Deriving estimates of OFL for species in the "Other Fish" complex

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Seven species (Table 1) currently managed in the "Other fish" complex were lacking proposed OFLs for the 2013-2014 management cycle. The following work proposes OFLs for each of these species, with methods to estimate OFLs for six of the seven species identified (detailed below). Given the lack of any biological and fisheries information on finescale codling and the fact that the overall species complex OFL is the sum of all component species OFLs, an OFL of 0 is proposed for finecalse codling so as to reduce the risk of inflating a complex-level OFL that contains species with variable vulnerabilities (Cope et al. 2011). The authors caution that risk of overfishing for each component stock is difficult to measure when combining small OFLs for targeted species (e.g. cabezon, kelp greenling) with relatively large OFLs for bycatch and underutilized species (e.g. ratfish, Pacific grenadier) into a grouped OFL.

Table 1. Species currently within the "Other Fish" species complex and their associated OFLs (mt) for 2013-2014. The italicized species were previously lacking estimates and are the ones addressed in this work.

Stock	**2013 OFL**	**2014 OFL**
Other Fish Complex	6864	6832
Big skate	*458*	*458*
Cabezon (WA)	*4*	*3*
California skate	*86*	*86*
Finescale codling	*0*	*0*
Kelp greenling (CA)	118.9	118.9
Kelp greenling (OR & WA)	*28*	*27*
Leopard shark	167.1	167.1
Pacific grenadier	*1519*	*1519*
Ratfish	*1441*	*1441*
Soupfin shark	61.6	61.6
Spiny dogfish	2,980	2,950

OFL estimates derived from survey biomass and MSY harvest rates

We estimated Overfishing Limits (OFLs) for four species currently managed in the 'Other Fish' complex by applying approximate MSY harvest rates to estimates of stock biomass from the NWFSC West Coast Bottom Trawl Survey (Keller et al., 2008). We modified the approach of Rogers et al. (1996) to estimate OFLs for Pacific grenadier (*Coryphaenoides acrolepis*), big skate (*Raja binoculata*), California skate (*Raja inornata*), and spotted ratfish (*Hydrolagus colliei*) using the equation

$$OFL = F_{MSY} B_w$$

where F_{MSY} is the fishing mortality rate that maximizes long-term yield, and B_w is an inverse-variance weighted average of recent survey biomass estimates. For all species, we made a simplifying assumption about survey catchability, namely that $q = 1$, which is likely to result in conservative estimates of OFL for species whose range extends beyond survey boundaries or that occupy habitats inaccessible to survey gear.

To estimate F_{MSY} for each species, we took the product of estimates for the natural mortality rate (M) and the ratio F_{MSY}/M. Natural mortality rates were obtained from the literature or estimated from maximum observed ages using Hoenig's method (Hoenig, 1980). Maximum reported ages for Pacific grenadier and big skate were 73 and 26 years, respectively (Andrews et al., 1999; McFarlane and King, 2006). No published estimates of maximum age for California skate were found, so we assume a maximum age equal to that of big skate (26 years). Barnett (2008) reports a range for M of 0.17 – 0.26 for spotted ratfish based on reproductive output. For the ratio F_{MSY}/M, previous studies (e.g. Dick and MacCall, 2011) followed the suggestion of Walters and Martel (2004) that $F_{MSY} = 0.8M$ for demersal groundfish in the northeast Pacific. The present analysis incorporates estimates of F_{MSY}/M, tailored to specific taxonomic groups, from a recent meta-analysis based on more than 200 species (Shijie Zhou, CSIRO; personal communication).

To propagate uncertainty in M and F_{MSY}/M into the OFL estimates, we specified probability density functions for each quantity (Table 2). For Pacific grenadier and the two skate species, we assumed M was lognormally distributed with a species-specific mean and a log-scale standard deviation of 0.4 (CV = 0.417; Dick and MacCall, 2011). Ageing methods for ratfish remain highly imprecise, so we assumed a uniform distribution of M over the range 0.17 – 0.26, following Barnett (2008). The meta-analysis of Zhou (pers. comm.) reports estimates of the mean and CV of the posterior predictive distribution of F_{MSY}/M for teleosts (mean = 0.87, CV = 0.55) and chondrichthyans (mean = 0.41, CV = 0.55). We assume lognormal distributions for F_{MSY}/M.

Trawl survey estimates of abundance were provided by NWFSC staff (A. Keller and B. Horness, personal communication) for the years 2003-2010. Estimates were stratified by year, depth, and INPFC area. We calculated annual biomass and variance estimates as the sum of stratum-specific biomasses and variances within each year (Table 3, Figure 1). To reduce the effect of spurious annual estimates, we assume current biomass is the inverse-variance weighted average over the most recent three years (2008-2010). This approach assumes that no significant changes in abundance occurred during this time period, which is not unreasonable for low-productivity stocks that are not primary targets of the fishery.

