also constructed for those stocks for which data were available for the 30-year period extending from 1978 to 2007 (adopting the same starting year as HB2005 but extending the time series from 2001 to 2007). For each stock, we standardized the spawning stock biomass data by dividing the annual estimates by the maximum recorded for each stock (SSBmax) and then log-transformed the data. For each year between 1978 and 2007, the multi-species index was calculated from the geometric mean across all stocks. To assist us in interpreting the results, we felt it would be informative to compare the current total biomass and fishing mortality experienced by each stock relative to those associated with target reference points appropriate for each stock. The fishing mortality data will be made available when the database contents are published. The target reference points are BMSY and FMSY, which represent the estimated total biomass and fishing mortality, respectively, at which the maximum sustainable yield (MSY) can be achieved. These reference points are those reported by Worm et al. (2009). To conform with the terminology used in the only national jurisdiction (U.S.) for which overfishing and its associated management responses have been articulated by legislation, a stock is experiencing overfishing when $F_{current} > F_{MSY}$ and a stock is in an overfished state when $B_{current} < 0.5B_{MSY}$.

3 Results

Globally, among the 114 stocks (65.5% of all stocks examined) in decline prior to 1992 ($slope_{pre1992} < 0$), the slope difference for 66.7% of these was positive, indicative of an easing of their rates of decline after 1992. Regionally, the slope difference was positive for all stocks in the Middle North Atlantic (100% of 9 stocks), more than half the stocks in the Northwest Atlantic (85% of 13 stocks), Northeast Atlantic (72% of 25 stocks), Northeast Pacific (75% of 32 stocks) and South Africa (75% of 4 stocks) (Figure 1a, 1b, 1c, 1d and 1f). By comparison, the slope difference was positive for slightly less than half of the stocks in decline prior to 1992 in Australia/New Zealand (45% of 20 stocks) (Figure 1e).

Some stocks for which the rate of decline had lessened were still in decline after 1992: 6 of 18 in the Northeast Atlantic; 5 of 24 in the Northeast Pacific; 9 of 9 in Australia/New Zealand; and 1 of 3 in South Africa. For a number of stocks, their rate of decline increased after 1992, the slope difference being negative for: 2 stocks in the Northwest Atlantic; 7 in the Northeast Atlantic; 8 in the Northeast Pacific; 11 in Australia/New Zealand; and 1 in South Africa.

Species for which the rate of decline increase after 1992 were generally those feeding at high trophic levels (defined as those whose maximum trophic level, given by www.fishbase.org, exceeds 4.2), such as Atlantic cod (*Gadus morhua*), Plaice (*Pleuronectes platessa*), Blue Whiting (*Micromesistius poutassou*), sablefish (*Anoplopoma fibria*), rockfishes (*Sebastes* spp.), and Hoki (*Macruronus novaezelandiae*).

The multi-species abundance indices were based on abundance data for 142 stocks. Based on data for all species globally, the multi-species index declined 26% from an average of 0.54SSBmax to 0.40SSBmax (Figure 4). Distinguishing species by their primary habitat/life style, the pattern of temporal change in the index differed between pelagic and demersal species. The index for pelagic species increased from the late 1970s through the mid 1980s (Fig. 2b). Since reaching a peak between 1986 and 1988, the index has declining steadily through 2007. By contrast, the demersal species index peaked at 0.65SSBmax during the earliest part of the time series before declining steadily through the mid 1990s to a level ranging between 0.40 and 0.44SSBmax where it has remained through 2007, possibly exhibiting signs of an increase in later years (Fig. 2b).

Regionally, pelagic species have been increasing since 1978 in the Northeast Atlantic (N = 12 stocks) and possibly the Northeast U.S. (based on 2 stocks); overall, pelagics have shown declines in the Canadian Atlantic (N = 4) and Australia/New Zealand (N = 40) (Figs. 2c-f). With the exception of stability in Australia/New Zealand, demersal species have shown declines throughout the time series, with evidence of increases in the past decade in the Northeastern U.S (N = 5 stocks) and possibly the Canadian Atlantic (N = 15 stocks).

