BIG SKATE (*RAJA BINOCULATA*) AND LONGNOSE SKATE (*R. RHINA*) STOCK ASSESSMENTS FOR BRITISH COLUMBIA

Image: A) Big Skate (Raja binoculata) and B) Longnose Skate (R. rhina). Image credit: Fisheries and Oceans Canada.

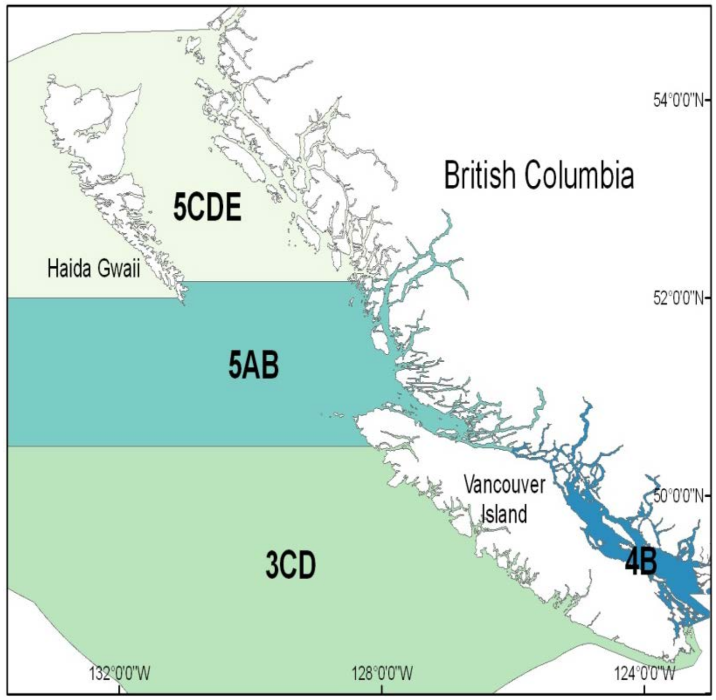

Figure 1. Skate Management Areas used for assessment and provision of advice.

Context

Big Skate (Raja binoculata) and Longnose Skate (R. rhina) (Images) are exploited primarily by trawl fisheries, but also by hook and line fisheries, particularly the Halibut fleet. Targeted exploitation began in 1996 and to date management caps have been implemented only in Statistical Areas 5CD (combined areas) for trawl fisheries, and trip limits (all species of skates combined) have been implemented coast-wide for hook and line fisheries. These species have been identified in the Halibut Marine Stewardship Council certification process as a significant component of the Halibut fleet catch. A risk-based assessment is therefore required to maintain certification. A full detailed stock assessment has never been done for Pacific stocks.

In the context of Fisheries and Oceans Canada's (DFO's) Fishery Decision-making Framework Incorporating the Precautionary Approach, advice was requested by DFO Fisheries Management on the current stock status and potential yields for Big Skate and Longnose Skate in the waters of British Columbia. Science advice is provided by newly proposed Skate Management Areas (Figure 1).

SUMMARY

- Big Skate (*Raja binoculata*) is an important component of both the trawl and the hook and line commercial groundfish fisheries off British Columbia, Canada. Currently, the largest fishery in British Columbia that encounters skate is the groundfish trawl fishery. Big Skate are predominately captured by bottom trawl in Hecate Strait (5CDE). The majority of Longnose Skate catch (*R. Rhina*) is made off the west coast of Vancouver Island (3CD). Hook and line catches of Longnose Skate are currently larger than trawl catches in Queen Charlotte Sound (5AB) and in Hecate Strait.
- Based on tagging results and fishery spatial patterns, science advice was provided by four Skate Management Areas (Figure 1): 3CD (including minor areas 19 and 20 of 4B); 5AB (including minor area 12 of 4B); 5CDE; 4B (minor areas 13 – 18, 28, 29 only). Based on feedback from the commercial sector, coastwide harvest advice was provided for Longnose Skate, in addition to the four proposed Skate Management Areas.
- Several methods (including Bayesian surplus production modeling and data-limited approaches) were explored to provide detailed stock assessments for these data-limited species. None were able to provide reliable estimates of biomass, preventing evaluation of current and future stock status relative to reference points.
- It was recommended that harvest yields should be selected based on mean historic catch, with consideration given to results of trend analyses of research survey indices and to the ranges of maximum sustainable yield (MSY) estimates identified by the new Catch-MSY approach. The Catch-MSY results were extremely sensitive to assumptions and so could not be used as the sole basis of advice to managers.
- For area 4B, insufficient data existed for Catch-MSY or survey trend approaches. The recent average catch is only 9 t for both species combined, and information on mean historic catches and spatial distribution was provided.
- For Big Skate, there were no significant trends in abundance indices from surveys. For all Skate Management Areas, average historical catches were below the maximum MSY estimate from the Catch-MSY results.
- For Longnose Skate, trawl survey data indicated statistically significant declines in abundance; no significant trends were detected for the longline survey data. For all Skate Management Areas (and the coastwide aggregate), average historical catches exceeded the maximum MSY estimate from the Catch-MSY results.

INTRODUCTION

Big Skate (*Raja binoculata*) and Longnose Skate (*R. rhina*) are coastal species of Elasmobranchs found along the continental shelf of the eastern Pacific from central Baja California to the eastern Bering Sea, and account for more than 95% of the skate taken commercially in British Columbia Fisheries. Big Skate and Longnose Skate are encountered in Groundfish trawl and hook and line fisheries throughout British Columbia (Figure 2). Currently, the largest fishery in British Columbia that encounters skate is the groundfish trawl fishery. Big Skate are predominately captured by bottom trawl in Hecate Strait (5CDE). The majority of Longnose Skate catch is made off the west coast of Vancouver Island (3CD). Hook and line catches of Longnose Skate are currently larger than trawl catches in Queen Charlotte Sound (5AB) and in Hecate Strait. Catches of both species are low in the Strait of Georgia (4B). In 2010, incidental catches of Big Skate and Longnose Skate in the BC Halibut fishery represented about 5% of the annual Halibut catch.

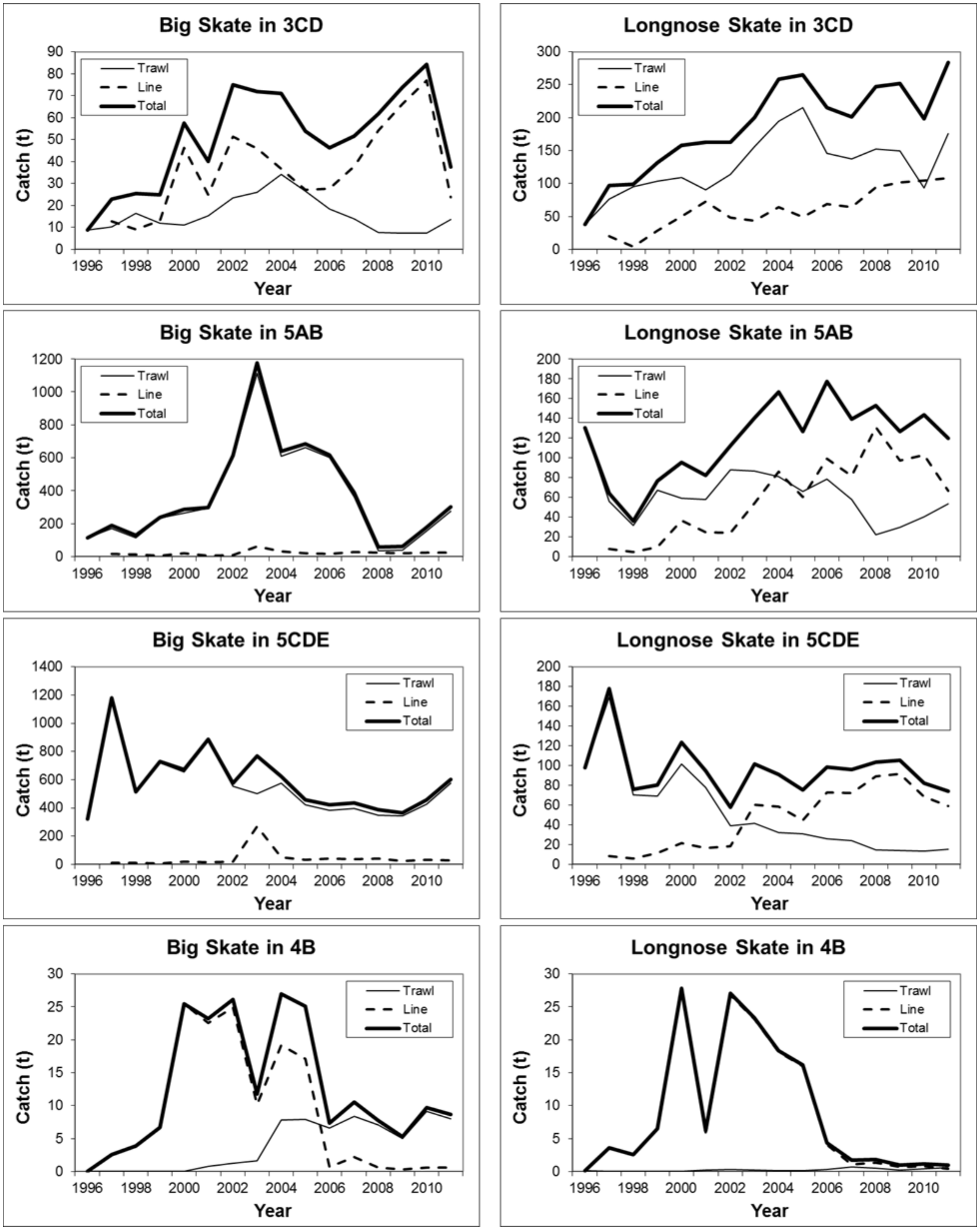

Figure 2. Big Skate and Longnose Skate catch (landings and discard mortality in tonnes) by trawl (thin line) and line (dashed line) gear by Skate Management Area. Thick line is total catch (tonnes).

Since 2002, the trawl fishery for Big Skate and Longnose Skate in Hecate Strait (Major areas 5C and 5D) has been subject to Total Allowable Catches (TACs) of 567 tonnes and 47 tonnes, respectively; there are no annual limits on trawl catches of skates in other areas. Since 2006, line fisheries for skate (all species combined) have been subject to a 2.7 tonnes maximum trip limit coastwide, excluding inside rockfish vessels which are subject to a skate trip limit of 20 kg, and inside halibut vessels which have non-retention of skate.

Based on tagging results and fishery spatial patterns, four Skate Management Areas are proposed (Figure 1): Skate Management Area 3CD is Groundfish Major Areas 3C, 3D, and Minor Areas 19 and 20 of 4B; 5AB is Major Areas 5A, 5B, and Minor Area 12 of 4B; 5CDE is Major Areas 5C, 5D, and 5E; 4B is Minor Areas 13-18, 28, and 29. Based on feedback from the commercial sector, coastwide harvest advice was provided for Longnose Skate in addition to the four proposed Skate Management Areas.

ASSESSMENT

Data Sources and Methods

Advice is provided based on two sources of data: commercial catch data (1996-2011) and fishery-independent indices of relative abundance derived from research surveys (1980-2011). Data and methods are documented in King et al. (unpublished manuscript)[1].

Commercial catch data since 1996 identify skate to species, include estimated discards for some fisheries, and are based on observer and/or fisher logbooks which are verified by dockside monitoring programs. Catch is defined as the sum of landings plus the dead discards. Dead discards were estimated by applying a constant discard mortality rate to the estimated total discards. A discard mortality rate of 50% was assumed for the skate trawl fishery, based on an approximate average of published rates. A discard mortality rate of 10% was assumed for the skate line fishery. There are no research studies to date for line gear discard mortality rates for skates or rays, but feedback from participants in the commercial line fishery suggests that 10% is a reasonable estimate.

Fishery-independent indices of relative abundance were available from a number of bottom trawl or longline research survey series conducted along the British Columbia coast between 1980 and 2011, although the coverage of these survey series has been patchy through time. For all research trawl surveys, a biomass index was determined as the catch rate per swept area, expanded by the total area in each stratum. For longline surveys, catch rates were calculated as pieces per 100 hooks. Bootstrapped estimates of coefficient of variance (CV) on mean annual biomass estimates or annual catch rate estimates were used to assess the relative error. A survey series was considered to adequately index either Big Skate or Longnose Skate biomass if the mean of the CVs of the survey indices was < 0.4. Trend analyses on survey series that were considered adequate were used to identify any statistically significant trends in relative abundance over time.

To augment information on historic catch levels and trends in research survey indices, ranges of maximum sustainable yield (MSY) were estimated using the Catch-MSY approach (Martell and Froese, 2012). This approach estimates MSY based on time series of removals (catch) along with estimates of the maximum rate of population increase (r) and carrying capacity (K) for a given stock. In addition, prior estimates of depletion are required at the start and end of the catch time series. Catch-MSY was applied to both species in all Skate Management Areas but

[1] King, J.R., Surry, A.M, Garcia, S., and Starr, P.J, in press [2014]. Big Skate (*Raja binoculata*) and Longnose Skate (*R. rhina*) stock assessments for British Columbia. Draft Research Document.

results were extremely sensitive to assumptions, and were without consistent responses across areas or assumption combinations. The resultant ranges of MSY estimates are therefore only to be used as guidance for setting harvest levels and are not intended as specific harvest advice.

Results

The commercial catch data are summarized as long-term (1996 – 2011), 10 year (2002 – 2011) and 5 year (2007 – 2011) means for each species by Skate Management Area and coast-wide for Longnose Skate (Table 1). Commercial trawl and line data were combined; catch data included landings and the estimated discard mortalities (discards scaled by fishery-specific discard mortality rate).

For Big Skate, reliable indices of abundance are available in each of the Skate Management Areas from either trawl surveys (5CDE) or longline surveys (3CD and 5AB). Trend analyses did not detect a slope or annual change significantly different from zero for any time series (Figure 3, Table 1). There were no reliable indices of abundance from research surveys for Big Skate in 4B. These results suggest that historic levels of removal have not resulted in a significant decline in abundance of Big Skate. The mean historic catch levels do not exceed the range of MSY estimates resultant from the Catch-MSY approach (Table 1).

For Longnose Skate, several trawl and longline surveys provided indices of abundance in each Skate Management Area. Trend analyses for trawl surveys suggested that in all areas, the historic levels of removal have paralleled declines in Longnose Skate abundance that are significantly different from zero (Figure 4, Table 1). However, no trends were detected in any of the longline surveys (Figure 4, Table 1). In all Skate Management Areas and coast-wide, the mean historic catch levels of Longnose Skate exceed the range of MSY estimates produced by the Catch-MSY approach (Table 1).

Big Skate and Longnose Skate catches in 4B (Minor areas 14 – 18, 28 – 29) are exceptionally small (Figures 3 and 4) and preclude provision of advice using the standard stock assessment approaches. In addition, there are no research surveys of adequate precision to provide indices of relative abundance. There is not enough information available to provide advice on trip limits or Total Allowable Catches in this area. However, as a broad overview, mean catches for each species have been summarized for the long-term (1996 – 2011), 10 year (2002 – 2011) and 5 year (2007 – 2011) periods. In addition, spatial distributions of commercial trawl and survey catches are provided to show where fishing occurs, where skates are encountered, and their relative spatial overlap (Figure 5).

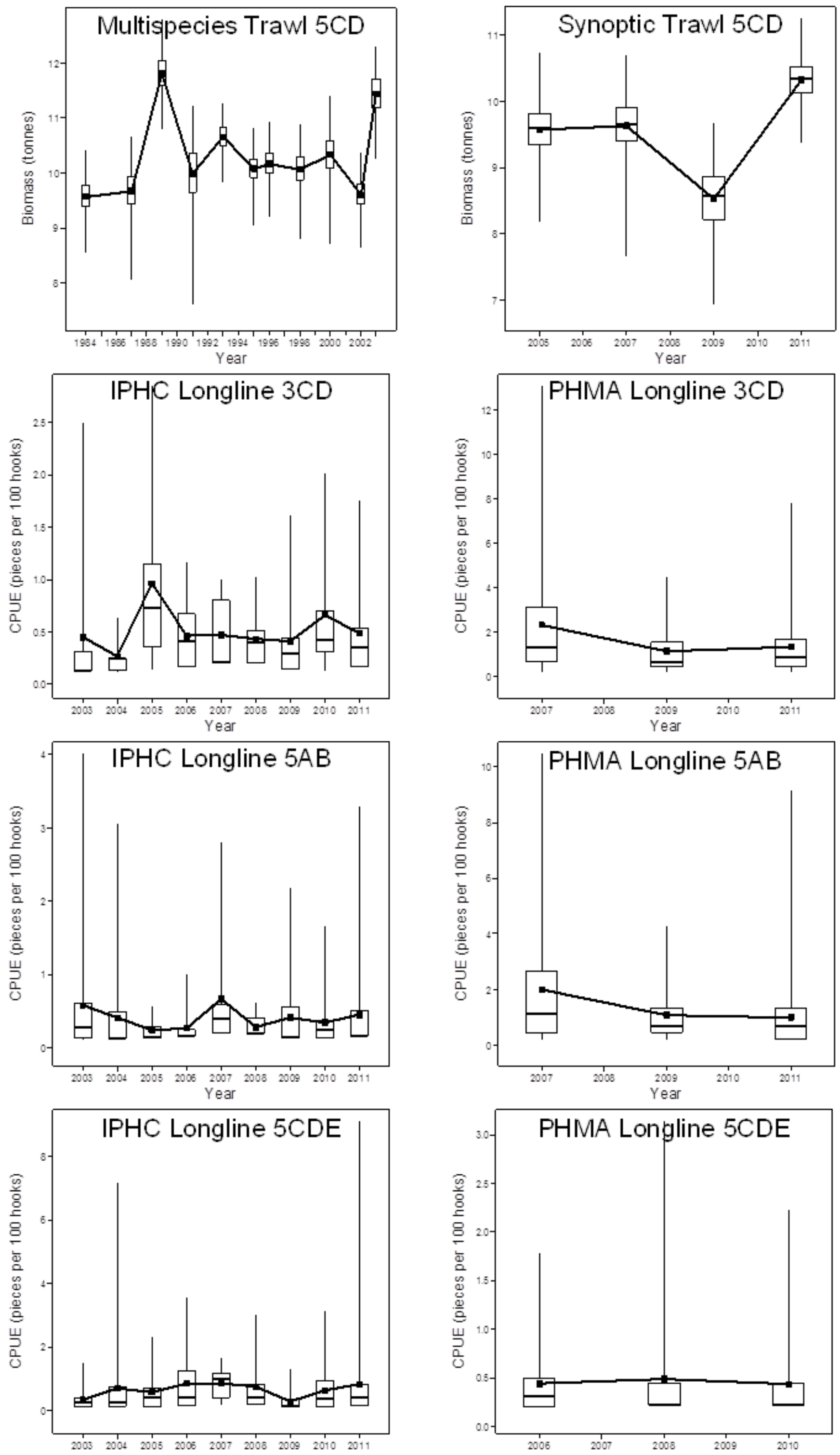

Figure 3. Big Skate indices from trawl and longline research surveys. Annual mean biomass (solid squares) is estimated by stratified swept-area calculation. Annual mean catch per unit effort (CPUE, solid squares) is calculated as pieces per 100 hooks. Bootstrapped replicates (1,000 random with replacement) were used to estimate 95% confidence intervals (vertical lines), 25th and 75th quantiles (boxes) and median (horizontal lines). Trend analyses and bootstrapped estimates of slope and annual rate of change did not detect any trends significantly ($p<0.05$) different than zero.

*Table 1. Results for Big Skate and Longnose Skate by Skate Management Area (and coast-wide for Longnose Skate only). Mean commercial trawl and line catch (landings and discards*discard mortality [tonnes]) are for long-term (1996 – 2011), 10-year (2002 – 2011) and 5-year (2007 – 2011) periods. The Catch-MSY range is the range of mean MSY estimates (tonnes) produced across all scenarios from the Catch-MSY approach. Results of trend analyses are for indices of relative abundance available from research trawl or line surveys. Numbers in parentheses are timespans of surveys; two time series denote two survey indices available for trend analyses.*

	Skate Management Area				
	3CD	5AB	5CDE	4B	Coast-wide
Big Skate					
Mean Historic Catch					
Long-term	50	373	587	13	--
10-year	63	471	509	14	--
5-year	62	197	450	8	--
Catch-MSY range	31 – 86	277 – 845	358 – 1064	--	--
Trend Analyses					
Trawl Surveys	--	--	No Trend (1984-2002; 2005-2011)	--	--
Line Surveys	No Trend (2003-2011; 2007-2011)	No Trend (2003-2011; 2007-2011)	No Trend (2003-2011; 2006-2010)	--	--
Longnose Skate	3CD	5AB	5CDE	4B	Coast-wide
Mean Historic Catch					
Long-term	186	118	96	9	409
10-year	228	140	89	10	467
5-year	236	136	92	1	466
Catch-MSY range	90 – 140	59 – 97	35 – 87	--	203 – 320
Trend Analyses					
Trawl Surveys	Declining trend (2003-2012; 2004-2012)	Declining trend (2003-2012; 2003-2011)	Declining trend (2006-2012) No Trend (2005-2011)	--	--
Line Surveys	No Trend (2003-2011; 2007-2011)	No Trend (2003-2011; 2007-2011)	No Trend (2003-2011; 2006-2010)	--	--