Table 2. Assumed distributions for natural mortality (*M*) and F_{MSY} / *M* by species, with associated coefficients of variation (CV). For spotted ratfish, bounds of the assumed uniform distribution on *M* are provided in place of a CV.

	Pacific grenadier	**Big skate**	**California skate**	**Spotted ratfish**
Natural Mortality, M yr^{-1}				
Distribution	lognormal	lognormal	lognormal	uniform
Expected Value	0.053	0.162	0.162	0.215
CV (range)	0.417	0.417	0.417	(0.17, 0.26)
F_{MSY} / M				
Distribution	lognormal	lognormal	lognormal	lognormal
Expected Value	0.87	0.41	0.41	0.41
CV	0.55	0.55	0.55	0.55

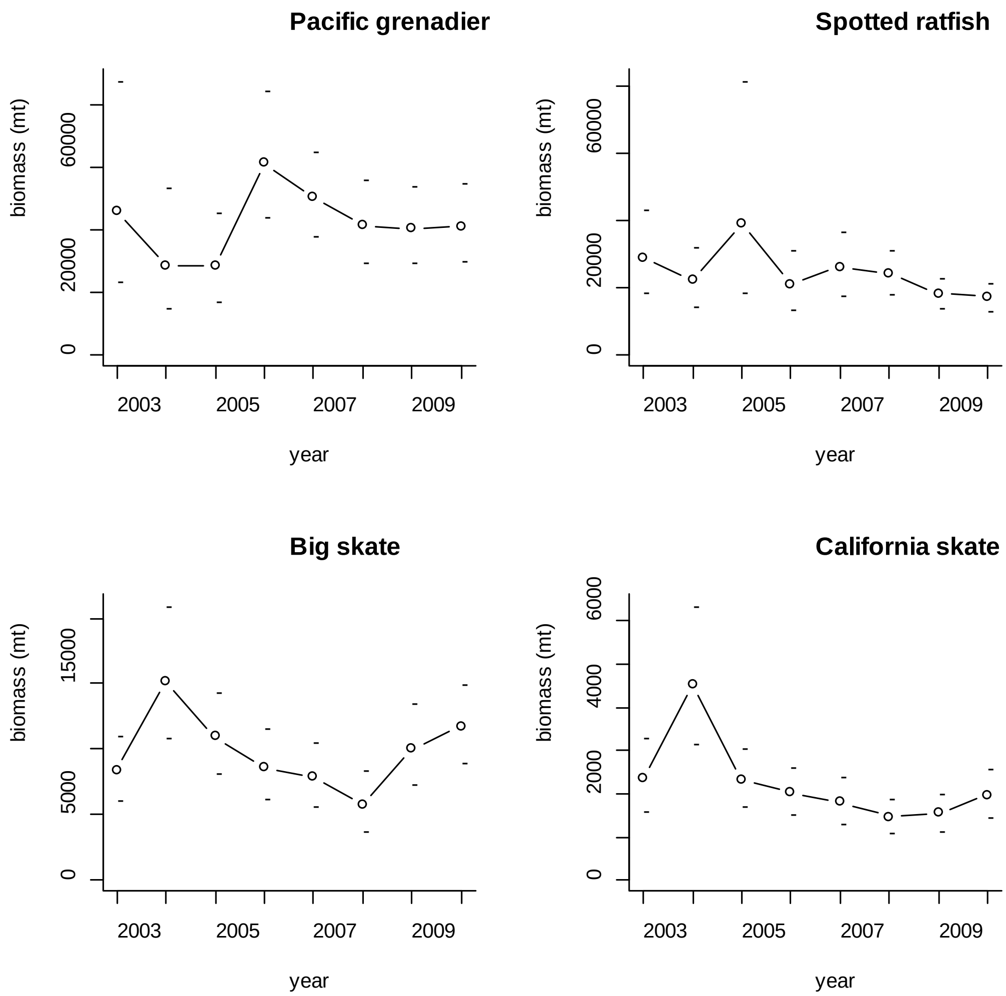

Figure 1. Time series of estimated survey biomass (mt), 2003-2010, with estimated 95% confidence intervals.

Table 3. Biomass estimates (mt) and associated coefficients of variation (CV) from the NWFSC trawl survey, by year and species.