4 Discussion

The present work represents a significant spatial and temporal expansion of data considered in the only previous analysis of changes in the rate of decline of marine fishes. Whereas HB2005's data were limited primarily to North Atlantic and Canada's Pacific waters, our study also included North America's entire Pacific coast, the Mediterranean Sea, and the waters surrounding Australia and New Zealand. Although our sample size was slightly less than the 177 considered previously, the present analysis was restricted to 157 stocks for which assessment-based estimates of SSB were available. HB2005, whose data set included 103 SSB abundance-based stocks, also analyzed trends in stocks for which only alternative abundance metrics were available, e.g., fisheries-independent survey catch rates. The multi-species abundance indices constructed here include data current to 2007, extending those considered by HB2005 by six years. Most of the world's fish stocks assessed by national and international agencies (66%) were declining prior to 1992, a result consistent with previous studies of marine fish abundance (Hutchings, 2000; Myers and Worm, 2005). Since 1992, the rate of decline has been reduced in 67% of these stocks (N = 70), a pattern consistent with the 2010 CBD Biodiversity Target. However, for the remaining 33% of stocks (N = 34), which represent species feeding at the highest trophic levels, the rate of decline has increased. The percentage of stocks whose trends conform with the 2010 Target reported here (67%) is less than the 81% reported by HB2005, meaning that declines in marine fish biodiversity have not been arrested to as great an extent as previously thought. (If one restricts HB2005's analysis to the 103 stocks for which abundance data were based only on SSB, 65% of stocks would have conformed with the 2010 Target.)

Questions:

1. Of those stocks in decline before 1992, and increasing since 1992, what

is the current B and F relative Bmsy and Fmsy?

2. Of those stocks in decline before 1992, and declining at faster rate since 1992, what is the current B and F relative Bmsy and Fmsy?

Acknowledgements

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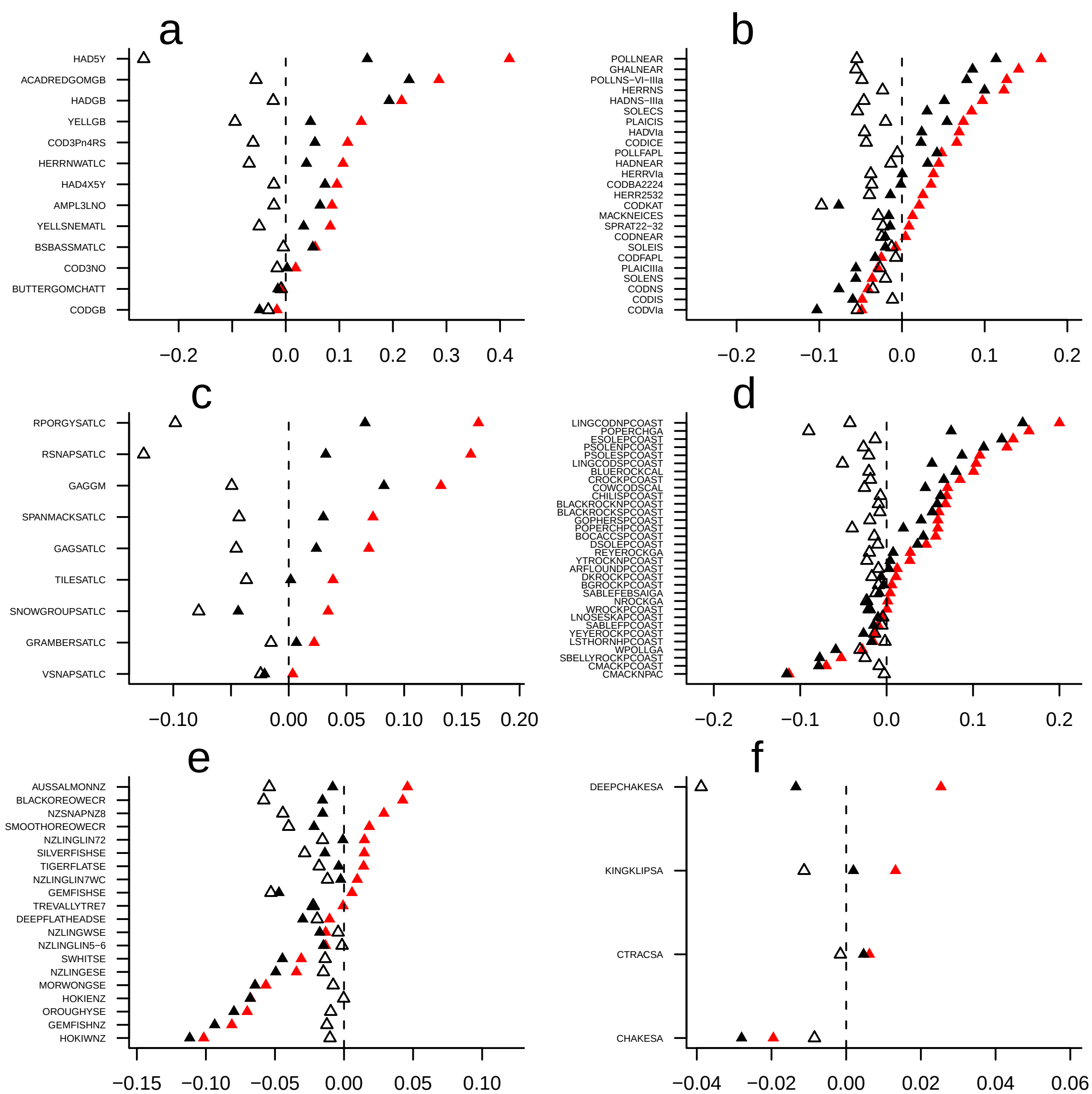
Figures

