Agenda Item I.3.b
GMT Report
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GROUNDFISH MANAGEMENT TEAM PROGRESS REPORT ON DEVELOPING MORTALITY RATES FOR ROCKFISH RELEASED USING DESCENDING DEVICES

Contents

A subgroup of the Groundfish Management Team (GMT) has been working on the issue of accounting for the use of descending devices in catch accounting since the June 2012 Council meeting, as time and other duties allowed. Additionally, the entire team worked on this issue at the September 2012 Council meeting and at the October GMT work session. This document is a progress report on this work as of the October 11, 2012 briefing book deadline, some sections are still being worked on, and in those sections there may just be bullet points of the GMT's thoughts so far. These thoughts are incomplete and require more discussion and work; however the Team wanted to include them to show the nature of the discussions and issues that have arisen.

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Executive Summary

The Groundfish Management Team (GMT) considered published research, unpublished information, and personal communications with researchers working on barotrauma effects on rockfish and ways to mitigate barotrauma when releasing rockfish using recreational hook-and-line gear. The GMT used that data to begin developing methodologies for determining mortality rates for rockfish released with descending devices. We present some strawman methodologies here not only for review by the Scientific and Statistical Committee (SSC) but also to give the Pacific Fishery Management Council (Council) a sense of the data available, some of the considerations in using that data, and data gaps that need to be filled to more appropriately account for increased survival of rockfish released with descending devices. The GMT is not recommending any methodology at this time. Likewise, application of any method approved by the SSC and the Council would require additional work to incorporate it into state recreational sampling protocols and catch statistics.

Proposed discard mortality rates for yelloweye rockfish and cowcod released with descending devices are based on results of rockfish recompression and tagging studies. In the recompression studies, observations of rockfish mortality were made by researchers who returned fish to the bottom in cages (Jarvis and Lowe 2008 (Hannah, *et al.* 2012; Jarvis and Lowe 2008) or subjected fish to equivalent bottom pressures in hyperbaric chambers (Parker, *et al.* 2006; Pribyl, *et al.* 2012; Smiley and Drawbridge 2007). In a tagging study, mortality of yelloweye rockfish after release at the bottom was estimated with a mark-recapture model (Hochhalter and Reed 2011). In an acoustic tagging study undertaken by the National Marine Fisheries Service (NMFS) Southwest Fisheries Science Center (SWFSC), rockfish including cowcod were released using descending devices following tagging. Tagged fish that showed movement after release were assumed to be live fish, whereas continuously stationary tags were assumed to be dead fish (Wegner, Pribyl, and Hyde, in prep.). Though the sample sizes for each of these studies may be limited for cowcod and yelloweye rockfish and only applicable to equal or shallower depths in which the studies were conducted, they provide a basis for direct estimates or proxies based on other shelf rockfish sampled in the studies. Basing descending device discard mortality rates on telemetry movement data may result in overestimation due to possible mortality occurring from the tagging event and since tag losses from live fish would appear as mortalities.

Summary of Alternatives

The GMT had lengthy discussions about short term vs. long term mortality and how to account for that mortality. A similar framework to that employed in estimating surface mortality rates can be applied in estimating mortality rates expected for fish released using a descending device by the simple modification of replacing the short term surface mortality rate with the two or four day mortality rates estimated from research projects discussed below. When determining surface release mortality rates for cowcod there was not a sufficient number of samples available to provide a direct estimate and, as a result, a proxy estimate from other members of the deep demersal guild was used. Direct estimates for cowcod are also lacking from two day cage studies, but estimates from other deep demersal guild species are available. As with surface release mortality rates, the three factors can be combined to estimate mortality rates for fish released using descending devices comprised of 2-4 day (short term) mortality, short term bottom mortality (8.3%, Albin and Karpov 1996), and a long term bottom mortality (5%/10 fm).

An alternative method of estimating mortality rates would involve combining discard mortality rates for two day cage studies with long term three to ten day mortality rates. The combination of the two day tagging study data depends on the species to which it is being applied and the depth in which the data was collected. Data was also available from the acoustic tagging study to inform a single total mortality rate for 0-10 days providing a complete estimate of total mortality for a limited number of samples for comparison to the composite estimates from the combination of 2-4 day mortality from recompression studies combined with long-term mortality rates.

The proportion of fish released using the devices and the proportion of catch by depth will determine the magnitude of the difference in mortality when the rates reflecting use of descending devices are applied instead of surface release. Greater reductions in mortality are expected in deeper depths where the surface release mortality rate approaches 100 percent due to the inability of fish to escape the surface subjecting them to predation by avian and pinniped predators as well as sun exposure and thermal shock. To account for uncertainty surrounding long term mortality, an additional mortality rate may be added to the discard mortality rates to provide a precautionary buffer.

Specific Questions for the SSC

1. Are the research results cited sufficient to develop mortality rates for cowcod and yelloweye released using descending devices at the depths provided in this progress report?

2. What are the research and data needs to better inform the development of mortality rates of cowcod and yelloweye using descending devices?

3. Given the uncertainty in mortality rates from barotrauma studies conducted to date, what level of precaution should be considered for applying a survival rate credit for anglers using descending devices?

4. If survival credit is given, there will be necessary changes to recreational surveys to document the proportion of rockfish by species released using descending devices. Are the current sampling rates sufficient to gain a representative sample of the use of descending devices by fleet?

Questions that Council Members Need to Consider

1. With the mortality rates from barotrauma studies conducted to date, apparent reduction in mortality relative to surface release, and uncertainty associated with the estimates, what level of precaution should be considered for accounting for the reduction in mortality resulting from the use of descending devices in generating mortality estimates for management?

2. If use of descending devices are accounted for in mortality estimates, there will be necessary changes to recreational surveys to document the proportion of rockfish by species released using descending devices that will entail costs (e.g., lower sample rates) and benefits (e.g., potentially greater fishing opportunities). The Council needs to carefully consider costs and benefits associated with this initiative.

3. Should alternatives for other constraining rockfish species (e.g., canary) be developed?

Introduction

At the June 2012 meeting, the Council tasked the GMT with developing a report on how to integrate recreational angler use of descending devices into the management system for cowcod and yelloweye rockfish caught with rod-and-reel gear, with the goal of applying a discard mortality rate that reflects use of a descending devices in the release of fish rather than surface release beginning in 2013. Accounting for the use of descending devices in mortality estimates for additional rockfish species and for the commercial nearshore groundfish fishery may occur in the future, but only cowcod and yelloweye rockfish released by recreational fisheries were requested for immediate review due to GMT workload constraints and because regulations used to limit discard mortality of these species are most restrictive relative to other overfished species.

Although current catch accounting practices account for depth-dependent recreational rockfish discard mortality for fish released at the surface, the assumed discard mortality rates are based on simply throwing fish overboard and onto the surface. Applying these estimates to all discarded rockfish may result in an overestimate of total discard mortality used in management because some recreational fishermen release rockfish at the depth of capture with descending devices. Discard mortality rates are lesser for rockfish released at the bottom, as accomplished with descending devices, than at the surface (Hannah, *et al.* 2012; Hochhalter and Reed 2011; Jarvis and Lowe 2008). Applying lesser discard mortality rates to rockfish released with descending devices could allow greater opportunities for these fisheries since regulations are crafted in rod-and-reel fisheries to keep overfished species impacts within relatively low harvest guidelines.

To incorporate alternative mortality rates accounting for descending device use, the proportion of fish released with devices must be estimated and discard mortality rates for rockfish released with devices must be developed, which is the objective of this report. Since calculations to determine the proportion of fish released with devices may vary among the state recreational fisheries due to different catch accounting methods, the Council may consider whether agencies should independently calculate proportions of fish released with devices for their respective fisheries, or whether a uniform method should be applied to all states and fisheries. Calculations for determining both mortality rates and proportions of rockfish released with descending devices for the recreational fisheries should be reviewed by the SSC Groundfish Subcommittee. In addition, the methods of applying the mortality rates should be reviewed by the RecFIN Technical Committee.

Surface Discard Mortality Estimate

Currently all fish released from recreational fisheries are assumed to be discarded at the surface. The GMT developed a depth-dependent mortality matrix that is applied to those surface released fish (Table 1). The GMT evaluated three specific components of total mortality to develop a mortality proxy: a) short term surface mortality, b) short term bottom mortality, and c) long term delayed mortality (PFMC 2008). In developing these rates, the GMT considered "surface" mortality, one that is observable when a fish is brought to the surface, handled on deck, and thrown back. Short term surface mortality was estimated using the correlation of rockfish discarded onboard party boats with depth of capture in 10 fm increments using a generalized linear model (GLM). Second, the GMT considered short term, below surface mortality that had been documented by research at the time. The short term bottom mortality rate was derived from a study in which rockfish were vented and held at the surface in a live well from one to five days (Albin and Karpov 1996) resulting in a mortality rate of 8.3 percent. Lastly, the GMT took into consideration longer-term, below surface mortality that is essentially unobservable in the field and for which there was little information at the time (PFMC 2008). This precautionary long term delayed mortality rate of 5 percent per 10 fm of depth was applied as a buffer against uncertainty about the long term loss of fitness and delayed mortality on released fish that appeared to be alive when they returned to the bottom after five days.

These estimates of the components of mortality were combined using Equation 1. Details of the development of the surface mortality estimates in Table 1 can be found in Section 4.5.1.6, pages 276-290, of the 2009-2010 Groundfish Fishery Final Environmental Impact Statement (PFMC 2008). This method was approved at the March 2008 Council meeting for application in 2009-2010. These mortality rates are then applied to the number of released fish by species and depth bin on a monthly basis to determine the total discard mortality.

Equation 1. M = 1 – ((1 - short term surface mortality from GLM) x (1 - short term bottom mortality) x (1 - long term delayed mortality))

Table 1. Discard mortality rates, by depth bin (fm) of groundfish released at the surface (Table 4-56 in PFMC 2008).

Species Group	Species	Depth Bins (fm)			
		0-10	11-20	21-30	>30
Rockfish	Black	11%	20%	29%	63%
	Black and Yellow	13%	24%	37%	100%
	Blue	18%	30%	43%	100%
	Bocaccio	19%	32%	46%	100%
	Brown	12%	22%	33%	100%

Species Group	**Species**	**Depth Bins (fm)**			
		0-10	**11-20**	**21-30**	**>30**
	Calico	24%	43%	60%	100%
	Canary	21%	37%	53%	100%
	China	13%	24%	37%	100%
	Copper	19%	33%	48%	100%
	Cowcod	21%	35%	52%	100%
	Gopher	19%	34%	49%	100%
	Grass	23%	45%	63%	100%
	Kelp	11%	19%	29%	100%
	Olive	34%	45%	57%	100%
	Quillback	21%	35%	52%	100%
	Tiger	20%	35%	51%	100%
	Treefish	14%	25%	39%	100%
	Vermilion	20%	34%	50%	100%
	Widow	21%	36%	52%	100%
	Yelloweye	22%	39%	56%	100%
	Yellowtail	10%	17%	25%	50%
Other Fish	Cabezon	7%	7%	7%	7%
	California Scorpionfish	7%	7%	7%	7%
	Kelp Greenling	7%	7%	7%	7%
	Lingcod	7%	7%	7%	7%
	Pacific Cod	5%	32%	53%	97%
General Category	Flatfish	7%	7%	7%	7%
	Sharks and Skates	7%	7%	7%	7%
	Dogfish	7%	7%	7%	7%

An analysis was also conducted to estimate surface mortality for groups of species (‘guilds’) that have similar distribution in the water column (pelagic vs. demersal) and differences in depth distribution (deep vs. shallow; Table 2). Guilds were based on published information regarding depth distribution and orientation in the water column (Love, *et al.* 2002) and collective experience of team members at the time (PFMC 2008).

Table 2. Species composition of guilds based on depth distribution and orientation in the water column (Table 4-50 in PFMC 2008).

Guild	Rockfish Species Included in Guild
Shallow Pelagic	Black, Olive, Yellowtail
Shallow Demersal	Brown, Grass, Kelp, Treefish
Deep Pelagic	Bocaccio, Widow, Canary, Blue
Deep Demersal	Vermilion, Copper, Yelloweye, Gopher

During 2012, the GMT, in consultation with the Recreational Fisheries Information Network (RecFIN), did additional work to assign rockfish species currently not included in the matrix (Table 1) to guilds (Table 2) to determine the appropriate discard mortality rate to apply (Table 3). This allowed discard mortality to be calculated for all species encountered in the recreational fisheries.

Table 3. Guild based depth-dependent mortality rates for species not included in the original discard mortality rate table (Table 1).

Guild	Depth Bins (fm)			
	0-10	**11-20**	**21-30**	**>30**
Deep Demersal[1]	21%	35%	52%	100%
Deep Pelagic[2]	18%	30%	45%	100%
Other Fish[3]	7%	7%	7%	7%

[1] Deep demersal rockfish species are: Aurora, bank, blackgill, bronzespotted, chameleon, cowcod, darkblotched, dusky, dwarf red, flag, freckled, greenblotched, greenspotted, greenstriped, halfbanded, harlequin, honeycomb, Mexican, Pacific Ocean perch, pink, Puget Sound, pygmy, redbanded, redstriped, rosethorn, rosy, rougheye, semaphore, sharpchin, shortbelly, shortraker, silvergray, speckled, splitnose, squarespot, starry, stripetail, swordspine, whitebelly (copper), and yellowmouth.

[2] Deep pelagic rockfish species are: chilipepper,

[3] Other fish species are: longspine thornyhead, shortspine thornyhead, rainbow scorpionfish, and scorpionfish family

Potential Methods for Establishing Mortality Rates for Yelloweye Rockfish and Cowcod

Data Available to Inform Discard Mortality Rates Reflecting the Use of Descending Devices

Table 4. Information in this table is summarized from the actual reports described in Appendix 1. Estimates of mortality are taken directly from the studies.

Authors	Study Focus	Species Studied	Sample Size	Depth Range	Device Used	Results
Jarvis and Lowe, 2008	Effects of barotrauma on initial capture survival (10 min.) Study area: S. CA October 2004-March 2006	Nearshore and shelf rockfish, targeting demersal rockfish	168 rockfish representing 21 species. Vermilion (n=35, 19-52 fm); greenspotted (n=19, 41-103 fm); olive (n=16, 13-29 fm); halfbanded (n=15, 29-35 fm), rosy (n=12, 30-83 fm) and honeycomb (n=12, 25-42 fm) rockfish comprised the majority of the catch.	10-52 fm	Hook and line	Initial capture survival was 68% overall but varied by species. In general, fish caught at deeper depths showed higher numbers of trauma however, species caught at shallower depths showed relatively similar survival proportions as species caught in deeper depths. Short term survival varied across species, external signs of barotrauma weren't a good predictor of capture survival but surface holding time was.

Authors	Study Focus	Species Studied	Sample Size	Depth Range	Device Used	Results
Jarvis and Lowe, 2008	Short term (2-day) post recompression survival. S. California during the summer of 2004 & 2005	Nearshore and shelf rockfish	257 rockfish representing 17 species. Five species comprised the majority of the catch: Vermilion (n=73, 30-47 fm), bocaccio (n=64, 31-49 fm), flag (n=29, 30-49 fm), squarespot (n=28, 30-45 fm), honeycomb (n=17, 31-46 fm), Others: Copper (n=2, 31-46 fm) and Canary (n=1, 49 fm).	30-44 fm (avg 39).	Hook and line, coated wire mesh cage.	Rapid recompression significantly reduced discard mortality. Fish held at the surface for 10 min. or less had a 78% probability of survival from analysis in a Generalized Linear Model. Direct estimates of mortality for all species combined resulted in a 29% mortality rate. There was a significant difference in species survival among the five most abundant species. Bocaccio (31-49 f m, 80% survival); flag (30-49 fm, 80% survival); honeycomb (31-46 fm, 65% survival); squarespot (30-45 fm, 35% survival); vermilion (30-47 fm, 70% survival). Species specific differences in external signs of barotraumas appear to be related to species differences in body morphology and to the degree of movement within the water column. For example, species such as bocaccio, squarespot, and halfbanded rockfish with relatively elongated bodies and that occur in schools off the seafloor showed few signs of barotrauma. Fish such as vermilion, honeycomb, flag and starry with relatively deep bodies and are more demersal, showed a high degree of

Authors	Study Focus	Species Studied	Sample Size	Depth Range	Device Used	Results
						barotrauma. The odds of mortality 2 days after recompression increased 1.7 times for every 10 min increase in surface holding time and almost 2 times for every 1 °C increase in seafloor-surface temp. Fish with a thinner swim bladder (olive) may be more prone to severe rupture than a robust swim bladder (vermilion, copper and brown). 3% of the fished released alive were recaptured by anglers.
Hannah et al. 2012 and Hannah unpublished data	Used a cage system to measure 2 and 4 day, post recompression survival for common recreational rockfish in N. CA, OR and WA (NCOW) as a function of capture depth. Study area: Oregon coast	Nearshore and shelf rockfish in NCOW	288 rockfish, including 24 yelloweye rockfish (published) 49 yelloweye rockfish (unpublished) 73 total yelloweye rockfish	< 45 fm	Novel cage	With the exception of three blue rockfish, the condition of surviving fish after being in the cage was excellent. At capture depths up to 30 fm, survival was 100 % for yelloweye, quillback, canary, and copper rockfish, 90 % for black rockfish, and 78 % for blue rockfish. Combined mortality including all species was 7%. Results of additional trials (4 day holding periods instead of 2) for yelloweye rockfish (unpublished data): 25-35 fm = 100% survival (n=24) 35-40 fm = 93% survival (n=14) 40-45 fm = 100% survival (n=11)

Authors	Study Focus	Species Studied	Sample Size	Depth Range	Device Used	Results
						To model the relationship between survival post-recompression and depth, additional trials will occur in deeper depths Time on deck average less than 3 minutes.
Hochhalter and Reed, 2011	Effectiveness of deepwater release to improve the survival of yelloweye rockfish. Study area: Alaska Mark- recapture study to generate maximum likelihood estimate of the 17-day survival probability of yelloweye rockfish.	Yelloweye rockfish in Prince William Sound, Alaska	182 yelloweye	10-39 fm	Hook and line, inverted weighted hook	The average survival probability for yelloweye rockfish released at depth was 95% and positively correlated with individual length. Survival probability was not significantly influenced by the range of capture depths or exposure to barotraumas. The submergence success of yelloweye rockfish released at the surface was 22%. Evidence that the average 17 day survival of discarded yelloweye can be increased more than 4 times through the use of deepwater release compared to surface release. Lower survival for smaller fish could be due to increased predation compared to larger fish.
Wegner, Pribyl, Hyde (in prep.aration)	Used acoustic tags to study the survival and behavior of deep-	Shelf rockfish off southern California	50 rockfish including; bank (n=12), bocaccio	44-98 fm Mean = 73.6	Hook and line, weighted cage,	Over time fish emigrated from the study-site, the numbers presented reflect fish within detection range. 39 of the 42 fish (92.9%) detected at day 2 survived, 23 of

Authors	Study Focus	Species Studied	Sample Size	Depth Range	Device Used	Results
	dwelling rockfish captured and released back to depth with descending devices over a four month period.		(n=13), cowcod (n=9); starry (n=3) and sunset rockfish (n=13)	fm	SeaQualizer	the 30 fish (76.7%) detected at 10 days survived. 100% of the cowcod survived after 2-days, 4 of the 4 cowcod detected at day 10 survived, 5 cowcod emigrated from the study area between days 6-9 and their fate is unknown. All emigrants were actively swimming when last detected so loss of detection is not assumed to indicate mortality.
Smiley and Drawbridge, 2007	Used a specially designed hyperbaric chamber to quickly recompress rockfish captured with hook and line and allow decompression slowly to keep rockfish alive to hold as brood stock	Rockfish off southern California	16 cowcod	49-80 fm	Hook and line, hyperbaric chamber	69% (11/16) of the captured cowcod survived to feed following capture, recompression and decompression.