	Pacific grenadier		Big skate		California skate		Spotted ratfish	
Year	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV
2003	45796	34.3%	8331	14.6%	2340	18.4%	28895	21.5%
2004	28564	33.3%	15159	16.7%	4516	17.6%	22086	19.9%
2005	28395	25.1%	10943	14.3%	2336	14.5%	39262	39.0%
2006	61292	16.7%	8587	15.9%	2025	13.8%	21080	20.8%
2007	50235	13.6%	7844	15.7%	1804	15.1%	26030	18.2%
2008	41205	16.3%	5742	20.3%	1463	14.0%	24123	13.8%
2009	40267	15.7%	10070	15.3%	1546	14.2%	18151	12.7%
2010	41007	15.3%	11709	12.8%	1975	14.6%	17125	12.6%

OFL estimates

OFL point estimates are typically based on the median of the OFL distribution, as this statistic represents the catch associated with a 50% probability of overfishing. Median OFLs for Pacific grenadier, big skate, California skate, and spotted ratfish are 1519, 458, 86, and 1441 mt, respectively. Descriptions of the OFL distributions (mean, median, and selected percentiles) for the four species are provided in Table 4. Illustrations of prior distributions for M and F_{MSY}/M, along with derived distributions for weighted average biomass and OFL, are included in Figures 2-5. All distributions were approximated using 1 million Monte Carlo draws.

Table 4. Summary statistics for distributions of OFL (mt) based on estimated survey biomass and MSY harvest rates

		percentile				
Species	**Mean**	**2.5%**	**25%**	**50%**	**75%**	**97.5%**
Pacific grenadier	1882	421	977	1519	2361	5479
Big skate	568	127	294	458	713	1653
California skate	107	24	55	86	134	311
Spotted ratfish	1657	510	1009	1441	2059	4058

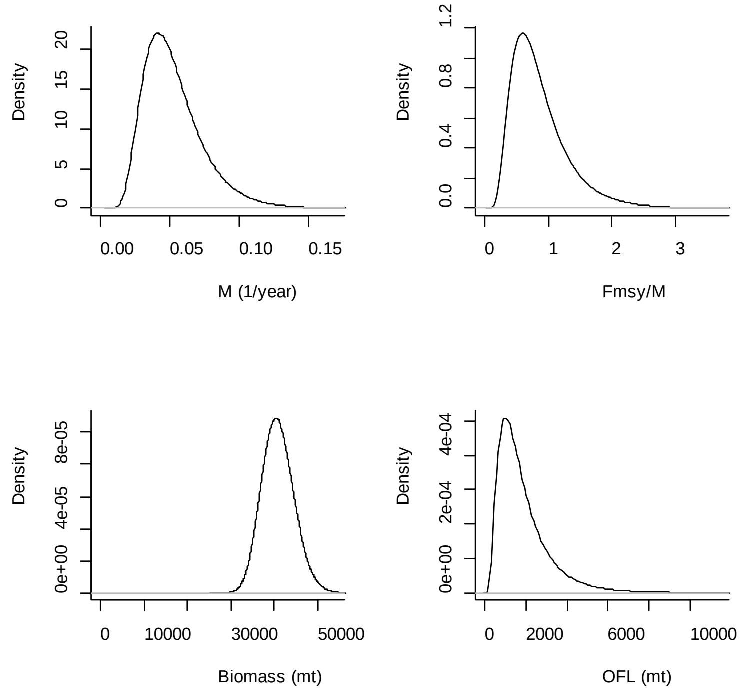

Figure 2. Assumed distributions for M and F_{MSY} /M (upper panels) and distributions of the weighted average survey biomass (2008-2010) and OFL (lower panels) for Pacific grenadier.

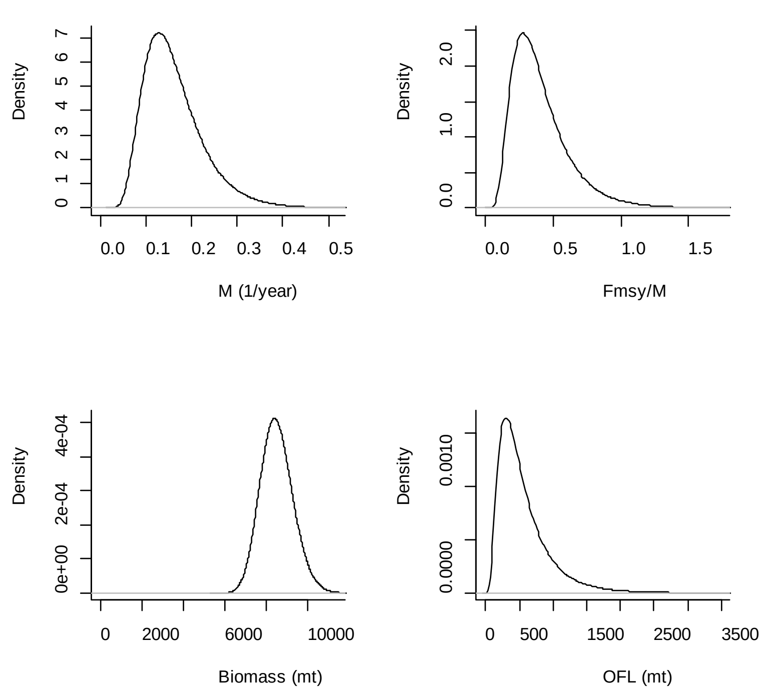

Figure 3. Assumed distributions for M and F_{MSY} /M (upper panels) and distribution of the weighted average survey biomass (2008-2010) and OFL (lower panels) for big skate.

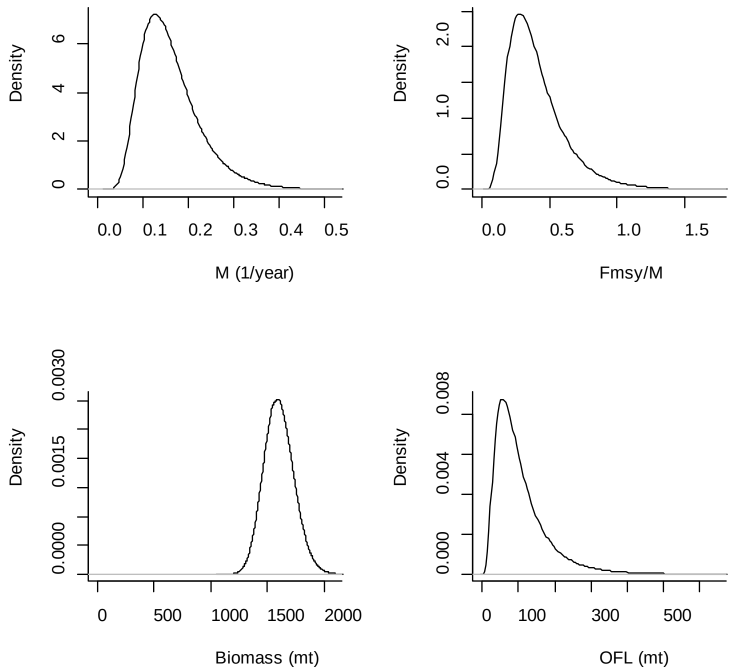

Figure 4. Assumed distributions for *M* and F_{MSY} /*M* (upper panels) and distributions of the weighted average survey biomass (2008-2010) and OFL (lower panels) for California skate.

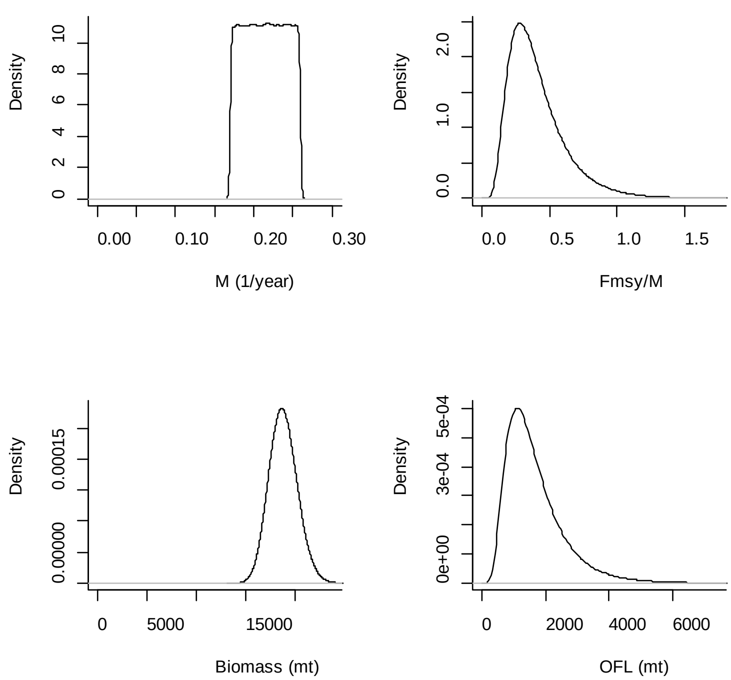

Figure 5. Assumed distributions for *M* and F_{MSY} /*M* (upper panels) and distributions of the weighted average survey biomass (2008-2010) and OFL (lower panels) for spotted ratfish.

OFL estimates derived using previous stock assessments

Cabezon (WA)

The 2009 Oregon cabezon assessment (Cope and Key 2009) was used as the base case to forecast catches in 2013 and 2014 for the Washington area. The first step entailed updating commercial and recreational catches in the Oregon assessment and re-running the forecast through 2014 to obtain updated estimates of Oregon OFLs for 2013-2014. Washington catch (recreational only; no commercial catches of cabezon were reported in PacFIN, with the missing RecFIN years 1989-1992 assumed the average of years 1980-1988) was then added to the Oregon assessment data and forecast files and the model re-run using the par file from the Oregon run to maintain input parameter estimates. The resultant OFL values were considered the Washington/Oregon combined estimate of OFL. The Washington contribution to the OFL was then determined by subtracting the Washington/Oregon and Oregon estimates, yielding 3.92 mt and 2.82 mt for 2013 and 2014, respectively.

Kelp greenling (OR/WA)

The 2005 Oregon kelp greenling assessment (Cope and MacCall 2005) was used as the base assessment to which Washington recreational catches (extracted from RecFIN) were added to the catch history up to 2004. Four recreational modes were used in the assessment, so catch was assigned to each mode. Only the combined shore-based mode catches were reported for years 1986-1988, so the harmonic mean of the proportion of the man-made mode to total shore-based catch was calculated, with 1 minus this value assigned as the beach-bank proportion. The shore-based catch for those missing years was then allocated to each mode using these parameters. All modes were missing 1989-1992, years that recreational catch data was not being sampled. Average catch from 1981to 1988 was used to interpolate these values for each mode. Catches for years 2005-2011 were updated in the forecast file, with years 2012-2014 estimated in the forecast file using the 40-10 option.

The resultant OFL for 2013 and 2014 is 28.1 and 27.3, respectively. This is compared to 19.8 and 20.2, respectively, if the Washington catches are not included.

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References

Andrews, A. H., G. M. Caillet, and K. H. Cole. 1999. Age and growth of the Pacific grenadier (*Coryphaenoides acrolepis*) with age estimate validation using an improved radiometric ageing technique. Canadian Journal of Fisheries and Aquatic Sciences 56: 1339-1350.

Barnett, L. A. K. 2008. Life history, abundance, and distribution of the spotted ratfish, *Hydrolagus colliei*. Masters thesis, Moss Landing Marine Laboratories, California State University, Monterey Bay. 173 p.

Cope, J.M., J. DeVore, E.J. Dick, K. Ames, J. Budrick, D. Erickson, J. Grebel, G. Hanshew, R. Jones, L. Mattes, C. Niles, S. Williams. 2011. An approach to defining species complexes for U.S. west coast groundfishes using vulnerabilities and ecological distributions. *North American Journal of Fisheries Management* 31: 589-604.

Cope, J.M. and M. Key. 2009. Status of Cabezon (*Scorpaenichthys marmoratus*) in California and Oregon Waters as Assessed in 2009. Pacific Fishery Management Council, 7700 Ambassador Place NE, Suite 200, Portland, OR 97220. 390 pp.

Cope, J.M. and A.D. McCall. 2005. Status of Kelp Greenling (*Hexagrammos decagrammus*) in Oregon and California Waters as Assessed in 2005. Pacific Fishery Management Council, 7700 Ambassador Place NE, Suite 200, Portland, OR 97220. 158 pp.

Dick, E. J. and A. D. MacCall. 2011. Depletion-Based Stock Reduction Analysis: A catch-based method for determining sustainable yields for data-poor fish stocks. Fisheries Research 110: 331-341.

Keller, A. A., B. H. Horness, E. L. Fruh, V. H. Simon, V. J. Tuttle, K. L. Bosley, J. C. Buchanan, D. J. Kamikawa, and J. R. Wallace. 2008. The 2005 U.S. West Coast bottom trawl survey of groundfish resources off Washington, Oregon, and California: Estimates of distribution, abundance, and length composition. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-93, 136 p.

McFarlane, G. A. and J. R. King. 2006. Age and growth of big skate (*Raja binoculata*) and longnose skate (*Raja rhina*) in British Columbia waters. Fisheries Research 78: 169-178.

Rogers, J. B. M. Wilkins, D. Kamikawa, F. Wallace, T. L. Builder, M. Zimmerman, M. Kander, and B. Culver. 1996. Status of the remaining rockfish in the *Sebastes* complex in 1996 and recommendations for management in 1997. Appendix E In Pacific Fishery Management Council Status of the Pacific coast groundfish fishery through 1996 and Recommended Acceptable Biological Catches for 1997. Pacific Fishery Management Council, Portland, OR. 59 p.