Figure legends

Figure 1. Slope of the temporal trends of $log(SSB)$ as obtained by a linear model with no continuity constraint for stocks located in a) the Northwest Atlantic (n=13), b) the Northeast Atlantic (n=25), c) the Middle North Atlantic (n=9), d) the Northeast Pacific (n=32), e) Australia and New Zealand (n=20) and f) South Africa (n=4). Open triangles represent the temporal slope prior to 1992, solid black triangles represent the temporal slope after 1992 and solid red triangles represent the difference in slope before- and after-1992. For each region, the stocks are ordered by the difference in slope before- and after-1992. The slope value represents the annual rate of change in population biomass.

Figure 2.

Figures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ACADREDGOMGB
HADGB
YELLGB
COD3Pn4RS
HERRNWATLC
HAD4X5Y
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YELLSNEMATL
BSBASSMATLC
COD3NO
BUTTERGOMCHATT
CODGB
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0.0
0.1
0.2
0.3
0.4
b
POLLNEAR
GHALNEAR
POLLNS−VI−IIIa
HERRNS
HADNS−IIIa
SOLECS
PLAICIS
HADVIa
CODICE
POLLFAPL
HADNEAR
HERRVIa
CODBA2224
HERR2532
CODKAT
MACKNEICES
SPRAT22−32
CODNEAR
SOLEIS
CODFAPL
PLAICIIIa
SOLENS
CODNS
CODIS
CODVIa
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−0.1
0.0
0.1
0.2
c
RPORGYSATLC
RSNAPSATLC
GAGGM
SPANMACKSATLC
GAGSATLC
TILESATLC
SNOWGROUPSATLC
GRAMBERSATLC
VSNAPSATLC
−0.10
0.00
0.05
0.10
0.15
0.20
d
LINGCODNPCOAST
POPERCHGA
ESOLEPCOAST
PSOLENPCOAST
PSOLESPCOAST
LINGCODSPCOAST
BLUEROCKCAL
CROCKPCOAST
COWCODSCAL
CHILISPCOAST
BLACKROCKNPCOAST
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DSOLEPCOAST
REYEROCKGA
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YEYEROCKPCOAST
LSTHORNHPCOAST
WPOLLGA
SBELLYROCKPCOAST
CMACKPCOAST
CMACKNPAC
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−0.1
0.0
0.1
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e
AUSSALMONNZ
BLACKOREOWECR
NZSNAPNZ8
SMOOTHOREOWECR
NZLINGLIN72
SILVERFISHSE
TIGERFLATSE
NZLINGLIN7WC
GEMFISHSE
TREVALLYTRE7
DEEPFLATHEADSE
NZLINGWSE
NZLINGLIN5−6
SWHITSE
NZLINGESE
MORWONGSE
HOKIENZ
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HOKIWNZ
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f
DEEPCHAKESA
KINGKLIPSA
CTRACSA
CHAKESA
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0.02
0.04
0.06