Yelloweye Rockfish

The two-day mortality rates from Hannah et al. (2012) were estimated for 24 yelloweye rockfish sampled from 0-30 fm in which 100 percent of fish returned to the bottom in a barrel survived in all depths after two days. Further, in recent four-day barrel trials (Hannah unpublished data), post-recompression survival of yelloweye rockfish was 100 percent from 25-35 fm (n=24), 93 percent from 35-40 fm (n=14), and 100 percent from 40-45 fm (n=11). In total, 72 of 73 (98.6 percent) yelloweye rockfish survived in depths < 50 fm.

Hannah et al. (2012) also observed 100 percent survival for canary (n = 41), copper (n = 10), and quillback rockfish (n = 28). Results for blue (n = 36) and black rockfish (n = 144) showed a significant correlation of mortality with depth which may reflect a greater sensitivity of species in the subgenus *Sebastosomus* of which these species are members, to barotrauma, potentially due to thin-walled swim bladders. In addition, no correlation of mortality with depth was found for the demersal non-*Sebastosomus* species. Recent additional sampling by Hannah (unpublished data) provided data for 49 more yelloweye rockfish subjected to the same methods but with a four day study period in depths between 25 and 45 fm. There was no apparent increase in mortality with depth, with only one mortality between 35 and 40 fm. Combining these samples with the samples from depth from the Hannah et al. (2012) the resulting survival rate was 99 percent (92.7-99.9, 95 percent Confidence Interval), validating expansion of the 1 percent mortality rate for application in 30 to 50 fm.

Confirming these results, the mark-recapture study conducted by Hochhalter and Reed (2011), on yelloweye rockfish caught at depths shallower than 40 fm, and released near the bottom, yielded an estimated average survival of 98.8 percent (95% CI=52.2 - 99.9 percent) after 17 days. The authors concluded that depth did not affect survival among the ranges of depths sampled in the study (< 40 fm). However, only 5 percent of their yelloweye rockfish were caught deeper than 30 fm and no tags were recovered from those fish.

The average mortality rate from these studies (~1 percent) is used as the discard mortality rate for only yelloweye rockfish caught in depths shallower than 30 fm and released with descending devices. One percent mortality is also used for depths bins from 30-50 fm in accordance with the results from the unpublished barrel trials, despite a mortality occurring from 35-40 fm (within the proposed 8.3 percent mortality rate for hooking-related injury; further explained below). An estimate of mortality of 7 percent was also calculated combining all species in the Hannah et al. (2012) study including blue and black rockfish in order to reflect uncertainty in the estimates for any one species since the sample size was relatively low for yelloweye rockfish alone. Inclusion of blue rockfish and black rockfish in this estimate may bias an estimate of mortality for yelloweye rockfish using this estimate high since mortality for the *Sebastosomus* appeared to be higher than others. The addition of short term bottom mortality and long term mortality is a further reflection of the expectation that some additional mortality is likely to result from hooking and handling as well as barotrauma.

There may be sufficient data from recompression studies to estimate discard mortality rates for yelloweye rockfish caught in depths shallower than 50 fm, and released with descending devices. Until survival of yelloweye rockfish caught in depths greater than 50 fm and released at depth is studied, speculative mortality rates for fish caught beyond this depth and released with descending devices may have to be used. The Council may consider a more conservative approach by applying a 100 percent discard mortality rate to yelloweye rockfish caught deeper than 50 fm, whether they were released with a descending device or not. However, survival studies (e.g., Hannah et al. 2012, etc.) demonstrate that it is unlikely that 50 fm is a "knife-edged" threshold depth beyond which all yelloweye rockfish die, when released with a descending device. Due to a lack of data beyond 50 fm, methods with varying assumptions, uncertainty and risk of underestimating mortality were used to project potential discard mortality rates for deeper waters using data from two day cage studies conducted by Jarvis and Lowe (2008) between 30 and 50 fm for comparison and acoustic tagging studies conducted by Wegner et al. (in prep.) to inform mortality between 50 and 100 fm described further below.

Cowcod

For cowcod released with descending devices, one alternative is to replace the surface mortality rate component used in calculating the surface release mortality rates with the 29 percent discard mortality rate, based on a study by Jarvis and Lowe (2008). In this study, a GLM was fit to mortality data for 306 shelf rockfish taken with rod and reel gear in 30 - 50 fm and returned to the bottom in cages for two days resulting in a survival probability of 78 percent or conversely, a 22 percent probability of mortality. Direct calculation of mortality rates from all species included in the two day mortality rate estimation resulted in an estimate of 29 percent mortality rate. No significant correlation of mortality with depth was found in this study over the sampled range of depths. With the exception of squarespot rockfish, no significant differences in mortality rates between species were found between bocaccio, vermilion, honeycomb, and flag rockfish. A longer duration of time on deck prior to release for sampled squarespot rockfish may account for the higher mortality in this species. The aggregate mortality rate of 29 percent was estimated while including squarespot rockfish and the other sampled species released within 10 minutes of capture. Given the lack of significant difference in mortality rates between species other than squarespot rockfish in this study and between non-*Sebastosomus* species in Hannah et. al. (2012), results from other shelf rockfish species provided in this study may provide a potential proxy for cowcod mortality rates in the sampled depths.

The 29 percent mortality rate may also be applied to shallower depths, though mortality rates for surface release are lower between 0 and 20 fm and could continue to be applied in these depths since release using descending devices would not be expected to be higher than surface release. In addition, given the greater thermocline with depth and greater expected thermal shock expected in the Southern California Bight, the results of this study may provide a suitable conservative proxy for survival of yelloweye rockfish in depths from 30-50 fm. Mortality rates are likely to be lower for yelloweye rockfish in these depths given lower thermal shock in northerly waters where they are found and the very low mortality rates observed between 0 and 50 fm (Hannah et. al. 2012 and unpublished data), making this a conservative proxy. Conversely, use of the results from all species from Hannah et al. (2012) as a proxy for expected cowcod mortality in depths less than 30 fm may be reasonable.

The results of yet unpublished acoustic tagging studies presented to the Council in June 2012 (D.2c_Sup_SWRSC_PPT_Vetter_June202BB.pdf, Wegner, Hyde, and Pribyl, in prep.) provides an alternative estimate of total mortality from direct observations of cowcod as well as proxy estimates based on other co-occurring shelf rockfish species. In this study 50 shelf rockfish predominantly caught between 70 and 100 fm were fitted with acoustic tags, released using descending devices and tracked with an array of six receivers that recorded depth and acceleration providing information on movement and mortality over a four month study period. Of the nine cowcod tagged in this study, five emigrated from the study area and all four that remained within the range of receivers survived. Until the time at which the five cowcod that emigrated from the study area departed, they were actively moving within the range of the receivers, providing no indication that they were in any worse condition than those fish that remained within the receiver range for the duration of the study (Hyde and Wegner, personal communication). Bank rockfish did not fare as well as the other four species in the study and it was found that the extent of the injuries suffered by this species were more severe than the other species indicating that they may be more susceptible to mortality due to barotrauma with only 33 percent (2/6) surviving to ten days (Hyde and Wegner, personal communication).

In this study, the majority of mortality occurred within the first few days and no additional mortality was observed in fish that remained within the range of receivers after six days through the remainder of the four month study. All the fish encountered were included in the study; none of the fish were selectively included in the study due to their relative condition at the time of capture. The study purposely tagged all encountered fish done to avoid biasing the results toward higher survival by selectively tagging fish that were in better condition. Of the tagged individuals remaining within the study area for ten days, 76.7 percent (23/30) survived and provides a proxy estimate of total mortality expected for shelf rockfish for four months since no additional mortality was observed beyond ten days for fish remaining within the range of the receiver array (Table 5).

The vast majority of the mortality occurred within two days as indicated by the low additional mortality of 14.8 percent between three and ten days (Table 5). Two day cage studies provide a proxy estimate of mortality that reflects the mortality rates expected for all released shelf rockfish with higher sample sizes. Since the majority of fish that died did so within the first two days, use of the cage study data combined with mortality three to ten days from the acoustic tagging study may provide an aggregate estimation of mortality that makes use of larger sample sizes from the two day cage studies and provides an informed estimate of long term mortality.

The mortality rate of 14.8 percent for all fish still alive and within the receiver range between day three and the end of the study can be combined with two day mortality rates from cage studies to provide a proxy estimate of mortality expected for shelf rockfish. The result is an expected total mortality rate of 39.5 percent for depths between 30 and 50 fm, incorporating the 29 percent mortality rate from the two day cage study and Jarvis and Lowe (2008) and the 14.8 percent long term mortality rate from the acoustic tagging study of Wegner et al. (in prep.).

The 39.5 percent mortality rate estimate should be considered precautionary given the mortality rate of the ten day observation of fish that remained within receiver range was 23.3 percent (23/30). The acoustic tagging study can also inform two day mortality rates and ten day mortality rates as well as a stand-alone estimate for total mortality expected over the course of 10 days, which may be assumed to reflect mortality expected through the duration of the four month study (Table 5). In studies where cowcod caught in 50 to 80 fm for exhibition in aquaria and recompressed in a hyperberic chamber resulted in a 69 percent survival rate (11/16, Smiley and

Drawbridge 2007), which is expected to be lower than for fish released using a descending device since fish were subjected to subsequent decompression according to Navy dive tables to allow them to be kept at surface pressure and they were subject to the continued stress of captivity. Combining this estimate with the samples (30) from the ten day observation from Wegner (in prep.) provides an estimated proxy aggregate mortality rate of 26 percent (34/46) and a direct estimate of aggregate mortality for cowcod of 25 percent (5/20) for fish caught in greater than 50 fm. Thus the proxy long term estimate of 39.5 percent mortality for 30-50 fm should be considered precautionary since it exceeds estimates expected from results of these directed studies and is far in excess of the 100 percent survival observed for the nine cowcod observed over the course of two days and the four within receiver range over the course of the ten day study caught in 50-100 fm. The higher mortality estimate for 30-50 fm may be in part due to the inclusion of squarespot rockfish in the two-day mortality estimate and bank rockfish in the long term mortality rates as well as the stress experienced by fish from confinement and repeated contact with the walls of the cages in two-day cage studies.

To provide a buffer for uncertainty surrounding long term mortality of fish consistent with that applied to surface release mortality rates developed by the GMT and previously reviewed and approved by the SSC, an additional 5 percent mortality per 10 fm of depth may be added to the discard mortality rates. The 3 to 10 day mortality rate of 14.8 percent from Wegner et al. (in prep.) provides an alternative estimate of long term mortality to combine with short term estimates from two day cage studies. This alternative method of accounting for long term mortality would address the potential overestimate of mortality rates due to the overlapping time period of the two day cage study mortality and one to five day mortality from Albin and Karpov (1996) if the method analogous to that employed by the GMT in estimating surface mortality rates were applied. Given the overall mortality rate of 23.3 percent for individuals of all species that remained within receiver range for more than ten days, the long term mortality rate assumption of 5 percent per 10 fm of depth of capture applied to fish discarded at the surface may be excessive, especially at depths greater than 20 fm where this proxy mortality rate combined with the 8.3 percent from Albin and Karpov (1996) well exceeds 15 percent. The total mortality rates for 10 days from Wegner et al. in combination with results from Smiley and Drawbridge (2007) are considered as an alternative measure of aggregate mortality for depths greater than 50 fm. The lower total mortality or three to ten day mortality rates provided from these studies may be more appropriate at these depths and can be applied in place of the arbitrarily precautionary 5 percent per 10 fm of depth intended to address uncertainty regarding long term mortality prior to these studies. The overestimation of mortality beyond two days may be exacerbated by of the 5 percent per 10 fm with the potentially excessive 8.3 percent from the Albin and Karpov (1996) estimate of one to five day mortality for fish vented, tagged and retained at the surface in live wells, which is partially redundant if combined with the mortality observed from the two day cage studies or acoustic tagging studies.

The results of Wegner et al. (in prep.) should be applicable to species found farther to the north where the thermocline is less extreme and lower mortality is expected as a result of reduced change in temperature and thermal shock. In addition, the greater depth of capture informs a mortality rate expected for shelf rockfish in deeper depths than sampled in Hannah et al. 2012 that could be applied to yelloweye rockfish in combination with the two-day mortality rate from Jarvis and Lowe (2008) from 30-50 fm providing an estimated mortality of 39.5 percent. Within

30 fm, a proxy combining the 1 percent mortality observed for yelloweye rockfish in the two-day cage study and the 14.8 percent mortality rate expected for fish from the south in much greater depths for day three through ten for long term mortality (assumed the same through four months) would result in a proxy estimate of mortality of 15.7 percent. Sample sizes, number of fish surviving, survival rates and confidence intervals for mortality rate estimates assuming a binomial distribution given the sample size from the studies discussed above are provided in Table 5. The survival rate estimates and confidence intervals are provided in Figure 1, which shows that the majority of the estimates are well above 50 percent is also the case for the lower 95 percent confidence intervals for survival.

Table 5. Total study sample (N), number of fish surviving (S), the binomial expectation of survivorship (Exp.), and the 95% binomial confidence intervals of survivorship (C.I.) by study, depth bins, and days after release for several rockfishes. Confidence intervals were calculated using binom.test in R ver. 2.15.1.

Species	Metric	Depth bin (fm) 0-30 2 and (4) days	31-50 4 days	51-80 10+ days	51-100+ 10 + days	71-100+ 2 days	71-100+ 3-10 days	71-100+ 10 days	Study
Yelloweye	N	24 (24)	25						2 day-Hannah et al. 2012; 4 day-Hannah unpub.
	S	24 (24)	24						
	Exp.	1	0.96						
	C.I.	0.86-1.00							
Cowcod	N			16	20	9	4	4	Smiley and Drawbridge 2007; Wegner et al. in prep..
	S			11	15	9	4	4	
	Exp.			0.69	0.75	1	1	1	
	C.I.			0.41-0.89	0.51-0.91	0.66-1.00	0.40-1.00	0.40-1.00	
Black	N	144							Hannah et al. 2012
	S	130							
	Exp.	0.9							
	C.I.	0.84-0.96							
Blue	N	36							Hannah et al. 2012
	S	28							
	Exp.	0.78							
	C.I.	0.61-0.90							
Canary	N	41							Hannah et al. 2012
	S	41							
	Exp.	1							
	C.I.	0.91-1.00							

		Depth bin (fm)							
Species	**Metric**	**0-30**	**31-50**	**51-80**	**51-100+**		**71-100+**		**Study**
		2 and (4) days	**4 days**	**10+ days**	**10 + days**	**2 days**	**3-10 days**	**10 days**	
China	N	3							Hannah et al. 2012
	S	3							
	Exp.	1							
	C.I.	0.29-1.00							
Copper	N	10							Hannah et al. 2012
	S	10							
	Exp.	1							
	C.I.	0.69-1.00							
Quillback	N	28							Hannah et al. 2012
	S	28							
	Exp.	1							
	C.I.	0.88-1.00							
Flag	N		32						Jarvis and Lowe 2008
	S		26						
	Exp.		0.81						
	C.I.		0.64-0.93						
Honeycomb	N		20						Jarvis and Lowe 2008
	S		13						
	Exp.		0.65						
	C.I.		0.41-0.85						
Squarespot	N		34						Jarvis and Lowe 2008
	S		13						
	Exp.		0.38						
	C.I.		0.33-0.74						

Species	Metric	Depth bin (fm) 0-30 2 and (4) days	31-50 4 days	51-80 10+ days	51-100+ 10 + days	71-100+ 2 days	3-10 days	10 days	Study
Vermilion	N		75						Jarvis and Lowe 2008
	S		56						
	Exp.		0.75						
	C.I.		0.63-0.84						
Bocaccio	N		66		10	12	9	10	Jarvis and Lowe 2008; Wegner et al. in prep..
	S		53		9	11	9	9	
	Exp.		0.8		0.9	0.92	0.7169	0.9	
	C.I.		0.69-0.89		0.55-1.00	0.62-1.00	0.72-1.00	0.55-1.00	
Bank	N				6	9	5	6	Jarvis and Lowe 2008; Wegner et al. in prep..
	S				2	8	2	2	
	Exp.				0.33	0.89	0.4	0.33	
	C.I.				0.043-0.78	0.52-1.00	0.05-0.85	0.043-0.78	
Starry	N				3	3	3	3	Jarvis and Lowe 2008; Wegner et al. in prep..
	S				3	3	3	3	
	Exp.				1	1	1	1	
	C.I.				0.40-1.00	0.40-1.00	0.40-1.00	0.40-1.00	
Sunset	N				7	9	6	7	Jarvis and Lowe 2008; Wegner et al. in prep..
	S				5	8	5	5	
	Exp.				0.71	0.89		0.71	
	C.I.				0.29-0.96	0.52-1.00	0.36-0.99	0.29-0.96	
Total	N	287	227	16	46	42	27	30	
	S	265	161	11	34	39	23	23	
	Exp.	0.92	0.71	0.69	0.74	0.93	0.85	0.77	
	C.I.	0.89-0.95	0.65-0.77	0.41-0.89	0.59-0.86	0.81-0.99	0.66-0.96	0.58-0.90	

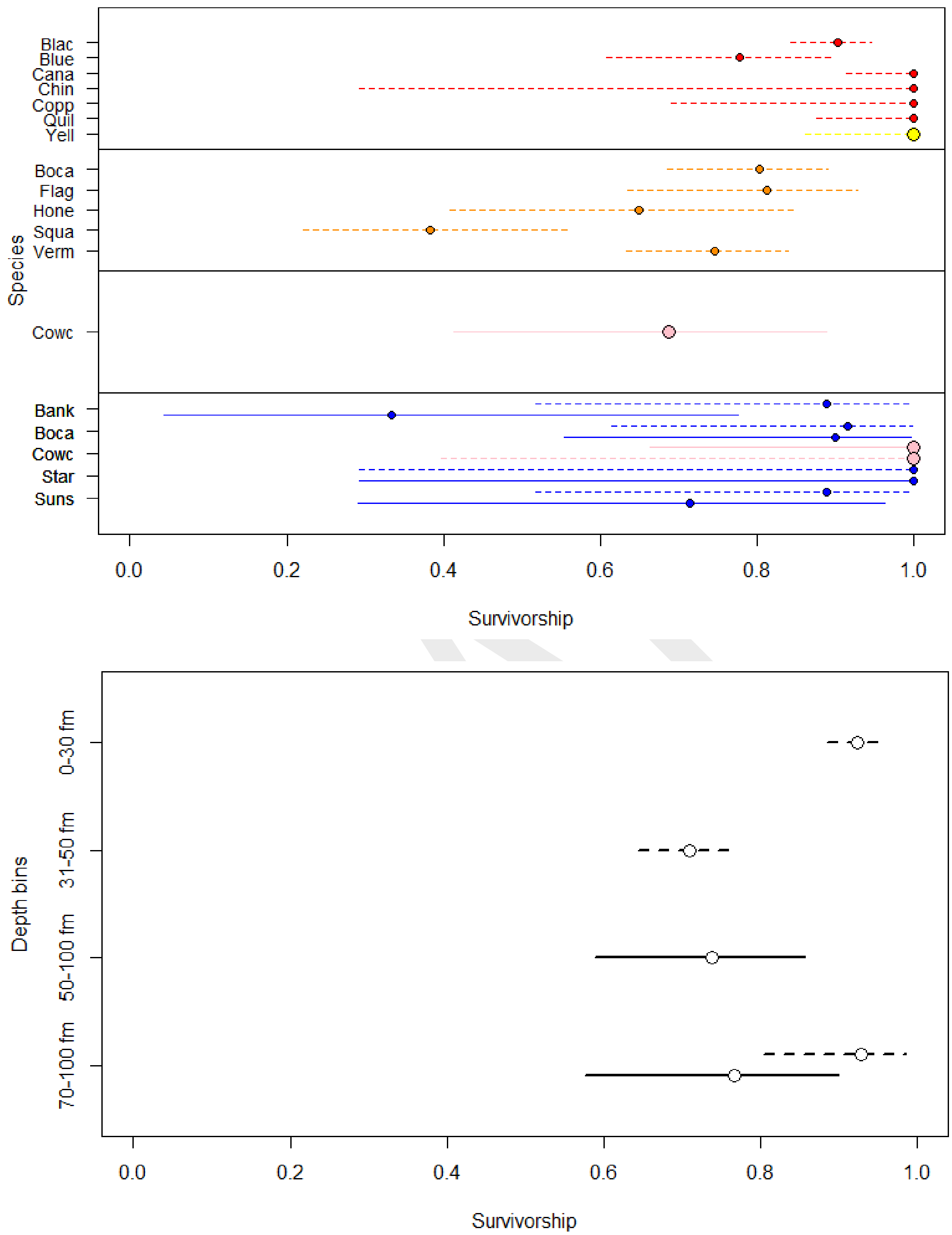

Figure 1. Expected survivorship (points) and 95% confidence intervals (horizontal lines) for several rockfish species (top panel) and depth bins (bottom panel). Depth bins are also given on the secondary y-axis of the top panel. Yelloweye and cowcod are focus species for this analysis, and thus are designated with larger points. Line types also designated survivorship up to 2 days (broken lines) and 10 days (solid lines) after release. Data sources are listed in Table 5.

Framework for Estimating Discard Mortality Rates

A similar framework to that employed in estimating mortality rates reflecting surface release can be applied in estimating mortality rates expected for fish released using a descending device, by the simply replacing the current short term surface mortality rate from the GLM with the two and four day mortality rate from a cage study such as (Hannah et al. 2012 and unpublished data) for yelloweye rockfish or Jarvis and Lowe 2008 for cowcod. When determining surface release mortality rates for cowcod there was not a sufficient number of samples available to provide a direct estimate and as a result, a proxy estimate from other members of the deep demersal guild was used. Direct estimates for cowcod are also lacking from two day cage studies, but estimates from other deep demersal guild species are available from Jarvis and Lowe (2008). The acoustic tagging study of Hyde et al. (unpublished data) provides two day estimates of mortality as well. As with surface release mortality rates, the three factors can be combined as in Equation 2 to estimate mortality rates for fish released using descending devices.

Equation 2. M = 1 – ((1 - two or four day mortality rates) x (1 - short term bottom mortality) x (1 - long term delayed mortality))

An alternative method of estimating mortality rates would involve combining discard mortality rates for two day cage studies by Jarvis and Lowe (2008) or Hannah et al. (2012) with long term three to ten day mortality rates from Wegner et al. (in prep.) using Equation 3. The combination of the two day tagging study data depends on the species to which it is being applied and the depth in which the data was collected.

Equation 3. M = 1 – ((1 - two or four day mortality rates from cage study) x (1 – three to ten day long term acoustic tagging mortality rates))

Mortality rates for each 10 fm depth increment can be determined in a number of ways depending on the direct or proxy estimates of short term and long term mortality rates applied, assumptions made about the applicability of the data to a given species or depth and acceptable levels of uncertainty. Descriptions of mortality estimation methods considered by the GMT in accounting for components of mortality in Equation 2 and the resulting mortality rates applied to yelloweye rockfish are provided in Table 6 and Table 7, respectively, while those reflecting application of Equation 3 are provided in Table 8 and Table 9, respectively. Descriptions of mortality estimation methods considered by the GMT in accounting for components of mortality in Equation 2 and the resulting mortality rates applied to cowcod are provided in Table 10 and Table 11, respectively, while those reflecting application of Equation 3 are provided in Table 12 and Table 13, respectively. In some depth bins for a given method, mortality rates from Hyde et al. (in prep.) reflecting 10 day aggregate mortality (representing 4 months of mortality) or for mortality rates derived by combining data from Wegner et al. (in prep.) and Smiley and Drawbridge (2007) for 10+ days are used as stand-alone estimates of mortality as they are assumed to reflect the full extent of mortality expected. Specific mortality rates and equations applied in each method for each depth bin are provided in footnotes below each table in which estimates are provided. Moving from left to right across the table, methods accrue increasing assumptions, uncertainty, and risk associated with the use of data from species other than cowcod or yelloweye rockfish or application of estimates from data collected from depths shallower than those in which they are being applied, which are explicitly reported in the table containing the descriptions of the methods.

Table 6. Description of methods applied in estimating mortality rates for yelloweye rockfish calculated using Equation 2, including whether the method uses data collected from yelloweye individuals and applies mortality rates in depths from which the data were collected. The assumptions, uncertainties, and risks associated with each method are also provided.

Method	Short Term Mortality Rate Estimation Description	Additional Mortality Rate Description	Direct Estimate for Species in Question	Depth Applied Same as Data Collection	Assumptions, Uncertainties, and Risks
1A	Hannah Yelloweye RF 0-50 fm, 100% Mortality 51-100 fm	Albin and Karpov 8.3% and 5% per 10 fm	Yes	Yes	Moderate sample size in 0-50 fm, arbitrary 5%/10 fm mortality, redundancy in Albin and Karpov 1-5 day and 2 day/4 day mortality short term mortality rates, assumes a 100% mortality rate 50-100 fm overestimating mortality
1B	Hannah All RF 0-30 fm, Jarvis and Lowe 31–50 fm, Wegner 2 Day All RF 51-100 fm	Albin and Karpov 8.3% and 5% per 10 fm	No	Yes	Proxy estimates from other species <50 fm, moderate sample size 51-100 fm, arbitrary 5%/10 fm mortality, redundancy in Albin and Karpov 1-5 day and 2 day mortality
1C	Hannah All RF 0-30 fm, Jarvis and Lowe 31-100 fm	Albin and Karpov 8.3% and 5% per 10 fm	No	No	Proxy estimates from other species in all depths, mortality rates from 31-50 fm to deeper depths, arbitrary 5%/10 fm mortality, redundancy in Albin and Karpov 1-5 day and 2 day mortality
1D	Upper 95% Confidence Interval 1A	Albin and Karpov 8.3% and 5% per 10 fm	Yes	Yes	Moderate sample size in 0-50 fm, arbitrary 5%/10 fm mortality, redundancy in Albin and Karpov 1-5 day and 2 day/4 day mortality, assumes a 100% mortality rate in 50-100 fm overestimating mortality.

Method	Short Term Mortality Rate Estimation Description	Additional Mortality Rate Description	Direct Estimate for Species in Question	Depth Applied Same as Data Collection	Assumptions, Uncertainties, and Risks
1E	Upper 95% Confidence Interval 1B	Albin and Karpov 8.3% and 5% per 10 fm	No	Yes	Proxy estimates from other species <50 fm, moderate sample size 51-100 fm, arbitrary 5%/10 fm mortality rates, redundancy in Albin and Karpov 1-5 day and 2 day mortality
1F	Upper 95% Confidence Interval 1C	Albin and Karpov 8.3% and 5% per 10 fm	No	No	Proxy estimates from other species in all depths, applies mortality rates from 30-50 fm to deeper depths though they may be acceptable since they are higher than estimated in deeper depths by other methods, arbitrary 5%/10 fm mortality rates, redundancy in Albin and Karpov 1-5 day and 2 day mortality

Table 7. Yelloweye rockfish mortality rate estimates in each 10 fm depth bin using the combination of the three components of discard mortality in Equation 2. Color coding reflects the description of the mortality rates applied in producing the composite estimate in each depth bin provided in the corresponding footnote below the table and use mortality estimates for components found in Table 5. Assumptions regarding the applicability of mortality rates to depths or species in question increase to the right.

Depth Bin (fm)	Surface Mortality Yelloweye	1A	1B	1C	1D	1E	1F
		Hannah Yelloweye RF 0-50 fm, 100% Mort. 51-100 fm	Hannah All RF 0-30 fm, Jarvis and Lowe 31–50 fm, Wegner 2 day 51-100 fm	Hannah All RF 0-30 fm, Jarvis and Lowe 31-100 fm	Upper 95% C.I. 1A	Upper 95% C.I. 1B	Upper 95% C.I. 1C
0-10	22%	13.8%[1]	19.9%[2]	19.9%	19.0%[5]	22.5%[6]	22.5%
11-20	39%	18.3%	24.1%	24.1%	23.3%	26.6%	26.6%
21-30	56%	22.9%	28.3%	28.3%	27.5%	30.7%	30.7%
31-40	100%	27.4%	47.9%[3]	47.9%	31.8%	52.3%[7]	52.3%
41-50	100%	31.9%	51.2%	51.2%	36.1%	55.3%	55.3%
51-60	100%	100.0%	40.3%[4]	54.4%	100.0%	48.0%[8]	58.3%
61-70	100%	100.0%	44.6%	57.7%	100.0%	51.7%	61.3%
71-80	100%	100.0%	48.8%	60.9%	100.0%	55.4%	64.2%
81-90	100%	100.0%	53.1%	64.2%	100.0%	59.2%	67.2%
91-100	100%	100.0%	57.4%	67.5%	100.0%	62.9%	70.2%

1. M = 1 – ((1 – 0.01 Hannah Yelloweye RF 2-4 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))
2. M = 1 – ((1 – 0.08 Hannah All RF 2 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))
3. M = 1 – ((1 - 0.29 Jarvis and Lowe 2 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))
4. M = 1 – ((1 – 0.07 Wegner 2 Day All RF) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))
5. M = 1 – ((1 – 0.07 95% CI Yelloweye RF 2-4 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))
6. M = 1 – ((1– 0.11 95% CI Hannah All RF 2 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))
7. M = 1 – ((1 - 0.35 Jarvis and Lowe 2 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))
8. M = 1 – ((1 – 0.19 Hyde 2 Day All RF) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))

Table 8. Description of methods applied in estimating mortality rates for yelloweye rockfish calculated using Equation 3, including whether the method uses data collected from yelloweye individuals and applies mortality rates in depths from which the data were collected. The assumptions, uncertainties, and risks associated with each method are also provided.

Method	Short Term Mortality Rate Estimation Description	Additional Long term Mortality Rate Description	Direct Estimate for Species in Question	Depth Applied Same as Data Collection	Assumptions, Uncertainties, and Risks
2A	Hannah Yelloweye RF 0-50 fm, 100% Mort. 51-100 fm	15% Wegner 3-10 day Mortality Rates	Yes	Yes	Moderate sample size in 0-50 fm, assumes 3-10 day mortality encompasses all long term mortality in 0-50 fm, assumes a 100% mortality rate in greater depths than samples were available, which is likely overestimating mortality in these depths.
2B	Hannah All RF 0-30 fm, Jarvis and Lowe 31–50 fm, Hyde / Smiley 10 day 50-100 fm	15% Wegner 3-10 day Mortality Rates 0-50 fm	No	Yes	Proxy estimates from other species <50 fm, moderate sample size 51-100 fm, assumes 3-10 day mortality encompasses all long term mortality in 0-50 fm, Smiley and Drawbridge cowcod from hyperbaric chamber may bias mortality high, assumes 10 day mortality encompasses all long term mortality

Method	Short Term Mortality Rate Estimation Description	Additional Long term Mortality Rate Description	Direct Estimate for Species in Question	Depth Applied Same as Data Collection	Assumptions, Uncertainties, and Risks
2C	Hannah All RF 0-30 fm, Jarvis and Lowe 31-100 fm	15% Wegner 3-10 day Mortality Rates	No	No	Proxy estimates from other species for all depths, applies mortality rates from 30-50 fm to deeper depths though they may be acceptable since they are higher than estimated in deeper depths by other methods, assumes 3-10 day mortality encompasses all long term mortality.
2D	Upper 95% Confidence Interval 2A	15% Wegner 3-10 day Mortality Rates	Yes	Yes	Low sample size 51-100 fm, Smiley and Drawbridge cowcod from hyperbaric chamber may bias mortality high, assumes 10 day mortality encompasses all long term mortality
2E	Upper 95% Confidence Interval 2B	15% Wegner 3-10 day Mortality Rates 0-50 fm	No	Yes	Proxy estimates from other species <50 fm, low sample size 51-100 fm, Smiley and Drawbridge cowcod from hyperbaric chamber may bias mortality high, assumes 10 day mortality encompasses all long term mortality
2F	Upper 95% Confidence Interval 2C	15% Wegner 3-10 day Mortality Rates 0-50 fm	No	No	Proxy estimates from other species <50 fm, low to moderate sample size 51-100 fm, Smiley and Drawbridge cowcod from hyperbaric chamber may bias mortality high, assumes 10 day mortality encompasses all long term mortality

Table 9. Yelloweye rockfish mortality rate estimates in each 10 fm depth bin using the combination of the two components of discard mortality in Equation 3 or 10 day mortality rates. Color coding reflects the description of the mortality rates applied in producing the composite estimate in each depth bin provided in the corresponding footnote below the table and use mortality estimates for components found in Table 5. Assumptions regarding the applicability of mortality rates to depths or species in question increase to the right.

Depth Bin (fm)	Surface Mortality Yelloweye	2A	2B	2C	2D	2E	2F
		Hannah Yelloweye RF 0-50 fm, 100% Mort. 51-100 fm	Hannah All RF 0-30 fm, Jarvis and Lowe 31–50 fm, Wegner / Smiley 10 day 50-100 fm	Hannah All RF 0-30 fm, Jarvis and Lowe 31-100 fm	Upper 95% C.I. 2A	Upper 95% C.I. 2B	Upper 95% C.I. 2C
0-10	22%	15.7%[1]	21.6%[2]	21.6%	38.6%[5]	41.3%[6]	41.3%
11-20	39%	15.7%	21.6%	21.6%	38.6%	41.3%	41.3%
21-30	56%	15.7%	21.6%	21.6%	38.6%	41.3%	41.3%
31-40	100%	15.7%	39.5%[3]	39.5%	38.6%	57.1%[7]	57.1%
41-50	100%	15.7%	39.5%	39.5%	38.6%	57.1%	57.1%
51-60	100%	100.0%	26.0%[4]	39.5%	100.0%	41.0%[8]	57.1%
61-70	100%	100.0%	26.0%	39.5%	100.0%	41.0%	57.1%
71-80	100%	100.0%	26.0%	39.5%	100.0%	41.0%	57.1%
81-90	100%	100.0%	26.0%	39.5%	100.0%	41.0%	57.1%
91-100	100%	100.0%	26.0%	39.5%	100.0%	41.0%	57.1%

1. **M = 1 – ((1– 0.01 Hannah Yelloweye RF 2-4 Day) x (1 – 0.15 Wegner 3-10 Day All RF))**
2. **M = 1 – ((1– 0.08 Hannah All RF 2 Day) x (1 – 0.15 Wegner 3-10 Day All RF))**
3. **M = 1 – ((1 - 0.29 Jarvis and Lowe 2 Day) x (1 – 0.15 Hyde 3-10 Day All RF))**
4. **M = 0.26 Wegner All RF 10+ Days**
5. **M = 1 – ((1– 0.07 95% CI Hannah Yelloweye RF 2-4 Day) x (1 – 0.34 95% CI Wegner 3-10 Day All RF))**
6. **M = 1 – ((1– 0.11 95% CI Hannah All RF 2 Day) x (1 – 0.34 95% CI Wegner 3-10 Day All RF))**
7. **M = 1 – ((1 - 0.36 95% CI Jarvis and Lowe 2 Day) x (1 – 0.34 95% CI Wegner 3-10 Day All RF))**
8. **M = 0.41 95% CI Hyde All RF 10+ Days**

Table 10. Description of methods applied in estimating mortality rates for cowcod calculated using Equation 2, including whether the method uses data collected from cowcod individuals and applies mortality rates in depths from which the data were collected. The assumptions, uncertainties, and risks associated with each method are also provided.

Method	Short Term Mortality Rate Estimation Description	Additional Long term Mortality Rate Description	Direct Estimate for Species in Question	Depth Applied Same as Data Collection	Assumptions, Uncertainties, and Risks
3A	Wegner Cowcod 2 day All Depths	Albin and Karpov 8.3% and 5% per 10 fm	Yes	Yes	Very low sample size, arbitrary 5%/10 fm mortality, redundancy in mortality between Albin and Karpov 1-5 day mortality and 2 day mortality
3B	Hannah All RF 0-20 fm, Jarvis and Lowe 21-50 fm, Wegner Cowcod 2 day 51-100 fm	Albin and Karpov 8.3% and 5% per 10 fm	No 0-50 fm Yes 51-100 fm	Yes	Proxy estimates from other species <50 fm, low sample size 51-100 fm, arbitrary 5%/10 fm mortality, redundancy in mortality between Albin and Karpov 1-5 day mortality and 2 day mortality
3C	Hannah All RF 0-20 fm, Jarvis and Lowe 21-50 fm, Wegner All RF 2 day 51-100 fm	Albin and Karpov 8.3% and 5% per 10 fm	No 0-50 fm Yes 51-100 fm	Yes	Proxy estimates from other species <50 fm, moderate sample size 51-100 fm, arbitrary 5%/10 fm mortality, redundancy in mortality between Albin and Karpov 1-5 day mortality and 2 day mortality

Method	Short Term Mortality Rate Estimation Description	Additional Long term Mortality Rate Description	Direct Estimate for Species in Question	Depth Applied Same as Data Collection	Assumptions, Uncertainties, and Risks
3D	Upper 95% Confidence Interval 3A	Albin and Karpov 8.3% and 5% per 10 fm	Yes	Yes	Very low sample size, arbitrary 5%/10 fm mortality, redundancy in mortality between Albin and Karpov 1-5 day mortality and 2 day mortality
3E	Upper 95% Confidence Interval 3B	Albin and Karpov 8.3% and 5% per 10 fm	No 0-50 fm Yes 51-100 fm	Yes	Proxy estimates from other species <50 fm, low sample size 51-100 fm, arbitrary 5%/10 fm mortality, redundancy in mortality between Albin and Karpov 1-5 day mortality and 2 day mortality
3F	Upper 95% Confidence Interval 3C	Albin and Karpov 8.3% and 5% per 10 fm	No 0-50 fm Yes 51-100 fm	Yes	Proxy estimates from other species <50 fm, moderate sample size 51-100 fm, arbitrary 5%/10 fm mortality, redundancy in mortality between Albin and Karpov 1-5 day mortality and 2 day mortality

Table 11. Cowcod mortality rate estimates in each 10 fm depth bin using the combination of the three components of discard mortality in Equation 2. Color coding reflects the description of the mortality rates applied in producing the composite estimate in each depth bin provided in the corresponding footnote below the table and use mortality estimates for components found in Table 5. Assumptions regarding the applicability of mortality rates to depths or species in question increase to the right.

Depth Bin (fm)	Surface Mortality Deep Demersal Species	3A	3B	3C	3D	3E	3F
		Wegner Cowcod 2 day All Depths	Hannah All RF 0-20 fm, Jarvis and Lowe 21-50 fm, Wegner Cowcod 2 day 51-100 fm	Hannah All RF 0-20 fm, Jarvis and Lowe 21-50 fm, Wegner All RF 2 day 51-100 fm	Upper 95% CI. 3A	Upper 95% CI. 3B	Upper 95% C.I. 3C
0-10	21.0%	13.8%[1]	19.9%[2]	19.9%	42.5%[5]	22.5%[6]	22.5%
11-20	35.0%	18.3%	24.1%	24.1%	45.5%	26.6%	26.6%
21-30	52.0%	22.9%	44.7%[3]	44.7%	48.6%	49.4%[7]	49.4%
31-40	100.0%	27.4%	47.9%	47.9%	51.6%	52.3%	52.3%
41-50	100.0%	31.9%	51.2%	51.2%	54.6%	55.3%	55.3%
51-60	100.0%	36.5%	36.5%	40.3%[4]	57.6%	57.6%	48.0%[8]
61-70	100.0%	41.0%	41.0%	44.6%	60.7%	60.7%	51.7%
71-80	100.0%	45.5%	45.5%	48.8%	63.7%	63.7%	55.4%
81-90	100.0%	50.1%	50.1%	53.1%	66.7%	66.7%	59.2%
91-100	100.0%	54.6%	54.6%	57.4%	69.7%	69.7%	62.9%

1. **M = 1 – ((1 – 0.01 Cowcod 2 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))**
2. **M = 1 – ((1 – 0.08 Hannah All RF 2 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))**
3. **M = 1 – ((1 - 0.29 Jarvis and Lowe 2 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))**
4. **M = 1 – ((1 – 0.07 Wegner 2 Day All RF) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))**
5. **M = 1 – ((1 – 0.34 95% CI Wegner Cowcod 2 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm)**
6. **M = 1 – ((1– 0.11 95% CI Hannah All RF 2 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))**
7. **M = 1 – ((1 - 0.35 Jarvis and Lowe 2 Day) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))**
8. M = 1 – ((1 – 0.19 Wegner 2 Day All RF) x (1 – 0.083 Albin and Karpov) x (1 – 0.05 per 10 fm))

Table 12. Description of methods applied in estimating mortality rates for cowcod calculated using Equation 3, including whether the method uses data collected from cowcod individuals and applies mortality rates in depths from which the data were collected. The assumptions, uncertainties, and risks associated with each method are also provided.

Method	Short Term Mortality Rate Estimation Description	Additional Long term Mortality Rate Description	Direct Estimate for Species in Question	Depth Applied Same as Data Collection	Assumptions, Uncertainties, and Risks
4A	Smiley / Wegner Cowcod 10+ day	15% Wegner 3-10 day Mortality Rates	Yes	Yes	Low sample size, Smiley and Drawbridge cowcod from hyperbaric chamber may bias mortality high, assumes 10 day mortality encompasses all long term mortality
4B	Hannah All RF 0-20 fm, Jarvis and Lowe 21-50 fm, Smiley / Wegner Cowcod 10+ day 51-100 fm	15% Wegner 3-10 day Mortality Rates 0-50 fm	No 0-50 fm Yes 51-100 fm	Yes	Proxy estimates from other species <50 fm, low sample size 51-100 fm, Smiley and Drawbridge cowcod from hyperbaric chamber may bias mortality high, assumes 10 day mortality encompasses all long term mortality
4C	Hannah All RF 0-20 fm, Jarvis and Lowe 21-50 fm, Smiley / Wegner All RF 51-100 fm	15% Wegner 3-10 day Mortality Rates 0-50 fm	No 0-50 fm Yes 51-100 fm	Yes	Proxy estimates from other species <50 fm, low to moderate sample size 51-100 fm, Smiley and Drawbridge cowcod from hyperbaric chamber may bias mortality high, assumes 10 day mortality encompasses all long term mortality

Method	Short Term Mortality Rate Estimation Description	Additional Long term Mortality Rate Description	Direct Estimate for Species in Question	Depth Applied Same as Data Collection	Assumptions, Uncertainties, and Risks
4D	Upper 95% Confidence Interval 4A	15% Wegner 3-10 day Mortality Rates	Yes	Yes	Low sample size 51-100 fm, Smiley and Drawbridge cowcod from hyperbaric chamber may bias mortality high, assumes 10 day mortality encompasses all long term mortality
4E	Upper 95% Confidence Interval 4B	15% Wegner 3-10 day Mortality Rates 0-50 fm	No 0-50 fm Yes 51-100 fm	Yes	Proxy estimates from other species <50 fm, low sample size 51-100 fm, Smiley and Drawbridge cowcod from hyperbaric chamber may bias mortality high, assumes 10 day mortality encompasses all long term mortality
4F	Upper 95% Confidence Interval 4C	15% Wegner 3-10 day Mortality Rates 0-50 fm	No 0-50 fm Yes 51-100 fm	Yes	Proxy estimates from other species <50 fm, low to moderate sample size 51-100 fm, Smiley and Drawbridge cowcod from hyperbaric chamber may bias mortality high, assumes 10 day mortality encompasses all long term mortality

Table 13. Cowcod mortality rate estimates in each 10 fm depth bin using the combination of the two components in Equation 3 or 10 day mortality rates. Color coding reflects the description of the mortality rates applied in producing the composite estimate in each depth bin provided in the corresponding footnote below the table and use mortality estimates for components found in Table 5. Assumptions regarding the applicability of mortality rates to depths or species in question increase to the right.

Depth Bin (fm)	Surface Mortality Deep Demersal Species	4A	4B	4C	4D	4E	4F
		Smiley / Wegner Cowcod 10+ day	Hannah All RF 0-20 fm, Jarvis and Lowe 21-50 fm, Smiley / Wegner Cowcod 10+ day 51-100 fm	Hannah All RF 0-20 fm, Jarvis and Lowe 21-50 fm, Smiley / Hyde All RF 51-100 fm	Upper 95% C.I. 4A	Upper 95% C.I. 4B	Upper 95% C.I. 4C
0-10	21%	25%[1]	22%[2]	22%	49%[5]	41%[6]	41%
11-20	35%	25%	22%	22%	49%	41%	41%
21-30	52%	25%	40%[3]	40%	49%	56%[7]	56%
31-40	100%	25%	40%	40%	49%	56%	56%
41-50	100%	25%	40%	40%	49%	56%	56%
51-60	100%	25%	25%	26%[4]	49%	49%	41%[8]
61-70	100%	25%	25%	26%	49%	49%	41%
71-80	100%	25%	25%	26%	49%	49%	41%
81-90	100%	25%	25%	26%	49%	49%	41%
91-100	100%	25%	25%	26%	49%	49%	41%

1. **M = 0.25 Smiley / Wegner Cowcod 10+ Days**
2. **M = 1 – ((1– 0.08 Hannah All RF 2 Day) x (1 – 0.15 Wegner 3-10 Day All RF))**
3. **M = 1 – ((1 - 0.29 Jarvis and Lowe 2 Day) x (1 – 0.15 Wegner 3-10 Day All RF))**
4. **M = 0.26 Wegner All RF 10+ Days**
5. **M = 0.49 95% CI Smiley / Wegner Cowcod 10+ Days**
6. **M = 1 – ((1– 0.11 95% CI Hannah All RF 2 Day) x (1 – 0.34 95% CI Wegner 3-10 Day All RF))**
7. **M = 1 – ((1 - 0.36 95% CI Jarvis and Lowe 2 Day) x (1 – 0.34 95% CI Wegner 3-10 Day All RF))**
8. **M = 0.41 95% CI Wegner All RF 10+ Days**

Are these methods appropriate? Do the methods sufficiently account for uncertainty?

Although current catch accounting practices account for depth-dependent recreational rockfish discard mortality for fish released at the surface, the assumed discard mortality rates are based on simply throwing fish overboard and onto the surface. Applying these estimates to all discarded rockfish may result in an overestimate of total discard mortality used in management because some recreational fishermen release rockfish at the depth of capture with descending devices. Discard mortality rates are lesser for rockfish released at the bottom, as accomplished with descending devices, than at the surface (Hannah, *et al.* 2012; Hochhalter and Reed 2011; Jarvis and Lowe 2008). The surface mortality rates and mortality rates reflecting the use of descending devices with the application of Equation 2 and Equation 3 for yelloweye rockfish are provided in Figure 2 and Figure 3, respectively, while the results for cowcod are provided in Figure 4 and Figure 5, respectively. Comparing the mortality rates and the difference between mortality rates for surface release and release using a descending device, it is clear that substantial overestimates in the mortality could be made if their use was not accounted for.

The proportion of fish released using the devices and the proportion of catch by depth will determine the magnitude of the difference in mortality when the rates reflecting use of descending devices are applied instead of surface release. The proportion of catch of yelloweye rockfish and cowcod caught in each 10 fm depth increment are superimposed on mortality rates for surface release compared to each of options for estimating mortality of fish released using descending devices provided in Figure 2 and Figure 3 for yelloweye rockfish and in Figure 4 and Figure 5 for cowcod. Greater reductions in mortality are expected in deeper depths where the surface release mortality rate approaches 100 percent due to the inability of fish to escape the surface subjecting them to predation by avian and pinniped predators as well as sun exposure and thermal shock. Applying lesser discard mortality rates to rockfish released with descending devices would more accurately reflect mortality rates of fish discarded in a way that eliminates these sources of mortality. Accounting for the reduction in mortality from their use may allow greater opportunities for these fisheries since regulations are crafted in rod-and-reel fisheries to keep species within relatively low harvest guidelines.

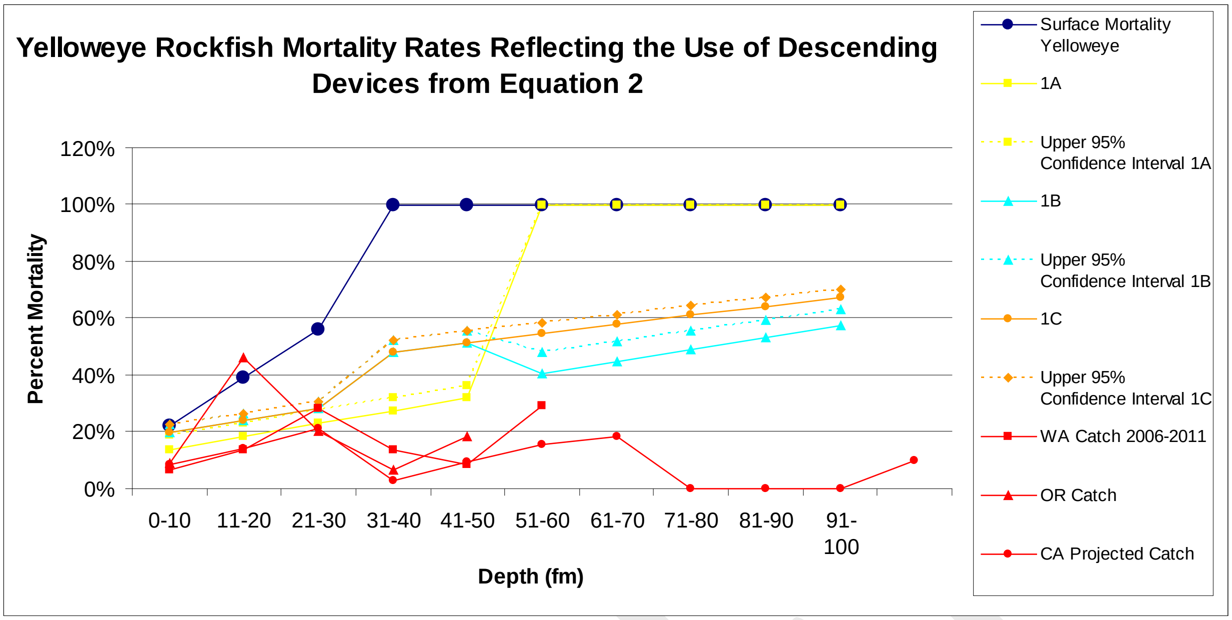

Figure 2. Plotted mortality rates by depth bin estimated for each method of estimating mortality rates for yelloweye rockfish using Equation 2. Surface release mortality is provided to allow comparison to current mortality rates applied to discards. Proportions of catch by depth from recent years for Oregon and Washington recreational fisheries and proportion of projected catch for all depths in California.

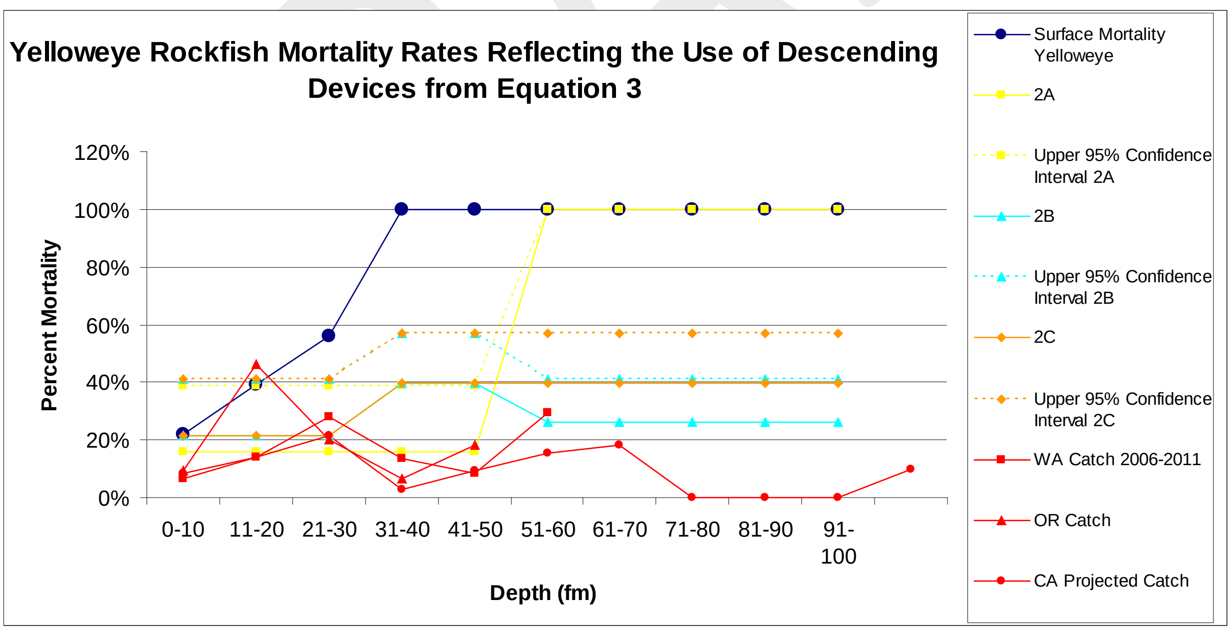

Figure 3. Plotted mortality rates by depth bin estimated for each method of estimating mortality rates for yelloweye rockfish using Equation 3. Surface release mortality is provided to allow comparison to current mortality rates applied to discards. Proportions of catch by depth from recent years for Oregon and Washington recreational fisheries and proportion of projected catch for all depths in California.

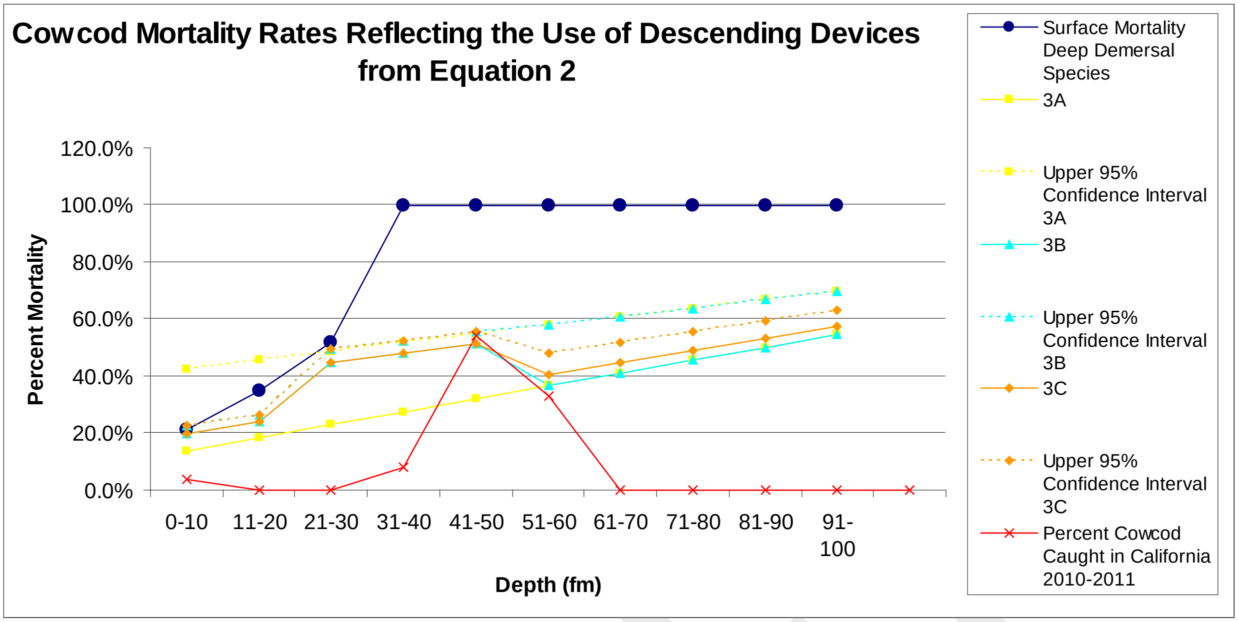

Figure 4. Plotted mortality rates by depth bin estimated for each method of estimating mortality rates for cowcod using Equation 2. Surface release mortality is provided to allow comparison to current mortality rates applied to discards. Proportions of catch by depth from 2010-2011 in the California recreational fishery.

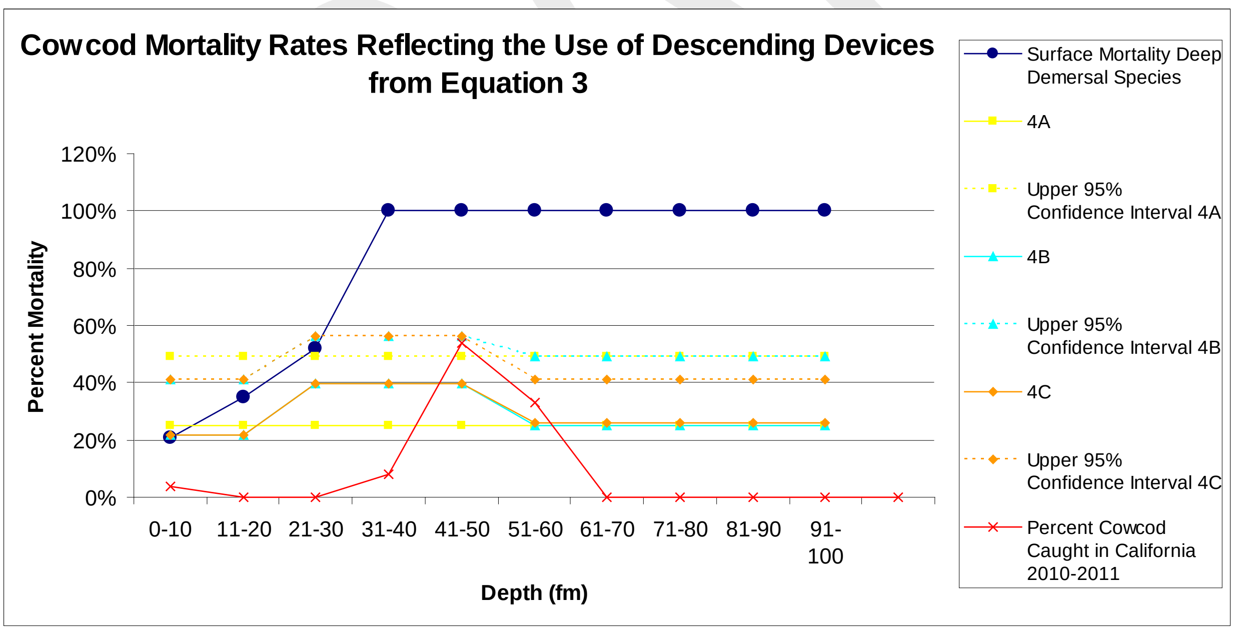

Figure 5. Plotted mortality rates by depth bin estimated for each method of estimating mortality rates for cowcod using Equation 3. Surface release mortality is provided to allow comparison to current mortality rates applied to discards. Proportions of catch by depth from 2010-2011 in the California recreational fishery.

Considerations Related to Mortality Estimates

Assumptions and Biases Implicit in Mortality Estimation Methods and Buffers Addressing Uncertainties

The one to five day mortality rates from Albin and Karpov (1996) may be biased high relative to release with a descending device due to the increased handling of sampled fish as a result of having been vented, tagged, and retained at the surface in a holding tank without the benefit of recompression and subsequent additional handling during their captivity. This may also be the case for cage studies in which fish were subject to stress from greater handling during tagging and measuring, unable to escape predation by sea lice, being confined and repeated contact with cage walls. On the other hand, the cages offered the potentially disoriented rockfish protection from predation by lingcod or pinnipeds. Barometric chamber studies by Parker (2006) subjecting fish to pressure equivalent to 40 fm then reducing pressure to zero followed by resumed pressure found a 3 percent mortality rate for black rockfish held for 21 days. This is far lower than that observed over two days in the Hannah et. al. (2012) study indicating that they may be more sensitive to other aspects of the treatment. Conversely, the black rockfish in the barometric chamber study were not subject to stress from handling and temperature change, making the results less representative of the expected mortality from release using a descending device, though they do provide an indication of the long term survivability of fish beyond two days.

Though each of the proxy estimates of mortality for fish discarded with a descending device have limitations, assumptions and biases associated with their application relative to outcomes from release with various devices, they do provide an indication of the expected response. With suitable buffers provided by the assumed long term mortality rates and redundancies between components of mortality, such estimates can be considered more or less conservative. Application of the rates from these studies to species or depths other than those sampled in the studies should be done with caution, considering the likely degree of violation of assumptions and magnitude of deviations from the estimated values in the context to which they are being applied. Consideration of whether existing buffers for uncertainty are sufficient or whether additional appropriate buffers can be applied to mitigate associated risk of an underestimate are essential in the event that proxy information is applied.

Additional Considerations

The field sampling methods used in deriving the mortality rates have inherent biases compared to fish that are released using a descending device that should be considered relative to their potential to underestimate or overestimate mortality. The trauma from increased handing, lack of access to food, abrasion and impact from containment and injury from tagging may bias high two-day mortality rates derived for rockfish returned to the bottom in cages (Jarvis and Lowe, 2008, Hannah et al. 2012). On the other hand, cages may prevent predation by lingcod or pinnipeds, though such rates may be limited by the presence of such predators at the time and location of release, while other biases are expected to result in overestimates of effect on all released fish.

Mortality from Multiple Capture Events

This section still needs discussion, and will be completed after the November Council meeting.

Time on Deck

It takes longer to release a cowcod or yelloweye rockfish with a descending device than at the surface. Since time on deck (surface holding duration) prior to recompression has been shown to increase the probability of mortality occurring in rockfish (Jarvis and Lowe 2008), a time on deck mortality rate may need to be applied to cowcod and yelloweye rockfish released with recompression devices. Additionally, anglers should be encouraged to have the devices ready to use prior to fishing.

Predation Due to Swimming Impairment

Yelloweye rockfish released with descending devices are not protected from predators like the fish from the barrel studies. Since impaired swimming ability has been modeled for yelloweye rockfish immediately post recompression in depths shallower than 30 fm (15 percent of individuals at 0 fm with a slight increase by depth to 25 percent of individuals at 30 fm, Hannah and Matteson 2007)), a portion of fish released with descending devices may be at greater risk of predation due to impaired swimming ability.

If and how long it takes for yelloweye rockfish to regain normal swimming behavior following recompression is unknown. Impaired swimming (maintaining neutral buoyancy) can be caused by ruptured swim bladders, which have been shown to heal for most (77 percent) black rockfish within 21 days (Parker, *et al.* 2006). The time it takes for yelloweye swim bladders to heal is unknown, but may take longer than for black rockfish due to thicker swim bladders (cite).

Low yelloweye rockfish mortality (1.2 percent) during the 17 day mark/recapture study (Hochhalter and Reed 2011) indicates that predation may not have occurred, since this covers the time period when the fish would be most vulnerable to predation (e.g., healing swim bladders and initial release). Although the Hochhalter and Reed (2011) study occurred in Alaska, many of the same predators occur within west coast waters (e.g., lingcod and pinnipeds). Further, lingcod, regardless of size, rarely eat rockfish over 6.5 inches (Beaudreau 2012) and anglers rarely, if ever, catch rockfish smaller than 6.5 inches.

Predation by pinnipeds is of greater concern since Pacific rockfish remains are commonly found in California sea lion scats (10-60 percent, highly variable by season and year, Lowry, *et al.* 1991). Presence of pinnipeds following tagging in the Hochhalter and Reed (2011) study site was not documented.

Physiological Impairment from Barotrauma

Although not sources of mortality (unless starvation due to severe vision loss occurs), effects on health and fitness affecting foraging ability (i.e., vision and hearing and fecundity are discussed.

Since yelloweye rockfish are visual predators and barotrauma can result in damages to the eye (i.e., stretching of the optic nerve and retinal tearing), starvation could be a source of morality. Although post-recompression visual performance has not been studied for yelloweye rockfish, studies have been done on other rockfish species. Rogers et al. (2011) examined post-recompression visual performance of rosy rockfish that had exhibited exophthalmia ("popped eyes") and found that vision quickly restored (four days) and improved after a month to the point where the fish could track small and fast moving objects. Similarly, Brill et al. (2008) examined post-recompression retinal function of black rockfish that had exhibited exophthalmia and found no measurable negative effects.

There is no evidence that barotrauma and recompression decreases reproductive viability of female yelloweye rockfish. Sixteen female rockfish were captured one to two years after recompression at the same reef (< 40 fm) from the Hochhalter and Reed (2011)) mark/recapture study, and all had successfully gone through gonadal development, mating, larval gestation, and half had gone through parturition (spawning; personal communication between Brittany Blain, University Alaska-Fairbanks and Alena Pribyl, NOAA SW Fisheries Science Center; PFMC 2012).

Venting

Venting rockfishes prior to release is not recommended. Venting may result in pierced vital organs, as well as increased risk of infection {Parrish and Moffitt 1993; Keniry, 1996 #386; Theberge, 2005 #395}. Further, even with proper venting techniques by trained biologists, studies have found that venting does not significantly decrease mortality {Gotshall, 1964 #396; Bruesewitz and Coble 1993; Render and Wilson 1993}.

Implementation

Implementation of differential mortality rates when descending devices are used will be somewhat dependent on the SSC review of the above methodology. Therefore, the sections below may be incomplete, and will be updated with more details after the SSC review in November.

To account for the use of descending devices in mortality estimates, not only must the mortality rate reflecting their use be determined, but the proportion of fish released with devices and proportion of encountered fish released using a descending device in each 10 fm depth increment must also be estimated to apply the mortality rates. Since calculations used to determine the proportion of fish released with devices and the proportion encountered at each depth may vary among the state recreational fisheries due to different catch accounting methods, it is important to consider whether agencies should independently calculate proportions of fish released with devices for their respective fisheries, or whether a uniform method should be applied to all states and fisheries. Calculations for determining both mortality rates and proportions of rockfish released with descending devices for the recreational fisheries should be reviewed by the SSC Groundfish Subcommittee. In addition, the methods of applying the mortality rates should be reviewed by the RecFIN Technical Committee. The following are descriptions of the existing data available for these calculations, the additional data elements that would be required and limitations to collecting this data in each state.

Dockside Angler Interview Background Information

The sampling programs in all three states have been recently reviewed by the national Marine Recreational Information Program. Links to the reviews are below.

Washington:
https://www.st.nmfs.noaa.gov/mrip/projects/downloads/MRIP_OSP_Review_Report_Final.pdf

Oregon:
http://www.countmyfish.noaa.gov/projects/downloads/MRIP_ORBS_Review_Report_Final.pdf

California:
http://www.countmyfish.noaa.gov/projects/downloads/MRIP_CRFS_Review_Report_Final.pdf

Appendix 3 contains the "Interview Section" of the Oregon Ocean Recreational Boat Survey (ORBS), as an example of the interview questions and procedures that samplers are asked to follow when they sample a vessel. Washington and California have similar procedures and questions, though there may be some variation. This information is provided as an example of what samplers are currently asking each vessel. An "interview" consists of a sampler's complete interaction with a vessel, including asking the questions about effort, catch, location, etc. and collecting biological samples (lengths, scanning for coded wire tags, etc.). ORBS samplers currently ask 16 questions, some with multiple parts, such as the species encounter question.

The amount of time for each interview varies depending on the number and species of the catch. The required biological sampling varies with species, some take more time than others. The time per interview can range from 2 to 10+ minutes. For each additional question or task asked of the dockside samplers there is a trade-off in the total number of interviews or sampling rate.

There is concern that adding questions regarding descending device will reduce sample rates. Sample rates would only be affected by additional questions during high effort periods (sample rates more commonly affected by slow returns of anglers to port). Secondly, the descending device questions would only apply to a small percentage of interviews since it is conditional on the release of a yelloweye rockfish or cowcod (2 percent of interviews in Oregon in 2011; 497 of

22,678). Lastly, the descending device questions should only add minimal time to interviews that range from two to 10+ minutes, with most of that time being attributed to obtaining biological data (e.g., lengths and weights) or scanning for tags (e.g., coded-wire and PIT).

Washington

A detailed description of the Washington Department of Fish and Wildlife's Ocean Sampling Program (OSP) is available on the Pacific States Marine Fisheries Commission Recreational Fisheries Information Network (PSMFC RecFIN) website.

http://www.recfin.org/documents/wa-osp-methods102008-0

The OSP estimates total ocean recreational effort and catch by boat type (charter and private), port, catch area, and trip type (primary target species). Boat trip sampling is conducted randomly to generate estimates of catch for most ocean-caught species: salmon, rockfish and other groundfish, halibut, albacore, sharks, and cods. Estimates of released fish are also generated using angler interviews.

The catch per boat is sampled through intercept surveys. Returning boats are systematically sampled at a minimum target rate of 20% within each boat type (charter and private). Boats are randomly selected for sampling to maintain a consistent sampling rate throughout the day; boats are included in the sample regardless of size, mooring location, trip type, etc. The sampling rate for the day depends on the projected effort and the number of available samplers. Overall, the sampling rate in each port in a year averages over 50% for charter boats and over 40% for private boats.

Since 2002, as part of the field intercept survey, OSP samplers have been asking anglers whether they discarded any fish during their fishing trip, and if so, to identify discarded catch by species and number. Discarded catch is expanded in the same manner as retained catch to produce estimates of total discarded catch.

The OSP has been collecting information on the depth of capture since 2003. Samplers ask the depth at which the majority of the catch was caught and record only one depth. It is assumed that fish are discarded at the same depth as the depth of capture. Depth data is not used in any catch expansion algorithm. Each month, along with estimates of total catch, OSP provides RecFIN with the raw intercept data that includes the depth of capture by species. RecFIN uses the OSP intercept data to estimate the proportion of fish caught in each of the GMT depth categories and then applies the GMT mortality rates to produce estimates of discard mortality.

In addition, the OSP collects biological information such as lengths for bottomfish and halibut and salmon and asks about interactions with birds during each interview.

The OSP does not currently collect data on the use of descending devices in our recreational fishery. To apply mortality rates for fish released with a descending device our sampling approach would need to be modified to ask anglers additional questions to determine the proportion of anglers that are using the device. It will be important to consider the implications of adding a series of additional questions to the angler interview. Samplers are already at the point where their ability to gather all of the needed data during each interview while maintaining required sampling rates is at risk. Discussions on how to collect additional information such as whether or not an angler released any fish with a descending device will include trade-offs such as losing other important data such as the number fish lengths samplers are able to collect or reduced sampling rates.

As a first step, to collect information where it would be most beneficial to the recreational fishery while minimizing impacts on sampler interview data, WDFW could consider only asking about the use of descending devices when an angler reports discarding prohibited species such as yelloweye or canary rockfish. Questions on the use of descending devices could be asked only on trips targeting bottomfish and halibut and avoid questions on salmon trips to maintain salmon sampling rates that are necessary to achieve sampling rates for coded wire tags.

Alternatively, a supplemental sampling project could be developed to collect information on the use of descending devices. This would likely come at a significant cost but could be considered as a temporary measure to collect baseline information on a temporary basis while more permanent solutions are explored.

Proportion of Yelloweye Rockfish Encountered by Depth

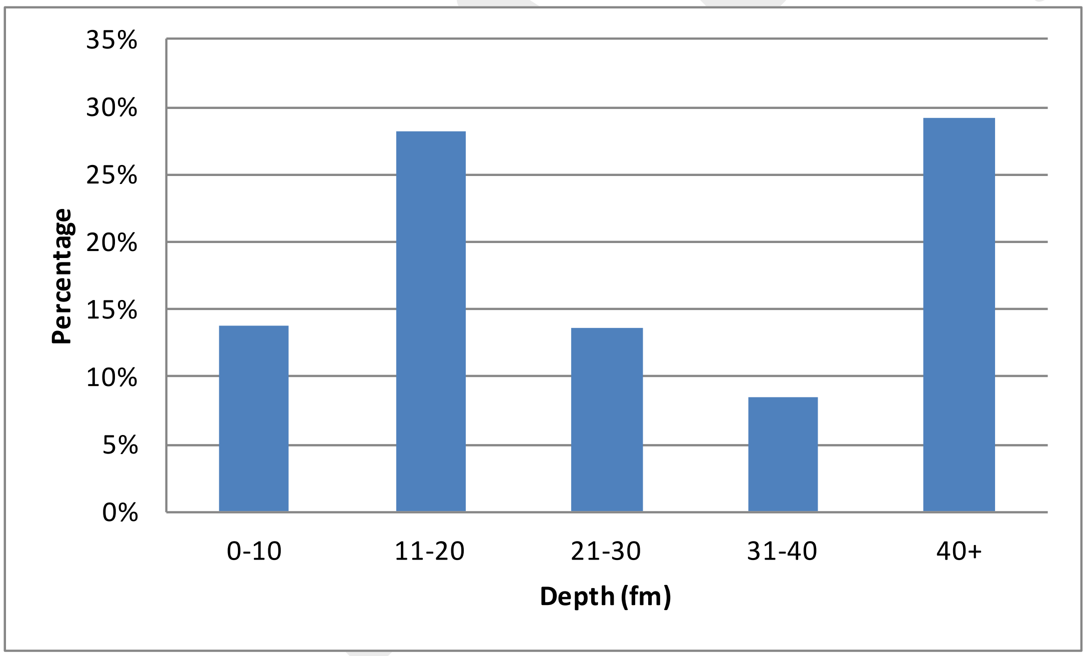

Figure 6. Yelloweye rockfish (retained and released) by depth bin from all Washington recreational trip types combined from 2006-2012.

Oregon

Sampling Rates

A detailed description of the Oregon Recreational Boat Survey (ORBS) sampling design can be found at: http://www.dfw.state.or.us/MRP/salmon/docs/ORBS_Design.pdf.

The primary goals of the ORBS dockside interviews are to generate accurate and unbiased estimates of anglers per boat and catch by species per boat for the ocean recreational boat fishery, and to sample for and recover from the ocean recreational salmon fishery coded wire tags (CWTs). Further, the estimates are expected to be accurate when stratified to the level of statistical week, port, boat type, trip type, season type, and area of effort/catch. To sample salmon adequately for CWTs, a minimum sampling rate standard of 20 percent of landed salmon by port and week has been established to better insure that CWT recoveries will represent the actual fishery interceptions occurring for any given strata. The ORBS has generally adopted this as the minimum standard for all fisheries, ports, and time periods sampled.

A variety of other data are also collected including information on the number of fish released, lengths and weights of fish, departure time, interview time, and information on estuary trips as well. Beginning in April of 2012, ORBS began obtaining data on the proportion of yelloweye and canary rockfish released with descending devices. The descending device question applies to all interviews, both charter and private, in which a yelloweye or canary rockfish discard is reported. The data are stratified by port and summed over ports to generate estimates for catch areas and the entire state.

Due to substantial differences between charters and private boats (i.e., charters often use moorage areas that are separated from the private boat use areas, have a wider range in number of anglers, and the fact that charter trip type and return time is available in advance), charter boat effort is stratified to trip type prior to the interview, and interviews are selected by samplers to be representative of the fleet activity for the various target species. Private boats cannot be stratified to trip type prior to the interview, and therefore, interviews are selected in a random fashion within the boat basin and launch ramp area to reduce potential sampling bias towards trip type.

ORBS samplers are instructed to interview private boats without prejudice to size, number of anglers, presence or absence of fish or fishing tackle, etc. Samplers are instructed to always interview the “next boat” that they see returning to their area of operation, and once that interview is completed look for the next returning boat. Private boat interviews are recorded for any boat that has completed their trip; regardless of whether they entered the ocean or even fished (correct proportion of non-fishing trips is needed to determine actual fishing effort).

Sampling schedules are set in advance by ORBS permanent staff to provide representative sampling coverage for all day types, season types, and to cover the hours of the day when charter and private fishing vessels can be expected to return from the ocean. Interviews are always initiated at the boat at the time that it arrives back at the dock or ramp to insure that all anglers and catch are present from the trip.

Proportion of Yelloweye Rockfish Encountered by Depth

ORBS samplers ask anglers if they released any rockfish, and if so from what depth. Figure 7 shows the percentage of yelloweye rockfish encountered in the Oregon recreational bottomfish and halibut fisheries by depth bin. Over 45 percent of yelloweye rockfish encountered were from 10 to 20 fm (Figure 7). Encounters in depths greater than 30 fm accounted for 24.5 percent of encounters.

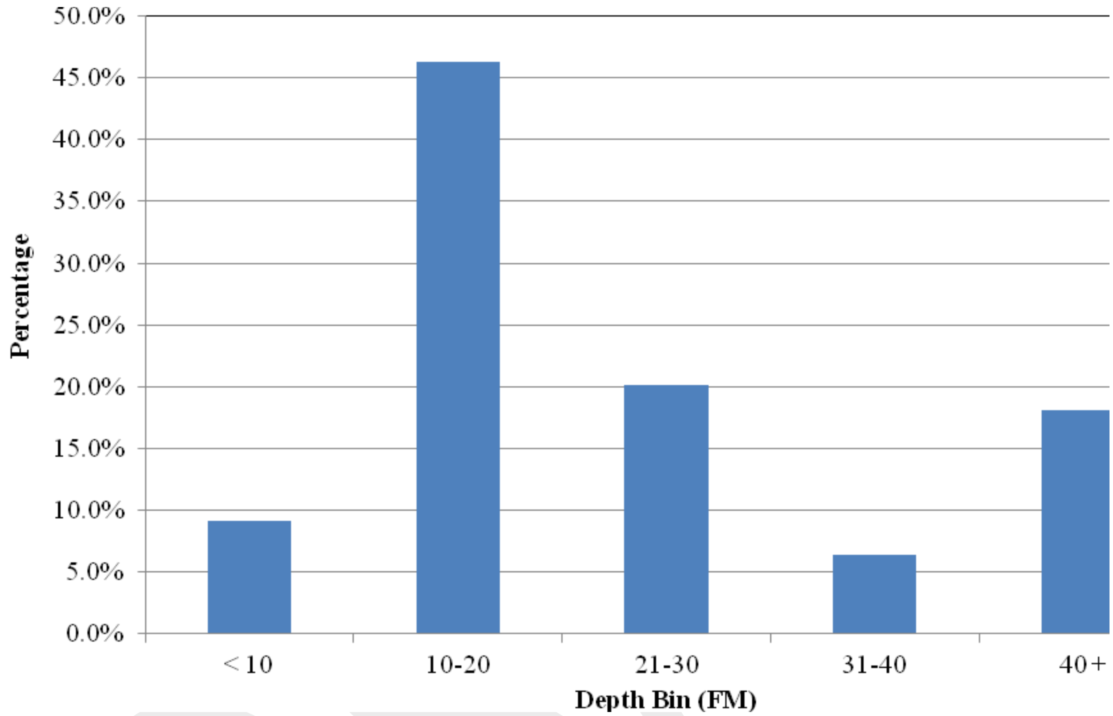

Figure 7. Percentage of yelloweye rockfish released by depth bin from the Oregon recreational bottomfish and halibut fisheries combined, 1 January 2010-10 September 2012.

Application of Mortality Rates

This section will be updated after the SSC review of mortality rates.

Current discard mortality calculation (100% assumed released at surface):

Discard mortality rate formula: $\sum_{depths}$ (P RS_{depth} x DMR RS_{depth})

Discard mortality (mt) formula: DMR x total fish (expanded) x avg. fish weight

Depth	Fish RS	P RS		DMR RS		Product	
0-10	6	0.133	x	0.22	=	0.03	
11-20	24	0.533	x	0.39	=	0.21	
21-30	12	0.267	x	0.56	=	0.15	
> 30	4	0.067	x	1.00	=	0.07	
					∑ =	0.45	= Overall mortality rate

RS = Released at surface; P = Proportion (of fish); DMR = Discard mortality rate; Depth is in fm.

Potential discard mortality calculation with proportion released at surface and at depth:

Discard mortality rate formula: $\sum_{depths}$ (P RS_{depth} x DMR RS_{depth} + P RD_{depth} x DMR RD_{depth})

Discard mortality (mt) formula: DMR x total fish (expanded) x average weight of fish

1. For each depth bin, multiply proportion of fish released by at surface by at-surface discard mortality rate, multiply proportion of fish released at depth by at-depth discard mortality rate, and add products

2. Sum added products from step 1 for each depth bin (overall discard mortality rate) and multiply by estimated total fish and by average weight of discarded fish

Example:

Depth	Fish	Fish RD	Fish RS	P RD		DMR RD		P RS		DMR RS		Product	
0-10	6	3	3	0.065	x	0.05	+	0.065	x	0.22	=	0.02	
11-20	24	12	12	0.261	x	0.10	+	0.261	x	0.39	=	0.13	
21-30	12	6	6	0.13	x	0.15	+	0.13	x	0.56	=	0.09	
> 30	4	2	2	0.043	x	0.20	+	0.043	x	1.00	=	0.05	
											∑ =	0.29	= Overall mortality rate

RS = Released at surface; RD= Released at depth; P = Proportion (of fish); DMR = Discard mortality rate; Depth is in fm; used theoretical values for DMR RD

California

What data is Currently Collected?

Sampling rates and data elements collected differ among boat modes in the California recreational fishery sampled by the California Recreational Fisheries Survey (CRFS). The boat modes sampled by the CRFS include the party charter mode (PC), the primary private and rental boat mode (PR1), and the secondary private and rental boat mode (PR2). The division between the two private and rental boat modes allows greater sampling effort to be focused on those locations where the majority of the catch occurs. The PR1 mode accounts for about 90 percent of the private and rental boat effort and catch for species that are a management priority including rockfish, while the PR2 mode accounts for the remaining 10 percent (CDFG 2011).

The private and rental boat fleet is sampled at dockside at locations accessible by samplers including launch ramps and public docks. The PR1 mode is sampled at a rate of 20 percent of the days of the month, while the PR2 mode is sampled at a rate of 10 percent of the days per month. In both surveys, data is collected on whether a given fish was discarded live or dead. In most cases, the depth and location of capture of the majority of the fish in the catch or that were discarded if no fish were retained is recorded by the sampler and applied to all fish in the catch. If fish were caught at more than one location, a second location and bottom depth can be listed for PR2 interviews and for each sampler-observed or angler-reported fish, it is indicated whether the fish was caught at the location where most of the fish was caught, though often times the angler cannot provide this information. In the PR1 mode, multiple locations and depths of encounter can be entered, but anglers often report the location where the majority of the fish were landed if there was landed catch or discarded in the event that no catch was landed but fish were discarded. Anglers sampled at PR1 locations who reported discarding rockfish are asked whether a descending device was used during the course of the trip, though the question is not asked specifically with regard to the disposition of any one fish. The PR2 survey is not currently collecting information about the use of descending devices.

Less than 5 percent of the PC mode trips are sampled in each CRFS district. These trips are either sampled onboard or dockside with the preference to sampling onboard for trips targeting rockfish to collect data on discard length, depth of capture data and spatial data on the location of capture. At each stop, the sampler records the beginning location and bottom depth (not fishing depth) and the end location and bottom depth. The sampler also records whether the boat was anchored, stationary, drifting or trolling. In the past, samplers conducting PC interviews at dockside inquired with the deckhand or captain as to the depth and location where the majority of the fish were caught, though this information was not collected in 2012, but may be collected in the future. Most rockfish trip data is collected onboard party boats for which location and depth data is recorded at each stop, providing depth data for the majority of sampled trips.

Data on the disposition of each fish released while sampling onboard party boats are currently collected at the level of discarded live or dead at each stop, with the exception of observed released cowcod, for which additional information is provided on whether the fish was released with or without a descending device. At each stop, the sampler observes some of the anglers on the boat and records whether a descending device was used by those anglers at that stop, though data is not collected on the disposition of individual fish with the exception of cowcod. When sampling the PC mode at dockside, the sampler asks whether any fish were discarded and records their disposition, but no disposition code of released using a descending device is currently provided for individual fish. In both PC onboard and dockside modes, the captain or crew of each boat that targeted groundfish is asked, “Did you use a descending device on this trip?” and the response is recorded at the boat level.

While data on depth of capture is already being collected to inform the proportion of catch by depth, additional discard disposition data would have to be collected to determine the proportion of rockfish released using a descending device. To be certain that a descending device was used to release a particular individual fish, an additional inquiry would have to be made regarding which of the fish that were released were released using a descending device. Gathering this additional data for all discarded rockfish may be time prohibitive and may require that other data such as lengths of retained fish or interviews over the course of the day be forgone to have time to collect this data in some modes. Collection of such data in the course of onboard sampling through discard tally disposition data that requires only that the disposition be tallied in another entry may not result in conflicts, while the time intensive dockside sampling in the PR1, PR2 and PC require trade-offs that could adversely affect other estimates based on survey data.

To provide needed data on the proportion of fish released using a descending device in the PR1 mode would need to be added for a secondary question regarding disposition to inquire as to which, if any, of the released fish were released using a descending device. In the PR2 mode, addition of a disposition code indicating release with a descending device would also be required. In the PC mode, a third disposition of discarded using a descending device would need to be added to the discard tally data sheet to allow the proportion of fish released using a descending device to be recorded. This information is already being collected for cowcod in the PC mode, but entries would facilitate recording of this data for any species for which the data would collected. If reported disposition of encountered fish are to be used to estimate the proportion of fish released using a descending device in the onboard PC mode, then an additional entry would be needed to record this information on the interview form. A entry for released using a descending device would need to be added to the PC dockside survey to provide data to inform the proportion of fish of each species released using a descending device. Depth data for the PC dockside mode would be provide additional information regarding the depth of capture, though onboard sampling data could be used to represent the proportion of catch by depth in the appropriate stratum.

Limitations

One way to minimize trade-offs and forgoing other data elements to obtain additional disposition information would be to have a separate survey to collect data on discards, but this would require additional staffing and is likely to be cost prohibitive. Alternatively, while collection of this data for all species may not be possible, it may be possible to collect the additional disposition data for all of the overfished or season limiting species. Collection of this data for species like cowcod and yelloweye rockfish that are rarely encountered would not pose an issue since the infrequent encounters would not demand as much time to be taken from other duties. More common species like canary rockfish, black rockfish and bocaccio would pose more of an issue since they are more frequently encountered and more time would be required to collect the additional disposition data. Though black rockfish has the potential to be a season-limiting species and bocaccio is an overfished species, neither limit current fishing season length or depth restrictions. Thus, if collection of data for yelloweye rockfish, cowcod and canary rockfish could be achieved, this would allow benefits to be derived from the use of descending devices to accrue to anglers, as a result of their efforts to release them with descending devices. The only concern is that the lack of accounting for other species may not provide an incentive to release them using a descending device that is present for the others, though this information is not common knowledge.

One concern relative to uncommon species such as cowcod and yelloweye rockfish is that very few individuals are encountered in any one month in each district, water area and trip type stratum and thus random sampling error may result in imprecision in the estimates of the proportion of fish released using descending devices and proportion of catch by depth. This can be addressed through the use of pooling rules which could be applied to increase the sample size. This may only be an issue in some districts and pooling rules can be established to achieve a minimum sample size by increasing the number of months and years included or by borrowing data from an adjacent district. While the proportion of fish released using a descending device may not be likely to differ between districts since outreach is carried out statewide, the proportion of catch by depth may differ due to differences in the depth distribution of reefs and thus effort or depth restrictions between areas affecting the depth to which anglers fish and encounter the species in question. Thus, pooling by time would be preferred in attaining a sufficient sample size within a district as long as the depth restriction between periods was the same. The results for each stratum in each district would be applied to the expanded estimates of encountered fish, thus attaining a suitable representative sample size through pooling would be essential to accurately reflect the use of the devices and reduction in mortality relative to surface release.

Ascribing all fish in the catch in the PR modes or in future PC dockside mode to the depth at the location where majority of the fish were caught presents a source of uncertainty regarding the actual proportion of catch by depth. The specific depth of capture for each individual is assumed to be the average depth of catch for the day, though some fish were caught shallower or deeper. Even the depth of encounter informing the proportion of catch by depth in the PC mode is provided by the average of depth at the beginning of the drift and the end of the drift, resulting in some uncertainty as to the actual depth of catch for an individual along the course a drift. Refining the resolution by asking more specific questions about the depth of capture of each fish in the PR mode is limited by the ability of the angler to differentiate between fish of the same species in their catch and where each of them were caught. Such a request pushes the bounds of the ability of anglers to recall such information accurately as well as their patience in continuing the interview. In addition, the additional time it would take to collect such data would be time prohibitive and would be likely to cause other data elements or interviews to be forgone. Collection of additional data for rarely encountered species may be more feasible, but would still carry an added time burden and require samplers to recall the need to ask the question for this subset of species.

Application of the mortality rates determined for these species would assume that the gear being used effectively to return fish to depth and the rates are representative of the mortality rates expected for discarded fish sampled in the field. Some of the uncertainties in the estimates of mortality rates are in part addressed by including species that may be more sensitive to barotrauma (i.e., bank rockfish in Wegner, Pribyl and Hyde, in prep.) or that were kept on deck longer than others (i.e., squarespot rockfish in Jarvis and Lowe, 2008). Explicit buffers can also be added to the proportions of fish released using descending devices to address concerns regarding reporting bias by anglers who may report using a descending device when the fish was actually released at the surface. One has to ask why the angler would even report the fish if they were going to be less than honest about its disposition, so this may not be a valid reason for a buffer. Concerns also arise relative to the potential for the observer to affect the frequency of use on observed PC trips and how representative the estimates will be of behavior of unobserved trips to which the proportions of fish released are expanded.

If a fish has been on deck for greater than the ten minutes for which the estimate from Jarvis and Lowe (2008) was derived, its condition may not be likely to motivate them to use a device in returning the individual to depth and thus it may not be returned using a device. To address uncertainty in the efficacy of use of the devices to return a fish to sufficient depth for it to return to and stay at the bottom, a nominal buffer may be warranted. Some data is available on the efficacy of the devices though newer lip grip devices have come on to the market since the study that allow pressure/depth specific release and may cause estimates of failed descent to be overestimated. Outreach and education by CDFG have focused on the use of these devices and industry/angler advocacy groups have provided pressure release lip grip devices to their member PC boats to increase the frequency of use and effectiveness of their application. When anglers take time to put the fish back down, they are likely to use the most effective means possible or become technically proficient with the gear at hand as not to waste time that could be spent doing other tasks or fishing, in part reducing concerns regarding efficacy of use. As new devices that are more effective come on to the market, less effective means are likely to decline in use, improving efficacy. Better understanding variation in efficacy of use may be an area of future research or additional data mining by the GMT. In addition, uncertainties and assumptions involved in the application of mortality rates in total mortality estimates is a subject for review by the RecFIN Technical Committee as well as the SSC.

Considerations Related to Implementation

This section will be updated after the SSC review of mortality rates. It is included in this report to help facilitate discussions with the SSC, other advisory bodies, and the Council. After the discussions in November, the GMT will update, organize, and refine this section.

- Coastwide consistency
- Data availability from each state
- Are 10 fm bins too fine scale for the data we have available?
- Don't think enough research to support 10 fm bins, maybe more nearshore (<30 fm) and offshore (>30 fm)
- Is management data robust enough to support 10 fm depth bins
- Sampling program trade-offs
- What is the cost to other sampling duties of adding questions?
- Overall duties (salmon, bio samples)
- Groundfish information
- Sampling program priorities
- MRIP review said some parts being oversampled
- May be necessary to meet CWT collection goals
- For groundfish might be best to handle through RecFIN technical committee
- Overall need to include the salmon folks
- If only collect data from one mode, don't apply to all
- Conversely, if can't collect data from all modes, doesn't mean can't use it for those that do collect data
- Match sampling precision to estimation precision and management objectives

- All states are assuming that fish are discarded (descending) at the same depth as average catch

Conclusions/GMT Recommendations

At the June 2012 meeting, the Council tasked the GMT with developing a report on how to integrate recreational angler use of descending devices into the management system for cowcod and yelloweye rockfish caught with rod-and-reel gear, with the goal of applying a discard mortality rate that reflects use of a descending devices in the release of fish rather than surface release beginning in 2013. Accounting for the use of descending devices in mortality estimates for additional rockfish species and for the commercial nearshore groundfish fishery may occur in the future, but only cowcod and yelloweye rockfish released by recreational fisheries were requested for immediate review due to GMT workload constraints and because regulations used to limit discard mortality of these species are most restrictive relative to other overfished species. Mortality rates determined here for yelloweye and cowcod should be applicable to other demersal rockfish other than the subgenus *Sebastosomus* as there was little variation across estimates provided for such species.

Mandatory use of descending devices in the recreational fisheries may be ill-advised, because discard data are obtained from angler reports and accuracy of reports may be reduced if reporting an illegal activity is required. However, a mandatory requirement to carry descending devices during all recreational trips would be beneficial as it would likely maximize use of the devices. In the interim, outreach and education should be continued to motivate anglers to have and use descending devices. Should the Council decide to account for the use of descending devices in catch accounting, this fact should be included in outreach to inspire anglers that require additional motivation beyond knowledge that they are reducing their impacts to use them.

Additional research should be undertaken to obtain additional data for a broader suite of species over a greater range of depths for both long term and shorter term mortality. The cost of acoustic tagging and the intensity of sampling activity required to maintain the array makes it expensive to obtain mortality rates on all released fish regardless of condition. Use of two day cage studies to collect information on short term mortality for all encountered fish regardless of condition may allow collection of data for a greater number of species over a wider range of depths. Acoustic tagging of fish in better condition to or of all encountered fish for high priority species to reflect mortality over the longer-term, can provide a better indication of long term mortality rates and should be pursued in addition to cage studies. Though it may be time prohibitive to collect data on the proportion of fish that are released using a descending device for all species without forgoing other data elements, obtaining estimates of mortality rates for as many species as possible over a wide range of depths will make mortality rates available should these species become a priority in catch accounting if deemed overfished and thus represent limitation of season length or depth restrictions.

Review of the methods and data elements required to apply mortality rates reflecting the use of descending devices should be developed by the states and reviewed by the RecFIN Technical Committee. Ideally, once mortality rates for fish released with descending devices are established, RecFIN should use the individual state estimates of the proportion of fish released with descending devices to produce estimates of mortality for these fish as is currently done to apply estimates of mortality for fish released at the surface. Should issues arise as to the validity of the methodology for applying the mortality rates in catch accounting, perhaps funding for additional research or assistance of consultants can be obtained through the Marine Recreational Information Program (MRIP). Discussion of the necessary data elements with state data collection staff to coordinate collection of the data and development of forms and database configurations allowing its integration into estimates will be essential and require additional staff work load. Each state may be in a different phase of implementation and leeway should be given to allow states to bring forth methods for review and a timeline for integration of the alternate mortality rates into catch accounting as soon as 2013 and the intent should be for all states to account for their use by the 2015 season.

Methodology Reviewed but Rejected

Proxy Species—Black or Blue Rockfish

In the Hannah et al. (2012) cage study, 25 yelloweye rockfish were caught in depths shallower than 30 fm, held in cages (barrels) at the bottom for two days, and all survived. In the Hochhalter and Reed (2011) mark-recapture study, yelloweye rockfish were caught in depths shallower than 40 fm, released at the bottom, and estimated average survival was 98.8 percent (95% CI=52.2 - 99.9 percent). The authors concluded that depth did not affect survival among the ranges of depths sampled in the study (< 40 fm); however, only 5 percent of their yelloweye rockfish were caught deeper than 30 fm, and no tags were recovered from those fish. Therefore, the average mortality rate from these studies (~1 percent) could be used as the discard mortality rate for yelloweye rockfish released with descending devices only for depths shallower than 30 fm (Options 1, 2A, 2B; Table 14).

Table 14. Proposed discard mortality rates by depth bin of capture for yelloweye rockfish released at the surface and with descending devices. Option 1 is a conservative approach that assumes 100 percent mortality in depths where survival has not been determined in recompression studies (> 30 fm). Options 2A and 2B, less conservative but potentially more accurate approaches, are based on theoretical yelloweye rockfish survival curves that were developed by shifting the blue rockfish (Option 2A) and black rockfish (Option 2B) curves seaward and having the decline in survival begin at 30 fm (Figure 8). Survival at midpoints of the 10 fm depth bins (e.g., 35 fm for 31-40 fm depth bin) were used for mortality rates.

		Descending devices		
Depth bin (fm)	Surface	Option 1	Option 2A	Option 2B
0-10	22%	1%	1%	1%
11-20	39%	1%	1%	1%
21-30	56%	1%	1%	1%
31-40	100%	100%	2%	2%
41-50	100%	100%	16%	5%
51-60	100%	100%	79%	23%
61-70	100%	100%	97%	56%
71-80	100%	100%	100%	83%
81-90	100%	100%	100%	91%
> 90	100%	100%	100%	100%

Until survival of yelloweye rockfish caught in depths greater than 30 fm and released at depth is studied, speculative mortality rates for fish caught beyond this depth and released with descending devices will may to be used.

A more conservative approach (Option 1; Table 14) would be to apply a 100 percent discard mortality rate to yelloweye rockfish caught deeper than 30 fm, whether they were released with a descending device or not.

However, it is unlikely that 30 fm is a "knife-edged" threshold depth beyond which all yelloweye rockfish die. The actual relationship between depth of capture and probability of survival likely resembles a logistic curve (with a tapering of survival by depth), similar to what was modeled for blue rockfish and black rockfish post-recompression survival in the Hannah et al. (2012) cage study (Figure 8). Since 100 percent survival of yelloweye rockfish occurred in the study depths (< 30 fm), the authors could not model the relationship between depth and yelloweye rockfish survival beyond 30 fm, which is necessary data for developing discard mortality rates with descending devices.

To predict this relationship in depths beyond 30 fm, the survival curves of blue rockfish and black rockfish could be shifted from their original depths of decline to 30 fm (depth beyond which yelloweye rockfish survival is unknown; Figure 8). These theoretical yelloweye survival curves could then be used to develop discard mortality rates for yelloweye rockfish caught deeper than 30 fm and released with descending devices (Table 14). Options 2A and 2B may still be considered conservative because the depth of declining survival begins at 30 fm, but may actually occur beyond 30 fm.

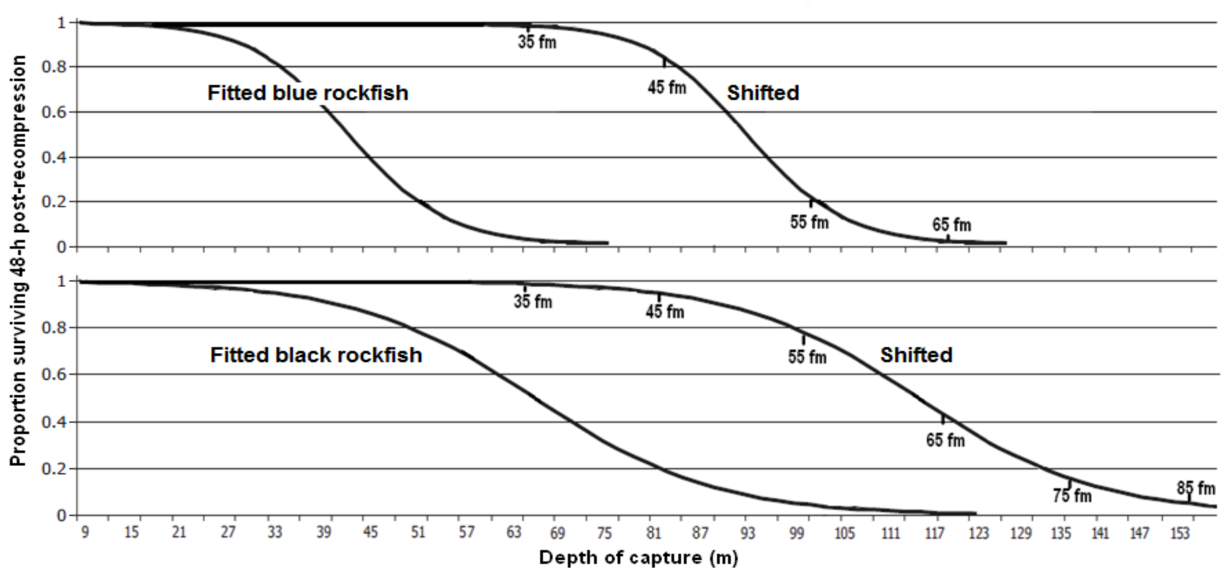

Figure 8. Fitted 48 hour post-recompression survival curves by depth for blue rockfish and black rockfish from Hannah et al. (2012) and shifted curves (point of initial decline of survival in each fitted curve shifted to 30 fm). Shifted curves are theoretical relationships between depth and survival of yelloweye rockfish released with descending devices.

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Appendix 1. Overview of Current Research

Several recent studies have looked at the physical effects of barotrauma on rockfish and at the effectiveness of deepwater release to improve the survivability of rockfish suffering from barotrauma.

In general, these studies showed that rockfish released back to the depth of capture have improved survivability (reduced discard mortality) compared to fish released at the surface. Mortality rates for fish released back to the depth of capture are highly variable between species. Other variables such as temperature, time at the surface and depth of capture also affect survival. Most studies have looked at short term survival (two-four days) after recompression. There is little information on the effects of barotrauma on longer term survival.

The summary below focuses on research used in this report to produce estimates of mortality for yelloweye and cowcod rockfish released with a descending device. The annotated bibliography provided by Alana Pribyl for the June Council meeting offers a comprehensive summary of additional research related to barotrauma http://www.pcouncil.org/wp-content/uploads/D2a_ATT2_ANNOTATED_BIB_JUN2012BB.pdf .

Jarvis and Lowe, 2008 looked at the effects of barotrauma on both the initial capture survival and the short term (2-day) survival of line caught rockfish off southern California following recompression.

Initial capture survival was studied by characterizing captured fish according to external signs of barotrauma including stomach eversion, exophthalmia (bulging eyes), corneal gas bubbles, subcutaneous gas bubbles, and prolapsed cloaca. Demersal rockfish species were targeted in depths ranging from 10-52 fm. Handling time to measure and examine fish was kept to less than 2 minutes. Fish were placed in a live well with fresh seawater for 10 minutes and observed for gill ventilation as a sign of initial capture survival. The fish were then euthanized and dissected within 24-48 hours to determine the internal signs of barotrauma.

One hundred sixty-eight rockfish representing 21 species were captured and examined for external signs of barotrauma and initial capture survival. Vermilion, greenspotted, olive, halfbanded and honeycomb rockfish comprised the majority of the catch. Initial capture survival was 68 percent overall but varied by species. Eight of 12 species had greater than 75 percent initial capture survival, whereas olive and rosy rockfish had low survival. Fish caught at deeper depths generally showed higher numbers of trauma but species caught at shallow depths showed relatively similar survival proportions as species caught in deeper depths.

Two-day post recompression survival was studied by capturing nearshore and shelf rockfish at depths ranging from 27-49 fm. External signs of barotrauma, bottom depth, time of capture and standard length were recorded for each fish. Fish were externally tagged before being lowered back to the original capture depth in coasted wire mesh cages. Cages were left on soft bottom near the fished reefs for two days. After the two days, the cages were pulled up to 11 fm where divers met the cage and assessed each fish for mortality and external signs of barotraumas. The observation depth was chosen to reduce the probability of barotrauma injury resulting from the second decompression event. Dead fish were retained and examined for signs of internal barotrauma and live fish were released.

Three hundred twenty eight rockfish representing 17 species were captured and examined for external signs of barotrauma, 257 fish were recompressed to the original capture depth to assess the two-day post recompression survival. The average capture depth was 39 fm and ranged from 30 – 44 fm. Five species; vermilion, bocaccio, flag, squarespot and honeycomb rockfish comprised the majority (82 percent) of the catch. Overall short term survival of rockfish was 68%, similar to the initial capture survival (68 percent). Less than 1 percent of the caged fish showed external signs of barotrauma 2 days after recompression. Two-day post recompression survival was species-specific and ranged from 36 percent for squarespot to 82 percent for starry rockfish. There was a significant difference in species survival among the five most abundant species; squarespot rockfish showed the lowest survival and bocaccio rockfish showed the highest survival (89 percent).

The study found that although there were species-specific differences in the types and degree of barotrauma, most rockfish showed greater than 75 percent initial capture survival, suggesting that the degree of barotrauma is not a good predictor of initial mortality (within the first 10 minutes of capture).

The authors suggest that intraspecific variability in barotrauma responses of fish captured at similar depths could be due to differences in the relative volume of the swim bladders when the fish are caught. They explain that the extent of barotrauma will vary depending on whether the fish is neutrally buoyant at the depth of capture. In addition, interspecific variability in swim bladder morphology may influence the occurrence of swim bladder tears. The swim bladders of olive rockfish observed in this study were relatively thin compared to more robust swim bladders observed in vermilion, copper and brown rockfish. Olive rockfish showed high mortality and high occurrence of swim bladder tears.

The study suggests that species-specific differences in external signs of barotrauma could be related to species differences in body morphology and the degree of movement in the water column. Rockfish like bocaccio with more elongated, laterally compressed bodies that occurred in schools off the seafloor like showed few signs of barotrauma. Rockfish like vermilion with relatively deeper bodies that are more demersal showed a high degree of barotrauma. The researchers point out that although it might be expected that fish that showed a high degree of barotrauma would have low post recompression survival they did not observe that trend.

Depth was not a significant predictor of 2-day post recompression survival of rockfish in this study but other studies have shown depth to significantly affect post release survival (Wilson and Burns 1996; Morrissey et al. 2005; St John and Syers 2005). Differences in foraging behavior (benthic predators vs. water column planktivores) and differing swim bladder morphology suggest that depth effects on rockfish are likely to differ by species.

This study found surface holding time was found to have a significant effect on recompression survival. Fish held at the surface for 10 minutes or less had a 78 percent probability of survival following recompression and increased to 83 percent if fish were released within two minutes of landing. Surface holding time may explain species specific differences in survival in this study.

Of the five most abundant species caught, squarespot rockfish showed the lowest survival. These fish were held at the surface an average of 5 minutes longer than the other four species. The difference in holding time was not significantly different but may have been biologically different.

This research provides evidence of both short and long term post release survival of line-caught southern California nearshore and shelf rockfish recompressed to capture depths from 30- 44 fm and also found that recompression is most effective if fish are released back to depth within minutes of capture.

The authors point out that for long lived species like rockfish it may be important to consider cumulative mortality risk, which increases exponentially with every recapture (Bartholomew and Bohnsack 2005).

Hannah et al. 2012 used a cage system designed to minimize the adverse effects of caging fish in the field to evaluate the discard mortality of seven species of rockfish with barotrauma.

The primary objective this study was to measure short term (48 hour) post recompression survival for a variety of Pacific rockfish species commonly captured in the recreational hook and line fishery in the northern California, Oregon and Washington (NCOW) area as a function of capture depth.

The lack of information on post recompression survival for most NCOW can in part be attributed to the difficulties with controlling for the adverse effects of caging fish. Adverse effects can include strong currents and large waves that create movement in a cage moored to the seafloor and causes stress and injuries; parasitic amphipods or sand fleas may adversely affect the survival of cages fish. Cages constructed from netting or aluminum bars cause lesions from repeated contact with the sides of the cages and allowed caged fish to be susceptible to parasitic amphipods. A special cage system was designed for this study to minimize these adverse effects.

The key features of the cage used in this study included nonabrasive surfaces for any part that would come into contact with the fish and sufficient weight to resist movement in currents and movement caused by the mooring line and exclusion of amphipods while maintaining adequate water exchange. An opaque, non-abrasive plastic drum was used in place of a cage constructed of wire or netting. The drum was positioned so it was isolated from the mooring line and was attached directly to a heavy bracket to reduce the potential for movement. Ventilation holes were covered with fine mesh stainless steel screens to protect the fish from parasitic amphipods.

Rockfish were captured at reefs off Seal Rock, Cape Perpetua, and Lincoln City, Oregon using standard recreational hook and line gear. A variety of fish were targeted at depths ranging from 5-35 fm.

Following capture fish were scored for seven signs of barotrauma, measured for fork length and photographed. The fish were then place in cages and evaluated with respect to orientation (upright, on its side or belly up), activity level (strong, week or none) and the presence or absence of movement in the operculum, body and tail. The surface interval time was calculated from the time the fish was brought on board to the time the cage was deployed and was minimized as much as possible. It was assumed that minimizing the surface interval would best mimic the experience of a typical discarded rockfish. The target duration for cage confinement was 48 hours but at times it was necessary to shorten or extend the caging period. Upon retrieval, fish were evaluated while still in water in the cage for condition. Once removed from the cage signs of barotrauma were recorded. Each fish was released into the ocean and its ability to descend was noted.

While the primary interest was the effect of depth of capture on post recompression survival, three other variables that can be related to survival; fish length, the surface to bottom temperature differential and time at the surface were also evaluated.

Two hundred eighty-eight individuals of seven species were captured from six depth intervals and evaluated for 48 hour post recompression survival. Species collected included 144 black rockfish, 36 blue rockfish, 42 canary rockfish, 3 china rockfish, 10 copper rockfish, 28 quillback rockfish and 25 yelloweye rockfish. The rockfish ranged from 22-52 cm in total length and time on deck averaged less than 3 minutes per fish with a range of 1-9 minutes. Only 12 fish had a time on deck of 5 minutes or more and all of those survived.

Up to a capture depth of 30 fm post recompression survival was 100 percent for yelloweye rockfish and copper rockfish and 78 percent for blue rockfish. Up to a capture depth of 35 fm, survival was 100 percent for canary rockfish and quillback rockfish and 90 percent for black rockfish. Across species, the frequency of visible signs of barotrauma was not a good indicator of survival potential. The high survival of canary and yelloweye rockfish occurred despite the frequency of high visible barotraumas scores. The lower 48 hour post recompression survival of blue rockfish occurred despite relatively low visible barotraumas scores.

Logistic regression analysis showed that 48 hour post recompression survival in black rockfish was negatively associated with depth of capture ($P < 0.01$) and the surface-bottom temperature differential ($P < 0.01$) but not with fish length or surface interval ($P > 0.05$).

Fitted logistic curves showed that across the range of depths and temperatures observed in this study, depth of capture had a stronger negative effect on survival in black rockfish than did the surface-bottom temperature differential. Increasing depth of capture reduced post recompression survival more rapidly and at shallower capture depths for blue rockfish than for black rockfish.

The cage design was very effective at minimizing the adverse effects of caging rockfish. The majority of individuals were in excellent condition after cage confinement. Although adverse cage effects were greatly limited, the estimates of 48 hour post recompression survival from this study only apply to discards under a carefully considered set of conditions. Survival estimates from this study are only representative for quickly released rockfish that either descend to depth successfully on their own power or that are assisted to depth with recompression devices and not to situations when re-submergence is delayed or unsuccessful. The authors suggest that survival estimates from this study be viewed as the upper limit for post recompression survival because other possible effects such as deeper capture depths, predation on released fish, poor handling and any other adverse effects from recompression devices on survival were not considered.

The authors also caution that this study produced only small sample sizes for some species and depths indicating greater uncertainty in the mortality estimates generated for those species and depths. Longer term survival for the species in this study has not been studied.

Hochhalter and Reed, 2011 developed a study to quantitatively evaluate the effectiveness of deepwater release at improving the survival of discarded yelloweye rockfish in the wild.

The authors cite the Jarvis and Lowe, 2008 field study and Parker et al. 2006 laboratory study as examples of high sort term survival for rockfish released quickly back to the depth of capture but suggest that the mortality estimates from these reports may represent the upper bound of survival because they don't account for delayed mortality.

To address this, Hochhalter and Reed developed a study that would allow rockfish to be at liberty in the wild long enough to incorporate delayed mortality beyond two days and that would include the effects of behavior impairment and predation.

A mark recapture study was used to collect individual encounter histories of yelloweye rockfish released at depth. Anglers used hook and line to capture yelloweye rockfish on an isolated reef in Prince William Sound, Alaska in mid- May 2009. Fishing was conducted across the entire summer fishing season and included a wide range of tackle to represent the range of recreational fishing conditions. Fishing was conducted over a 7-day time period followed by a 10-day hiatus. Survival was estimated for the 17-day time interval separating the midpoints of the consecutive sample sessions. Time of hook-up, reaching the surface, beginning of descent, and release were recorded for each captured fish. Once at the surface, fish were measured for total length (mm), assessed for external signs of barotrauma, and examined for hook location. Fish were given a passive integrated transponder (PIT) tag as a primary mark and an individually numbered T-bar tag as a secondary mark. The presence or absence of external barotrauma signs was assigned using the criterion outlined by Hannah et al. (2008). Only 8 percent of the captured yelloweye rockfish were at the surface more than 10 minutes. Fish were released back to the bottom using a 680 g lead-head jig with the barb filed off.

A total of 182 individual yelloweye rockfish were captured and tagged. Forty five yelloweye were recaptured once and 8 were recaptured twice. Depths of capture ranged from 12-40 fm. The average survival probability for yelloweye rockfish released at depth was 98 percent

The study also looked at the ability of rockfish to successfully submerge after being released at the surface; this is considered the most critical step to surviving discard mortality and has been cited as an appropriate proxy for survival after release at the surface (Hannah et al. 2008).

Hook and line gear was used near the mark-recapture reef to target yelloweye rockfish and estimate submergence success. Captured yelloweye were measured and assessed for external signs of barotraumas. Fisher were then released at the surface and observed for 30 minutes.

A total of 95 yelloweye rockfish were captured and released at the surface to estimate the probability of re-submergence. Of the 95 individuals observed, 21 successfully re-submerged for a submergence probability of 22 percent. The estimate of submergence probability was used as a maximum survival estimate for yelloweye rockfish released at the surface and compared with the estimate of survival for fish released at depth. The results indicate that the average survival of discarded yelloweye rockfish can be increased by 4.5 times if the fish are released at depth quickly after capture (< 2 minutes) rather than at the water's surface.

Wegner, Pribyl and Hyde (in prep.aration) http://www.pcouncil.org/wp-content/uploads/D2c_SUP_SWFSC_PPT_VETTER_JUN202BB.pdf, studied the post release survival and behavior of deep-dwelling rockfish suffering from barotrauma.

In this study fifty shelf rockfish caught off southern California in 44-98 fm were fitted with acoustic tags and released using descending devices to reduce bycatch mortality. Tagged fish were tracked with an array of six receivers that recorded depth and acceleration providing information on movement and mortality over a four month study period. In addition to bank (n=12), bocaccio (n=13), starry (n=3) and sunset rockfish (n=13), 9 cowcod were also tagged.

Thirty nine (78 percent) of the tagged fish survived after two days and twenty three (46 percent) of the tagged fish survived ten days after being released. Three tagged fish died after two-days and seven died after ten-days. Eight fish were unaccounted for after two days and twenty fish were unaccounted for after ten-days.

Of the nine cowcod tagged in this study, all (100 percent) survived after two days, five were assumed to have emigrated from the study area and the four (44.4 percent) that remained within the range of the receivers survived. Bank rockfish did not do as well as the other four species in the study and the extent of barotrauma injuries suffered by this species were more severe than the other species suggesting they may be more susceptible to barotrauma with only 33 percent surviving to ten days. Excluding bank rockfish 87.5 percent (21/24) of the tagged rockfish that remained in the study area survived to ten days. If you include bank rockfish in the estimate of survival 76.7 percent (23/30) of the tagged rockfish survived to ten days.

The majority of mortality occurred within the first two days and no additional mortality was observed in fish that remained within the range of receivers between ten days and the remainder of the four month study. Some of the captured fish were selectively included in the study due to their relatively good condition at the time of capture which may bias the results toward higher survival.

Smiley and Drawbridge, 2007 used a portable hyperbaric chamber to evaluate the feasibility of restoring depleted rockfish stocks by breeding them in captivity and releasing offspring into the wild.

This paper describes the development of a portable hyperbaric chamber that allowed for fish to be caught manually by hook and line, quickly recompressed, transported and then decompressed over time while allowing for observation, stable water temperature and good water quality.

The study focused on bocaccio, cowcod and vermilion rockfish because of their commercial and ecological importance, depleted status and recognition that population rebuilding times would be long. Bocaccio and vermilion had been successfully kept alive following capture but because cowcod had not it was the focus of the study. Fish were caught between 50 and 80 fm.

The study was broken down into three phases for the development of the hyperbaric chamber

Phase I: Assessed gear types and ascent rates to determine species specific catch per unit effort and relative sensitivity to barotrauma.

Phase II: Designed to test the use of a two chamber hyperbaric system for onboard recompression and define all of the protocols associated with fish handling.

Phase III: Implemented the refined protocols and the four chamber hyperbaric system.

Once caught, fish were examined for external signs of barotrauma such as protruding eyes, extruded stomach, orientation, respiration and buoyancy.

In Phase III, 16 cowcod were recompressed and decompressed and 11 survived to feed, yielding a survival rate of 69 percent.

Appendix 2. Research and Data Needs

The following section is the result of a GMT brainstorming session, trying to determine possible future research and data priorities; it still needs to be organized and refined. It is included in this report to help facilitate discussions with the SSC, other advisory bodies, and the Council. After the discussions in November, the GMT will update, organize, and refine this section.

In Section 3, we outlined discussed methods of using the information currently available in the literature to inform discard mortality rates by depth when descending devices are used. However, it is possible that the literature does not yet contain a sufficient amount of information to inform the use of these methods for management.

Surface mortality

At the time the surface mortality rates were estimated (PFMC and NOAA, 2009), the GMT also identified uncertainties and data needs:

- Limited data for several species
- Very limited information about post-release mortality rates
- Insufficient data to evaluate differences in depth effects among species
- Lack of depth-specific information in delayed mortality adjustments
- No additional uncertainty associated with delayed mortality adjustment
- The data do not cover the entire coast (i.e. ends at the OR/WA border) and ignore possible regional differences, such as temperature effects.

Using proxy species for yelloweye rockfish and cowcod:

The GMT investigated the possible use of blue and black rockfish barotrauma studies to inform depth-based mortality rates for yelloweye (cite those studies). The GMT is not recommending the use of these species as proxies for yelloweye because:

- these studies indicated that barotrauma effects (visible and non-visible) varied by species, and by depth of capture and release; and
- it is therefore uncertain whether these species are appropriate proxies for yelloweye.

This dialogue on using proxy species prompted further discussions about what information would be needed to inform future management decisions regarding differential mortality rates when descending devices are used. Several GMT members and Council staff indicated that there is interest from the public (including academia) to conduct more barotrauma-related research that is more management relevant. The following questions were considered priorities for future research.

What is a sufficient sample size by species and depth? To help inform future research priorities, input from the SSC regarding minimum and maximum sample sizes would be helpful.

When considering the current body of research as a whole, are there species that would be appropriate proxies for yelloweye and cowcod?

Specifically, would more robust species with thick-walled swim bladders be appropriate for yelloweye and canary proxies? Particularly those species that are from the same guild or stock complex.

What specific research would help inform this? Increased depth sampling, commercial nearshore observer or electronic monitoring (EM), and tagging data could be integrated with existing studies and expanded.

Is rockfish physiology or depth of capture more indicative of an appropriate proxy species?

Collected more information on yelloweye and cowcod physiology relative to other species studied.

Is bottom shape more or less sensitive to barotrauma? For example, how do bocaccio more streamlined build),yelloweye (more deep-bodied), and squarespot (built more like uncommon, Southern CA species) compare in terms of their barotrauma effects?

Our understanding is that yelloweye and cowcod typically rest on the near the bottom. Therefore, to what degree do they use their swim bladders? Does this influence how much they are affected by barotrauma?

The GMT recommends inviting current experts in barotrauma research in order to continue this dialogue with the GMT, SSC, and the Council to help answer the questions above.

How often and how correctly descending devices are used:

In addition to the current state-of-our-knowledge relative to barotrauma effects on rockfish, a key component to implementing discard mortality rates is to understand how often and correctly are descending devices being used. To obtain this information, the GMT discussed the possibility of adding questions to the state-level dockside surveys that are currently conducted.

The following questions were proposed:

Of the yelloweye and cowcod released on this trip, what was the depth of capture and release?

Were descending devices used for releasing these species?

If so, how many yelloweye and cowcod were released with descending devices?

Please estimate the amount of time these yelloweye and cowcod spent on-deck, prior to being released with a descending device.

Answering these questions is important for both surface release and descending device assumptions. However, it is widely understood by the GMT that survey interviewers are often pressed for time, and have to consider how amenable fishermen are to being asked questions after their fishing trip.

Trade-offs relative to collecting information to answer this question:

Key questions to the state sampling programs: would the states be willing to change their survey question structure to accommodate the above questions (or similar questions)? If we add questions for yelloweye and cowcod, would adding these same questions for other rockfish species be an additional marginal or significant cost? If the cost is marginal, perhaps these questions could be asked for other rockfish species.

Members of the GMT noted at this meeting that adding even one or two questions to current survey efforts will likely result in losing some biological information (i.e., less time to ask all of these biological questions). Or, some proportion of interviews may be lost. ODFW mentioned that their samplers have indicated that approximately 1-2 interviews per hour would be lost, if more questions were added to their current survey. For this report, the WDFW and CDFG did not have enough time to characterize the cost to their current survey efforts.

Current state sampling rates:

We received input from Russell Porter (RecFIN) at this meeting. He mentioned that samplers have indicated that they are sampling at higher rates than is necessary. We would like to follow-up with him, and possibly others, for clarity. That is, is the sampling rate higher than is necessary for salmon sampling goals, relative to groundfish sampling goals? Based on Mr. Porter's comment, the following questions were proposed:

Would it be beneficial to scale back the number of interviews and focus on getting more detail in these interviews? I.e., adding barotrauma-related questions.
Has an analysis been conducted recently to determine appropriate sampling levels for groundfish management purposes?

The following section highlights some ideas on how this information could be collected, including some novel approaches that may help reduce the burden on state sampling personnel.

Technology and tools:

It may be beneficial to investigate methods of encouraging voluntary adoption of commonly used modern technologies to help augment current creel survey efforts. Increased popularity of iPads™, digital cameras, GoPro™ cameras, and social media could be merged with creel efforts in the future. Many fishermen carry digital cameras these days (e.g., on their smartphones) so this effort could allow for incorporation of digital verification of species to improve species identification accuracy. Additionally, if efforts on improved voluntary data acquisition prove to have merit, future tests merging creel survey efforts with voluntary methods could be realized. This information stream may significantly improve the ability of recreational fishery managers to manage fisheries in near real-time, especially in salmon fisheries, allowing greater Near Real Time (NRT) nimbleness in management response. Additionally, further research in species-object recognition could complement these efforts, and help prevent from the accumulation of unsampled digital photo data.

Provide voluntary sport logbooks, such as those with laminated data sheets, clipboards, and wax pencils. Also, dockside samplers could be furnished with digital cameras to take photos of these laminated data forms for incorporation into creel data during sampling downtimes and daily reconciliation. The log could include all species caught released, depth of catch and/or release, and GPS location.

Recommend the development, or use of, descending devices with a gauge that records depths of release. This would be a more accurate than relying upon angler memory of depth of release. Samplers could review the descending device records.

Create a website where anglers can submit voluntary information, with potential smartphone and/or tablet compatibility. Individual passwords for each fisherman would be provided to follow their efforts throughout the year. Fishermen could add photos when submitting information. Fisherman may have a greater sense of ownership of their data, and the assumptions that result from potential use of this data. Fisherman could then see their annual catch histories and any credits attributed to their use of descending devices. Other information that could be provided to anglers may include:

estimated catch summaries (by state, regional areas within states, etc.);

short term and long term trends in estimated harvest to show anglers the positive effects of using descending devices; and

any other information that could be incorporated into "canned" status reports such as fact sheets with illustrations of the more difficult species of rockfish to identify and tips on identifying rockfish.

Collect information about the use of descending devices by anglers in a manner similar to how economic data are currently collected by NMFS/MRIP for recreational fisheries nationwide ("economic add-on"). That is, at the end of their interview, ask anglers whether they would be willing to participate in a short follow-up interview, via phone, e-mail, or mail.

Create incentives for fishermen to participate in these programs

Recreational anglers with a track record for providing voluntary, high quality data, could be given “credits” that might translate to more fishing opportunities, similar to lottery hunting programs.
Recommend a version of the “master hunter” program where anglers are trained in species identification, the use of descending devices, etc. Anglers participating in such programs in one year could then be entered into a lottery for an additional fishing weekend the following year.

Outreach and education:

It may be worthwhile to add some sort of social media component such as linking to public education sites and giving “credits” to recreational anglers who participate in voluntary programs.

Appendix 3. Oregon Ocean Recreational Boat Survey Interview Guide

To provide an example of the information samplers are currently required to obtain during each interview, an excerpt from the ORBS Sampling Manual (2012) is below. The sampling programs in Washington and California have similar protocols, though the exact questions may vary.

INTERVIEW GUIDE FOR ORBS SAMPLING

Interviewing private anglers and charter boat captains can be challenging. The ORBS interview template provides an example on how to successfully conduct an interview by insuring that all questions are asked correctly and in a logical sequence. In addition, the template walks through the data elements that are required for the Nomad. Experienced samplers may develop their own method of conducting interviews provided that all data elements are collected. Remember when dealing with the public to be courteous and professional.

ORBS samplers should interview and sample catch from as many private boats as possible during working hours. In addition, samplers should interview as many charter boats as possible using a stratified sampling design to insure all trip types are interviewed for each statistical week. The procedure will vary slightly depending on the port configuration, but the general process is outlined here and will aid in guiding you through the interview and sampling methodology. The interview guide has been divided into two sections:

interviewing returning private boats, and

interviewing returning charter boats

Private Boat Interview

In a given area, the sampler will interview the first private boat seen coming in after the conclusion of the prior interview. Do not deviate from this selection process, even if you think the boat wasn't fishing.

Once the sampler spots a recreational boat returning, the sampler will attempt to follow that boat to its landing location. Always approach the boat with a good attitude, and be polite and professional.

Trip Interview

BOAT: Try to record in the Nomad the boat number when you are following the boat to its landing location, or when you first approach the boat. If not, record it when you first arrive. If the boat is mooring in a slip, wait for them to get the boat tied down before beginning your interview.

INTRODUCTION: "Hello, my name is _________ and I represent Oregon Department of Fish and Wildlife". At this point it is always good to converse briefly with the anglers about their trip, regardless if they were fishing or not. For example: "How was it out there?" or "Did you have a good time?", etc. Proceed to question 3.

INTENTION: "I have a few interview questions about your trip..." and if you know already that the boat was fishing then add "and would like to sample your catch". Proceed to question 4.

OceanEstuary FIELD: "Did you spend time in both the ocean and estuary, or only one?" If they went in both the estuary and ocean you will enter (Y) in this Nomad field and you will need to conduct two interviews starting with the ocean. If they only fished in one you will enter (N). If the trip was non-fishing, you will still need to enter where they went, in both the ocean and estuary (Y) or only one (N). Proceed to question 5.

TripType FIELD: If they went fishing ask "What was the main species that you fished for?" The pull-down menu will provide all possible options. Proceed to question 6.

Num of Anglers FIELD: "How many people were fishing on this trip?" Enter the number of anglers in this field. Note: some individuals aboard the boat may not have fished, therefore it is very important you ask, do not just assume all were fishing. Proceed to question 7. If it was a non-fishing trip (boat ride) you would enter in the angler field the total number of people in the boat.

Area FIELD: "What area did you fish?" or "where did you fish?" record the correct salmon management area in to this field. If the anglers were bottom, halibut, or spear fishing proceed to question 8, otherwise proceed to question 9.

Reef FIELD: If they were bottom, halibut, or spear fishing show them the reef charts and ask "What reef area did you catch the majority of your fish?" If they didn't catch any fish then ask "What reef area did you spend the majority of your time fishing?" Proceed to question 9.

Depth FIELD: "What was the bottom depth where you caught most of your bottomfish including any you released?" If they were bottom, halibut, or spear fishing and didn't catch any fish then ask "At what bottom depth did you spend the majority of your time fishing? Proceed to question 10, if the boat has landed and retained fish.

Departure time FIELD: For an estuary trip - "What time did you leave the dock this morning?", and for an ocean trip – "What time did you cross the bar this morning"? The next field, "TripHrs FIELD" automatically calculates the trip duration. If you don't enter the departure time right away during the interview, then the calculated trip duration is incorrect. If this happens you will need to correct the trip duration time. Proceed to question 11.

Crabbed FIELD: "Did you crab during the trip"? Enter (Y) for yes and (N) for no. If they crabbed enter the number of Dungeness crab retained in the "encounter screen". Do not enter any other crab species. Proceed to question 12.

The Nomad "trip screen" is completed once all the questions above have been answered. At this time, proceed to the "encounter screen" if the boat has landed and retained fish. If the trip was non-fishing, proceed to the next boat.

The following information is required to complete the "encounter screen":

Species name

Number landed and retained (which is the "catch" field in the encounter screen)

Number released by species

Number of salmon that were tagged with CWT

Number of salmon that have an adipose fin

The sampler is required to count and identify all fish species landed and retained. In addition, the sampler is required to bio-sample a portion of the catch and scan salmon, halibut, and black rockfish in accordance to the sampling goals. There are three ways in which the fish can be examined:

Onboard the boat

On the dock (ask the angler(s) to pass the fish to you on the dock), and

At the fish cleaning station. (follow the angler(s) to the cleaning station)

If the fish species are unknown, ask the angler(s): `"What fish species do you have onboard?"` Proceed to question 13.

Once the sampler knows what species are onboard, then a decision can be made on what information is required. If bio-samples and/or scanning is required then proceed to question 14, if not proceed to question 15.

Ask the angler(s): "I will need to examine the fish and sample the _____ species" and "The preferred method would be if you pass me the fish so that I can sample them on the dock." If the angler is reluctant to pass the fish to you then state "Alternatively, I could sample them aboard the boat." Proceed to question 16.

Ask the angler(s): "I will need to examine the fish" and "Would you prefer to pass them to me so that I can examine them on the dock or would you prefer me to examine them onboard your boat?" Proceed to question 16.

After you have examined all of the fish and collected all needed samples, then ask the angler(s): `“Did you release any fish during your trip?”` If they answer <u>No</u> then say `“thank you for your time.”` Record their answer and move to the next boat. If they answer <u>Yes</u> then ask: `“What species and how many?”` If they are uncertain of which species they released you can show them some printed information to assist them in identification. If they are still uncertain enter the unknown species code for that species group, i.e., unknown rockfish is code 410. Do not guess about what species were released. <u>Record their answer and move to the next boat</u>.

Interview protocol for incomplete private boat trips

In some ports, recreational fishing anglers may return to port for a variety of reasons (picking up or dropping off an angler, restroom breaks, etc.) even though they have not completed their fishing trip and plan to head back out. If you encounter this and <u>**the entire party intends to head back out**</u>, an interview with those anglers should be conducted as **Private, Non-fishing** and a note should be created in the notefield (see page ____) indicating the interview is **incomplete**.

If, however, <u>**any member(s) of the party do not intend to head back out**</u>, the angler(s) should be interviewed using the same methodology for a returning boat. Under this scenario, there would be no need for an incomplete interview note for any of the anglers since they completed their fishing trip. Additionally, as the boat heads back out with the remaining anglers, a new departure time should be assigned and the trip should be treated as a new fishing trip if it is interviewed later when the trip is complete for the remaining anglers.

If a boat returns multiple times on a given day, follow the procedure described above, interviewing any anglers that have completed their trips for the day and assigning new departure times to the boat each time it heads back out. Continue this methodology until the boat returns for the final time and the last interview is conducted.

Charter Boat Interview

The charter boat selection methodology is a modification of the private boat process. The two factors that need to be considered when selecting a charter boat are:

Sampling the first charter boat seen returning after the completion of the prior interview, and

Ensuring all trip types are covered during the statistical week.

Work with the other samplers in your port to ensure adequate coverage of all trip types.

Interview procedure

Each charter boat has unique sampling challenges, these challenges should be discussed during your in port orientation. In addition, you should make an effort to introduce yourself to the employees at the charter boat offices during the port orientation, and to the captain and crew of the charter boats as you encounter them. It is your responsibility to fully understand how best to sample the charter boats within your port. Contact Jason Edwards at (541) 867-0300 ext. 271 or your assigned sampling coordinator if you have questions.

Always approach the charter boat with a good attitude, and be polite and professional. This will aid in developing a good working relationship with the charter companies and boat captains, which will make your job easier and more enjoyable.

Trip Interview

In some cases the sampler will need to examine the fish first and then interview the charter captain. If you sample the catch first then proceed to step M, if however, you interview the captain first then proceed to question A.

BOAT: Try to record in the Nomad the charter boat name when you are following the boat to its landing location, or when you first approach the boat.

INTRODUCTION: You should already know the captain so there is no need to introduce yourself as an ODFW employee, just say `“Hello Captain ________”.` However, if it is your first time interviewing the captain then state. `“Hello, my name is _________ and I represent Oregon Department of Fish and Wildlife”.` At this point it is always good to converse briefly with the captain if he seems interested and if you have time, if not proceed to question C.

INTENTION: `“I have a few interview questions about your trip...”` Proceed to question D.

OceanEstuary FIELD: `“Did you fish in both the ocean and estuary, or only one?”` If they fished in both the estuary and ocean you will enter (Y) in this Nomad field and you will need to conduct two interviews starting with the ocean. If they only fished in one you will enter (N). If the trip was non-fishing, you will still need to enter where the boat went, in both the ocean and estuary (Y) or only one (N). Proceed to question E.

Fishery FIELD: `“Did you fish in the ocean, or in the estuary?”` Enter (O) for ocean or (E) for estuary in this field. Proceed to question F.

TripType FIELD: `“What was the main species that you fished for?”` The pull-down menu will provide all possible options. If the target species is different from the information you received from the charter office, then you will need to change the trip type on your Charter Effort Form (page ______) and possibly the Recreational Ocean fishery Effort Form (page ______) to match the interview, and write a note that there was a change in the Nomad **“note”** field **AND** on the Recreational Ocean Fishery Effort Form. Proceed to question G.

Num of Anglers FIELD: "How many people were fishing on this trip?" Enter the number of anglers in this field. Also, ask "Did any crew fish on this trip?" If the answer is yes then ask "Is that in addition to or does that include _______ anglers?" Proceed to question H.

Area FIELD: Ask them what salmon management area they fished in "What area did you fish in?" record the correct area in to this field. If they were bottom, halibut, or spear fishing proceed to question I, otherwise proceed to question J.

Reef FIELD: If they were bottom, halibut, or spear fishing show the captain the reef charts and ask "What reef area did you catch the majority of the fish?" If the boat didn't catch any fish (very unlikely) then ask "What reef area did you spend the majority of your time fishing?" Proceed to question J.

Depth FIELD: "What was the bottom depth where you caught most of your fish including any you released?" Proceed to question K.

Depart. Time FIELD: "What time did you cross the ocean bar this morning?", or in the case of an estuary trip "What time did you leave the dock this morning?" The Nomad automatically calculates the trip duration, which is the next field, "TripHrs FIELD." If you don't enter the departure time right away, during the interview or directly after, then the Nomad's calculated trip duration is incorrect. If this happens you will need to correct the trip duration time. Review the Nomad edit instructions. Proceed to question L.

Crabbed FIELD: "Did you crab during the trip?" Enter (Y) for yes and (N) for no. If they crabbed enter the number of Dungeness crab retained in the "encounter screen". Do not enter any other crab species. Proceed to question M.

The Nomad "trip screen" is complete once all the questions above have been answered. At this time, proceed to the "encounter screen". If the charter did not land and retain any fish proceed to the next boat. **Make sure you ask question "L" before proceeding to the next boat**. The vessel may have not landed any fish, but may have released some.

Encounter Screen or Worksheet Screen

Don't forget to ask the captain: "Were there any fish released during the trip?" Record the numbers by species in the Nomad. You can enter the released data before you enter the catch data if needed. Proceed to question N if you have not examined the catch. If you have already examined the catch, move to the next boat.

The following information is required to complete the "encounter screen".

Species name

Number landed and retained (which is the "catch" field in the encounter screen)

Number released by species

Number of black rockfish and halibut scanned for PIT tags (if applicable)

Number of salmon that were tagged with CWT

Number of salmon that had their adipose fins clipped.

Once all the fish species are available, the sampler should be able to collect all the required information to complete the interview process. Typically, during charter trips the returning anglers are provided with baskets to carry their fish. Once the angler disembarks the boat the fish are either filleted or transferred to a bag for home-packing. The sampler is required to count and identify all fish species landed and retained. In addition, the sampler is required to bio-sample a portion of the catch and scan salmon, halibut, and black rockfish in accordance to the sampling goals. There are three ways in which the fish can be examined:

Onboard the charter boat before the anglers disembark,

At the charter office fish fillet station, and

On the dock (some anglers may wish to dress the fish themselves)

An efficient way to count and identify the catch is to systematically examine each basket of fish on the dock or at the fillet station. Ask the filleter(s) before the boat arrives if you can use one of their baskets (make sure you clean the basket once you are finished). You can then move systematically down the line, moving fish from the angler's basket to the empty basket. This method provides three advantages:

No fish are missed,

Each fish is handled for identification, bio-sampling or scanning if needed, and

Each angler's catch is kept separate

For bio-sampling fish species remember to follow the **sampling methodology**. Discuss your intentions with the filleter(s) before the boat returns. The filleter(s) will want to start dressing the fish as soon as possible, so work out an arrangement with them before the charter boat arrives. Proceed to question O.

Ask the angler(s): `"I will need to examine your fish and sample the ______ species".` Use the systematic sampling method as described above, moving fish from the angler's basket to the empty basket. During this process you should take your bio-samples and scan all required fish. Proceed to question P.

Proceed to next angler and question N until all fish have been sampled. Move to the next boat once all the fish have been examined and you have interviewed the captain. However, if you have not interviewed the captain proceed to question A.