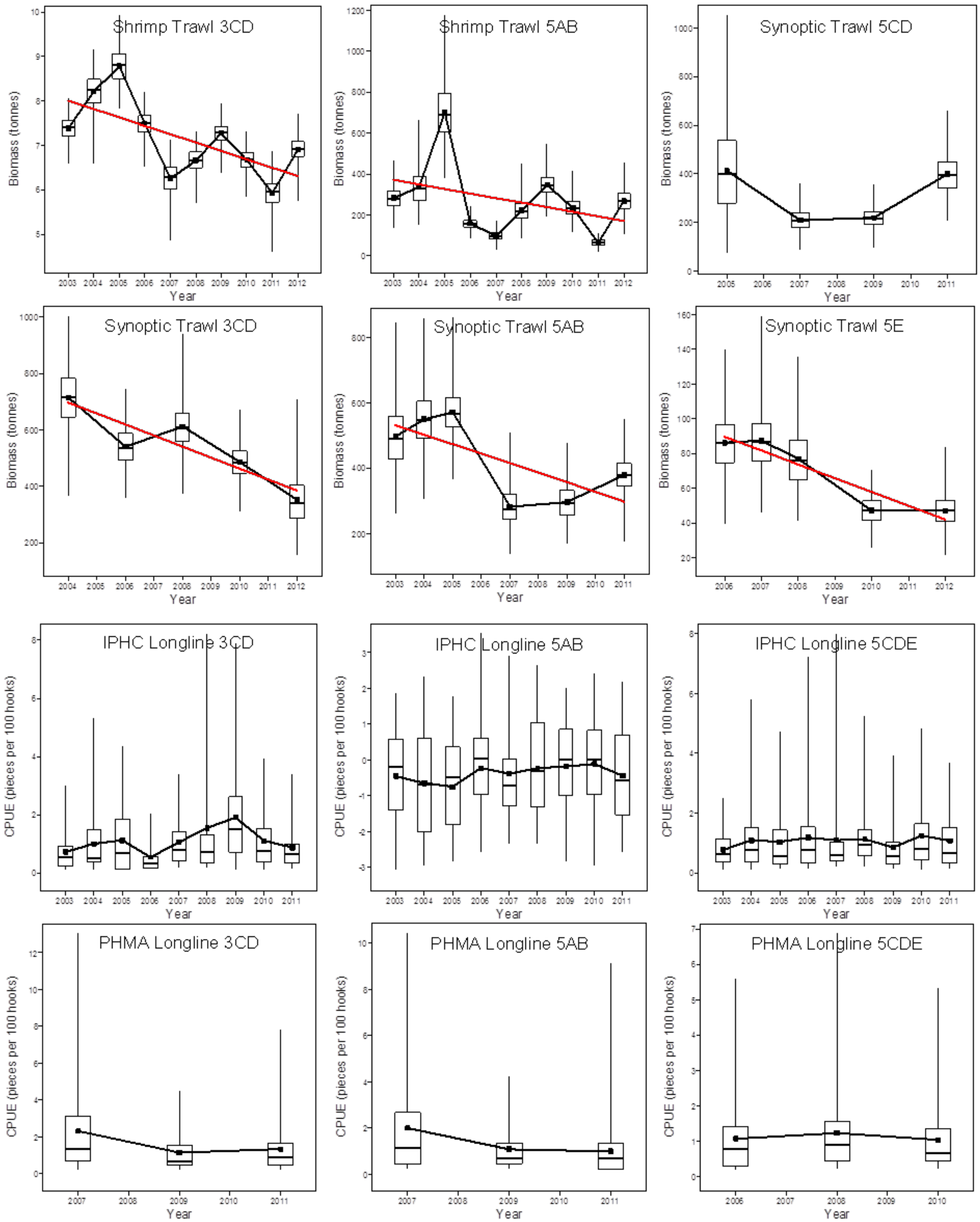

Figure 4. Longnose Skate abundance indices from trawl and longline research surveys. Annual mean biomass (solid squares) is estimated by stratified swept-area calculation. Annual mean catch per unit effort (CPUE, solid squares) is calculated as pieces per 100 hooks. Bootstrapped replicates (1,000 random with replacement) were used to estimate 95% confidence intervals (vertical lines), 25th and 75th quantiles (boxes) and median (horizontal lines). Only those trends (red line) significantly different (p<0.05) than zero are plotted.

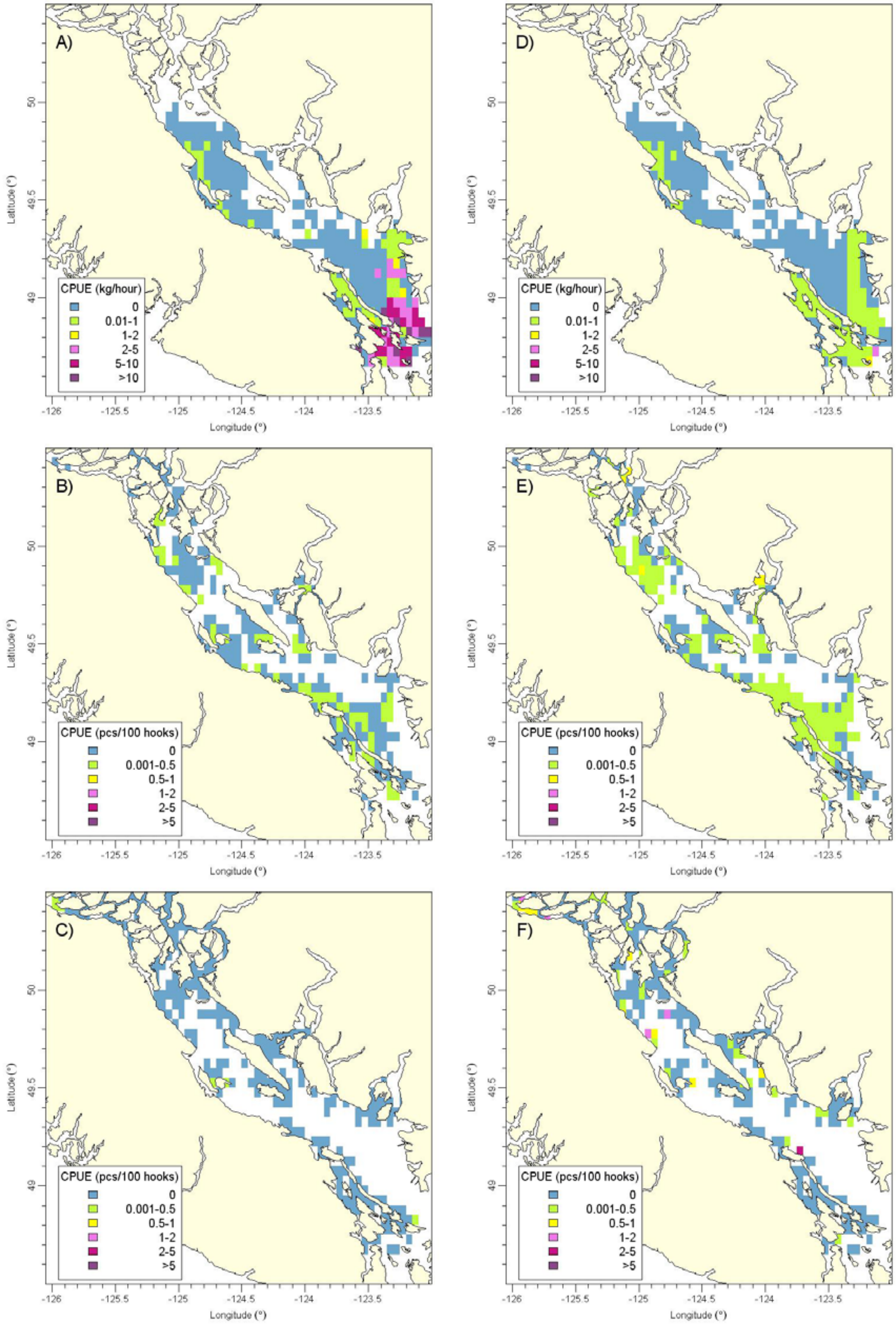

Figure 5. Mean catch per unit effort (CPUE) by 0.05° by 0.05° grid in Skate Management Area 4B for Big Skate captured in A) trawl commercial fisheries, B) line commercial fisheries, C) line research surveys and for Longnose Skate captured in D) trawl commercial fisheries, E) line commercial fisheries, F) line research surveys.

Stock Status

Despite having reliable estimates of commercial catch and life history variables, attempts to provide yield advice based on assessment modeling (Bayesian Surplus Production Model) and data-limited assessment approaches (Depletion-Corrected Average Catch Analysis and Catch-MSY Approach) produced unreliable results since the catch and abundance time series were not informative, i.e. lacked contrast. Assessment methods could not provide reliable estimates of biomass, preventing evaluation of current and future stock status relative to reference points.

Sources of Uncertainty

Historic mean catch includes landed weights of skates and estimates of dead skates discarded at sea, which relies on estimates of discard mortality. The mortality rate of 50% for trawl discards used in this assessment was based on published estimates for other skate species caught by trawl gear. It is unknown whether this represents the true discard mortality rate for Big Skate and Longnose Skate or if the rate varies with tow duration, depth or handling time. In addition, there were no published estimates of longline discard mortality for any skate species, and it is unknown if the mortality rate of 10% applied in this assessment is appropriate.

The stability of Big Skate and Longnose Skate abundance was assessed with trend analyses of relative abundance indices based on research survey data. This assumes that relative abundance indices derived from survey biomass estimates or catch rates are proportional to skate biomass.

The Catch-MSY approach is an approach newly developed for data-limited species and this is the first known application to an operating fishery with the intent of providing harvest advice. The assumptions are simple and transparent – they do not represent difficult biological concepts, and are relatively easy to interpret. However, the results obtained here were sensitive to the assumptions, particularly to the initial and final depletion levels. All posterior k distributions were updated from the uniform prior k distributions used for both species, implying that there is information about stock size in the catch history, when coupled with the informed priors on the r parameter. The informed r prior distributions were developed from published life history parameters and are the best estimates that can be made with the information available. However the r posteriors were not updated from the prior distribution, which is not surprising, given that catch histories can theoretically be generated by small or large stocks, depending on the level of productivity. Furthermore, some important limitations to this approach should be noted. MSY is an equilibrium characteristic for a stock and represents an estimate of the long-term yield of the population at average recruitment levels. The Catch-MSY approach does not include information about recruitment, selectivity, or any age-structured effects. Consequently, setting catch limits based on this approach could result in fishing mortality rates that may be inappropriate in any particular year. The Catch-MSY approach is also dependent on the catch history to set the level of the MSY and will fail to the extent that the catch history is not representative. The mean MSY estimates therefore represent a suite of plausible scenarios, based on a defensible life history of the species and using observed recent mortality levels, including discards, and the mean MSY estimates produced from this approach should not be used as a stand-alone methodology to set harvest levels.

CONCLUSIONS AND ADVICE

In lieu of specific harvest advice, this assessment summarizes average historic catches relative to the ranges of MSY estimated from the Catch-MSY approach to provide guidance for setting harvest levels (Table 1). The use of average catches to set potential yields is consistent with the "*Fishery Decision-making Framework Incorporating the Precautionary Approach*" (DFO 2009). For stocks that appear to have stable abundance indices, but lack estimates of stock status based on model results, historical fishing mortality can be used as yields limits (DFO 2009). The use of average historical catch levels as harvest yield advice requires that stocks appear stable. The results of trend analyses on relative abundance indices from selected research survey series (mean CV < 0.4) are provided to assess relative stock stability.

For Skate Management Area 4B which has insufficient data to estimate ranges of MSY or to assess stock trends, mean catches for each species have been summarized for the long-term (1996 – 2011), 10 year (2002 – 2011) and 5 year (2007 – 2011) periods. In addition, spatial distributions of commercial trawl and survey catches were provided to show where fishing occurs, where skates are encountered, and their relative spatial overlap (Figure 5).

SOURCES OF INFORMATION

This Science Advisory Report is from the May 16th, 2013 Regional Peer Review Meeting on the Review of Assessment of Longnose Skate and Big Skate stocks in areas 4B, 3CD, 5AB and 5CDE in British Columbia. Additional publications from this process will be posted as they become available on the Fisheries and Oceans Canada Science Advisory Schedule.

DFO. 2009. A fishery decision-making framework incorporating the Precautionary Approach.

Martell, S., and R. Froese. 2012. A simple method for estimating MSY from catch and resilience. Fish and Fisheries. (DOI: 10.11/j.467 – 2979.2012.00485.x)

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