Figure 1:

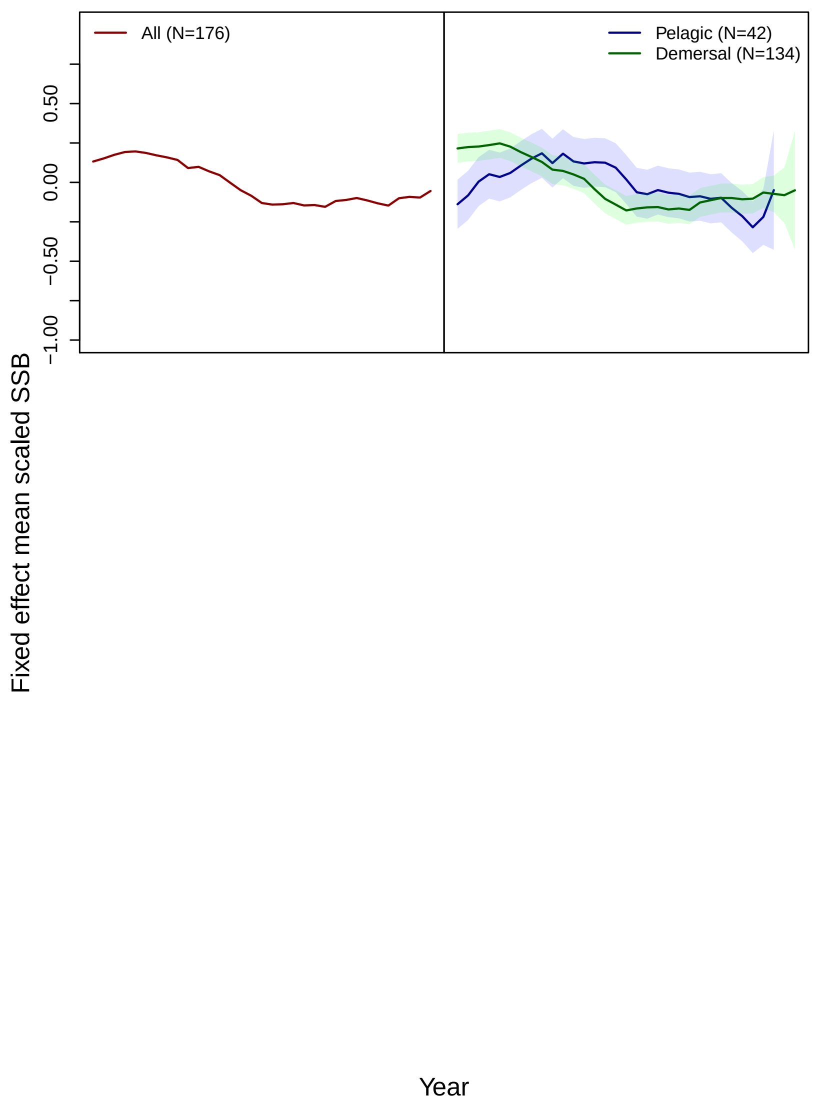
All (N=176)
Pelagic (N=42)
Demersal (N=134)
0.50
0.00
−0.50
−1.00
Fixed effect mean scaled SSB
Year

Figure 2: