Project Title:

PSMFC 2014 EM Research: Species Density and Discard Weight Studies

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Overview

Fisheries management of the Pacific Trawl Rationalization Program fishery relies on efficient and accurate estimation of the weight of discarded Individual Fishing Quota (IFQ) groundfish species (and species groups) that occur in the fishery. Quota management of these species is based on weight of fish harvested and discarded. At-sea compliance monitors are currently deployed into this fishery to identify and weigh all at-sea discards of IFQ species (100% monitoring).

This requirement is necessary since there are currently no other methods to speciate and estimate weights of at-sea discards. However, on-board monitors can increase costs and reduce flexibility in the fishery. Electronic monitoring systems, if able to provide IFQ grouping specific weights of discards, would increase fishery flexibility and may reduce costs. The question then is “Can EM technology be used to collect species-specific data used to estimate weights of discards to the IFQ grouping level?”

Electronic monitoring systems have been placed on a subset of vessels in the IFQ fishery to test the efficacy of electronic systems to help make weight estimations of IFQ species discarded at-sea. Camera systems cannot capture weight data directly without onboard scales and major changes in fisher behavior, but cameras can capture volume estimates or fish counts. Therefore, methods need to be developed to convert those volume and count data into weights for camera systems to be useful and effective in IFQ management.

The goal of this project is to evaluate whether data collected using proposed EM methods can be used to generate species-specific estimates of discard weight of the discarded groundfish species and species groupings (Appendix A.) that are included in the Pacific Trawl Rationalization Program. Two studies are proposed to address the speciation and weight estimation issues.

The first is a study that will use at-sea EM to measure the volume of retained catch and evaluate the potential of EM to estimate discard volumes. The second is an at-sea discard study where a discard chute with a dedicated camera will be installed onto active commercial trawlers to record images of fish that will be used for species identification and length determination for at-sea discards of IFQ groundfish.

Species Density Study

In this portion of the project, two approaches will be taken to try to estimate species-specific catch densities (weight per unit volume) that can be used to convert volume of catch to weight.

Two initial questions will be addressed:

1. Can prescribed species-specific densities be determined so that the total weight of at-sea discards can be estimated from the volume of discarded catch?
2. Can video monitoring of crew at-sea sorting of catch activities be used to collect species-specific catch volume measurements?

Background

Two studies have been conducted to evaluate the effectiveness of prescribed densities in catch sampling and estimation. The first was conducted in the Alaska in the mid-1990s in the Bering Sea Pollock fishery (AFA Pollock). This research resulted in the use of prescribed densities by the North Pacific Observer Program observers to determine the total weight of catches greater than 51% Pollock based on a volume of catch taken on catcher-only vessels (Dorn et al., 1999).

The second study, conducted in the New England fisheries in 2012, focused on using data from video monitoring to estimate total catch on two New England fishery trawlers (Pria et al., 2012). While this study estimated and used species-group-specific densities (gadids, flounders), these density estimates are not currently used in standard data collections. Volumes of catch were estimated based on the fullness (%) of containers of known volume; however, the fullness was measured qualitatively to the nearest 25%. In the density estimation portion of the study, the volume of 'full' containers was estimated to be 95%, since containers were known to be slightly under-filled. These approximations may have affected the precision of the resulting comparisons and density estimates.

Proposed Methods

There are two components of this study. In the first, known volumes of sorted catch (fish totes) will be weighed by dockside samplers at the point of landing allowing for calculation of species specific densities. The second component of the study incorporates the use of EM that is currently deployed into IFQ fisheries. Volumes of retained catch will be estimated from the video record while weight of the retained catch will be obtained from the landing receipts allowing for trip level species specific densities. If the estimated species (group) densities using the two methods (dockside direct measurements vs. EM estimated volume with fish ticket weights) are the same, we can conclude that the EM obtained volume measurements are unbiased.

In both approaches potential vessel, dealer, video reviewer and container effects will need to be accounted for in the data collection and analysis by conducting study activities over a range of shoreside processors and vessels and by utilizing two (or more) video reviewers.

<u>Dockside Sampling Component:</u>

In this portion of the study, a dockside sampler will visit shoreside processing facilities (first receivers) who are willing to cooperate with our sampling process along the Oregon and Washington coast and who receive fish from bottom trawlers fishing in the Pacific Trawl Rationalization Program.

Samplers will conduct dockside sampling of known volumes of sorted fish. They will be using the processors hopper or tote scale; each container will be measured precisely to obtain the container's volume. During the offload, the container is filled with sorted species-specific (or species group-specific) landed catch and the depth of fish will be determined by the dockside sampler. The weight of fish is recorded from the scale by the sampler. Observations will be taken for multiple totes (samples) of a species/grouping from each offload (Datasheet at Appendix B).

The volume and weight of ice will be measured (if possible), recorded on the data sheet, and subtracted from both the volume and weight of fish. Samples will be omitted from analysis in cases where the weight and volume of ice in the container cannot be accounted for by the dockside sampler. The frequency that this situation is encountered by the samplers will be recorded so that the prevalence of this activity can be documented.

The density of a species (species group) on a given trip will be estimated based on the samples for each species/grouping using a ratio estimator, equation 1.

$$\hat{D}_{ij} = \frac{\sum_{s=1}^{S_j} w_{ijs}}{\sum_{s=1}^{S_j} v_{ijs}} = \frac{\bar{w}_{ij}}{\bar{v}_{ij}} \qquad 1$$

Where *i* indexes species, *j* indexes the trip (*j*=1, …, *n* sampled trips), and *s* (*s*=1, …. S_j) indexes the all totes sampled for that trip. The variance for this trip-specific density estimate is based on the usual ratio estimator variance, equation 2 (Cochran, 1977).

$$V\hat{a}r(\hat{D}_{ij}) = \frac{\sum_{s=1}^{S_j}(w_{ijs} - \hat{D}_{ij}v_{ijs})}{\bar{v}_{ij}^2(s-1)} = \bar{w}_{ij}^2\bar{v}_{ij}^{-4}V\hat{a}r(\bar{v}_{ij}) + \bar{v}_{ij}^{-2}V\hat{a}r\left(\bar{w}_{ij}\right) - 2\bar{w}_{ij}\bar{v}_{ij}^{-3}C\hat{o}v(\bar{w}_{ij},\bar{v}_{ij}) \qquad 2$$

The above assumes that trips are independent observations of catch density for a given species or species group. Since trips will be distributed among vessels, processing plants, fishing areas, and time (*e.g. months*), those covariates may be evaluated if a sufficient number of trips are sampled. Multiple trips per IFQ species/grouping will be sampled. For any species or species-group sampled within a trip (samples within a specific delivery), multiple (minimum of three) totes will be measured and weighed.

Under the assumption that trips are independent observations, the overall density for a species or species group will be the average of the trip densities, equation 3, and the variance will be the average variance divided by the number of trips sampled, equation 4.

$$\hat{D}_i = \frac{\sum_{j=1}^{n}\hat{D}_{ij}}{n} \qquad 3$$

$$V\hat{a}r\left(\hat{D}_i\right) = \frac{\sum_{j=1}^{n}V\hat{a}r\left(\hat{D}_{ij}\right)}{n^2} \qquad 4$$

Where there are a total of *n* deliveries sampled, some possibly having multiple species in the landing. The final product will be a list of densities with their error estimates for each sorted IFQ species/grouping.

EM (at-sea) Volume Component

In a parallel portion of the study, we will use the estimated total volume of retained catch derived from data collected using onboard video monitoring (EM) and the total offload weight recorded on the fish ticket to derive estimates of species and trip-specific density. The standard Archipelago EM installations will be used onboard all vessels participating in this study (http://www.archipelago.ca/EMServices.aspx). EM imagery will be reviewed by PSMFC EM project staff.

On trips where EM data are available and where the dockside sampler sampled the delivery (above), the two density estimates (EM, shoreside sampling) can be compared; in the case where the estimates differ significantly the assumptions underpinning both methodologies should be carefully evaluated to determine the potential causes of the discrepancy. In particular, the potential biases in the at-sea volume measurements are of interest.

During equipment installation, dimensions of the vessel's checker pens, totes and sorting containers will be recorded (Appendix B). During the video review process, a visual estimate of container fullness (%) will be recorded. The video reviewer will record species, container type, known volume or dimensions of container, and percent fullness for all retained fish. These data will be aggregated to the trip level to obtain the total estimated volume of each species or species grouping retained on that trip.

Landing receipt data is summarized to total weight of each species or species grouping for each delivery. This will be the weight used to derive the density estimate for that trip and species or species group.

Since there is a single observation (no sample data) for each species and delivery, the estimated density is

$$D_{ij}^* = \frac{f_{ij}}{v_{ij}^*}$$

The overall density for a given species or species group is the mean of the estimated densities, averaged across all EM-observed trips. The variance for this overall density is the standard variance of a mean.

$$\widehat{D}_i^* = \frac{\sum_{j=1}^{n} D_{ij}^*}{n}$$

$$V\hat{a}r(\widehat{D}_i^*) = \frac{\sum_{j=1}^{n}(D_{ij}^* - \widehat{D}_i^*)^2}{n(n-1)}$$

Hypothesis Testing

On those deliveries where the delivery was sampled using the both the shoreside sampling and EM at-sea sampling protocols, we can test the hypothesis that the estimates generated using data from the two methods are not different; null hypothesis is $\widehat{D}_{ij} = \widehat{D}_{ij}^*$.

A set of hypothesis tests comparing the EM-based density with the shoreside-based estimate for each trip where both data elements exist can be conducted using a variant of a t-test (see Faunce *et al*., 2013). Whether this is worthwhile will depend on the number of deliveries where data from both data collection methods exists.

Additionally, we can test whether the species-specific density estimates generated from data collected under the two methods vary from each other. For any species, the overall density estimate can be compared across the two methodologies, one hypothesis test for each species. The null hypothesis to be tested is: the density of catch of a given species estimated using data from shoreside sampling is the same as the density for that species estimated from data collected using EM. If this null hypothesis is rejected, then one of the methodologies is possibly producing biased estimates of density.

For both portions of this study, it will be important to sample across a range of shoreside processors (dealers, first receivers) as feasible and across as many different species and species groups as possible.

At-Sea Discard Study (Species identification and weight estimation)

In this second portion of the project, we propose testing the accuracy of species identification and length determination through the use of onboard discard chutes fitted with mounted cameras to record images of each fish as it is discarded. The ability to successfully identify and determine the length of IFQ species / species group fish from EM imagery allows for estimation of discards of IFQ species using EM technology. This may in turn provide a viable EM-based method for monitoring of selective at-sea IFQ discards.

In this study, three questions will be addressed:

1) Can individual discarded fish be identified from video imagery to the IFQ species or species group?
2) Can the length of individual discarded fish be recorded accurately based on the available video imagery?
3) Can the weight of individual discarded fish be estimated from the video imagery-based length and published length to weight relationships?

For each observed trip, we will obtain species and length of fish from EM video imagery, and species, weight, and length of fish from at-sea compliance monitor data for all at-sea IFQ discards that are sent through the discard chute. Data for each fish will be recorded in the same order as the fish that are discarded through the chute so that individual fish from the EM record can be matched to individual fish from the at-sea compliance monitor record. For each fish the species identification based on EM and at-sea monitor will be compared. Similarly, the length measurements obtained from the EM imagery and the at-sea monitor will be compared. For each data source (at-sea compliance monitor, EM), the total weight of each species discarded through the discard chute will be estimated. The weight of fish estimated using EM data will be generated by converting each fish length to fish weight based on published length –weight regressions (Appendix D). The weight of individual and total weight of discards for each species will be compared between the two data sources.

Background

In 2008-2010, the Nature Conservancy conducted an EM study on longline gear vessels fishing in California. The study focused on species ID and piece counts between at-sea compliance monitor, logbook and video. Overall, species identification was not found to be feasible for the rockfishes, flatfishes, and thornyheads (Rienecke et al. 2010). In 2012, a PSMFC study conducted on CA fixed gear vessels found the same results. Counts of fish pieces at the species grouping level in both studies were close (PSMFC 2013).

There are two discard chute studies conducted on EM systems in the literature that focused primarily on species identification and fish length. Both of these studies were conducted on trawlers that were actively engaged in commercial fishing activities and both studies used EM for data collection. The Northeast Fisheries Science Center tested a combination of discard chutes and EM in the Gulf of Maine (GOM) groundfish fishery. The results from that study showed that roundfish were easier to identify (>90% accuracy) than some flatfishes (19%-97% accuracy) when using a discard chute. No rockfish-like family of fish are caught in the GOM groundfish fishery and so a comparison of accuracy rate for a diverse family of similar looking fish is not available (NMFS 2012).

In Alaska, a study was conducted in 2008-2009 on trawl vessels where EM technology was used to collect counts and lengths of Pacifc halibut using a discard chute (Bonney et al., 2009). Fish weights were derived from fish lengths. This study did not reject the null hypothesis; the video and at-sea compliance monitor data are not different.

In this proposed study, for each haul observed, both the video reviewer and the at-sea compliance monitor will identify each fish to the lowest taxonomic level possible, record the number of fish discarded, and the length of each individual fish. In addition, the on-board (human) monitor will collect the weight of each fish.

Proposed Methods

There is currently (winter 2013 – 2014) one volunteer vessel operator who is participating in this study; vessels have not been randomly selected from the fleet. Fishers have agreed to install a discard chute on deck. Crew will sort and the at-sea compliance monitor will sample catch as usual.

On each haul, the at-sea compliance monitor will randomly select 40 fish (or all fish if fewer than 40) from each IFQ species on each haul. The compliance monitor will record species, length (cm) and weight (lbs.) measurements for each fish before sending the fish down the chute under the camera (Appendix C). This controlled discarding will allow for tracking of each individual fish when comparing data to the data collected from the video of the mounted camera.

The chute will be indelibly marked with 5 cm length increments that are clearly visible to a camera that will be mounted over the chute. The video of the discard chute will be reviewed and each individual fish will be identified to the lowest taxonomic level possible. The total length measurement will also be recorded by the reviewer for each fish to the nearest cm based on the length markings on the discard chute. This will necessitate slowing or stopping the video so that a clear image of the fish can be used to record the length measurement. Length will be converted to weight for each fish using published length-weight relationships (Appendix D).

In order to test the accuracy of the species identification based on the EM record, we will send fish of several species through the discard chute in haphazard order. As fish are selected from the set-aside fish (40 of each species), the at-sea compliance monitor will discard fish from different species down the chute. Hence, several of the same species of fish will not be presented to the video reviewer consecutively.

We expect most hauls to have fewer than 3 IFQ species, although some may have as many as 15 species. Hence at-sea compliance monitors and EM can be expected to record data for 120 to 400 fish on each haul. This will equate to generally fewer than 100 pounds of fish; however in some cases may exceed 500 pounds.

In situations where the total amount of discard either exceeds 40 fish per species, or the at-sea compliance monitor cannot record data for 40 fish of each species, at-sea compliance monitor data will be collected in the aggregate. Any IFQ discards not included in the individually sampled fish portion of the study will be weighed in the aggregate (weight of each basket of fish) before those fish are discarded through the discard chute. Baskets may contain sorted or unsorted catch. Data from the EM system will consist of individual fish species identification and length data. This will allow conversion of the length to an estimated weight for each fish and will be aggregated to the basket level. Comparisons will be made for each basket of discarded fish.

Hypothesis Testing

We will test three hypotheses:

Hypothesis 1: For the discarded fish in this study, the species identification for an individual fish identified using EM is the same as the identification of that same fish by the at-sea compliance monitor.

Hypothesis 2: The estimated length of an individual fish based on the EM record is equal to the length for that fish obtained by the compliance monitor (using a scale).

Hypothesis 3: The estimated weight of an individual fish based on an EM recorded length and length to weight conversion is equal to the weight for that fish obtained by the compliance monitor (using a scale).

We will test whether the proportion of correct identifications is equal to or greater than some minimal acceptable proportion (*e.g.*, 90%) (Hypothesis 1) using a two-step process similar to that used by Faunce et al., 2013. In addition, logistic regression may be used to test for differences and for vessel or other effects, if model assumptions can be met.

To test whether the length of fish obtained by the at-sea compliance monitor are the same as lengths obtained using the EM video record (Hypothesis 2), species-specific paired t-test will be used where each individual fish has two paired length measures will be used to test whether the mean difference in the paired lengths is equal to zero. If enough measurements are available, generalized regression methods (e.g. generalized linear models) will be used to test for potential effects of covariates (vessel, trip, etc).

Since the EM system cannot be used to directly measure the weight of fish, the weights obtained will be estimates based on the length-weight regression. Although the weight observations will have associated variance (resulting from the use of the regression equation), in most cases these variances are not available, hence standard methods (paired t-test) will be used to test whether the weight of individual fish based on length-weight conversions are the same as the weight obtained by the at-sea monitor (Hypothesis 3). If appropriate regression data are identified, the modified paired t-test proposed in the Density Study will be used in this study to test whether the estimated weight (EM based) is equal to the weight measured directly by the at-sea compliance monitor. Similar to the analysis of length measurements, if enough observations are available potential effects of covariates will be evaluated using generalized regression methods.

In cases where the data are collected at the aggregate level, this same hypothesis 3 can be tested; however, the EM data will be aggregated to the basket level. The EM-based weight of a basket of fish will be estimated as the sum of individual weights based on the length conversion (regression). A paired t-test can be used to test whether the weights of a basket of fish (of potentially mixed species)

Lastly, EM-derived length to sea-sampler weight regressions will be fit for each species. Although these regressions cannot be used to predict weights within this study, the regression fit can be evaluated for potential use in future studies where the prediction variance can be incorporated into the analysis. By using the EM-derived lengths and sea-sample weights, the regression model will include errors associated with EM-derivation of length such as measurement errors associated with determining length from video imagery and variance added due to the granularity of measurements (to nearest cm). These regressions will provide the most appropriate conversions for use in future studies or final implementation of the EM system.

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Appendix A. Species and Species Groups used in Density Study

Flatfish (Individual Species):
Arrowtooth flounder
Dover sole
English sole
Pacific halibut
Petrale sole
Starry flounder

Other flatfish (Group):
Butter sole
Curlfin sole
Flathead sole
Pacific sanddab
Rex sole
Rock sole
Sand sole

Roundfish (Individual Species):
Lingcod
Pacific cod
Pacific whiting
Sablefish

Rockfish (Individual Species):
Bocaccio rockfish
Canary rockfish
Chilipepper rockfish
Cowcod
Darkblotched rockfish
Longspine thornyheads
Pacific ocean perch
Shortspine thornyheads
Splitnose rockfish
Widow rockfish
Yelloweye rockfish
Yellowtail rockfish

Minor slope rockfish (Group):
Bank Rockfish
Blackgill Rockfish
Blackspotted Rockfish
Redbanded Rockfish
Rougheye Rockfish
Sharpchin Rockfish
Shortraker Rockfish
Yellowmouth Rockfish

Minor shelf rockfish (Group):
Bronzespotted Rockfish
Chameleon Rockfish
Dark Rockfish
Dusky Rockfish
Dwarf-Red Rockfish
Flag Rockfish
Freckled Rockfish
Greenblotched Rockfish
Greenspotted Rockfish
Greenstriped Rockfish
Halfbanded Rockfish
Harlequin Rockfish
Honeycomb Rockfish
Mexican Rockfish
Northern Rockfish
Pink Rockfish
Pinkrose Rockfish
Pygmy Rockfish
Redstripe Rockfish
Rosethorn Rockfish
Rosy Rockfish
Silvergray Rockfish
Speckled Rockfish
Squarespot Rockfish
Starry Rockfish
Stripetail Rockfish
Swordspine Rockfish
Tiger Rockfish
Vermilion Rockfish

Appendix B. Fish Density Study – Proposed Field Data Sheet

SAMPLER NAME:	SAMPLE DATE:	PAGE #: __________ OF __________
VESSEL NAME:	USCG NUMBER:	GEAR:
DEALER NAME:	DEALER NUMBER:	PORT:
SCALE CERTIFIED? Y N	CERTIFICATION DATE:	FISH TICKET #:

	SPECIES/ GROUPING CODE	SPECIES/ GROUPING NAME	CONTAINER DIMENSIONS (METERS)			DEPTH OF TOTE ABOVE FISH (M)	WEIGHT (LBS)
			L	W	D		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
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25							

Appendix C. At-Sea Discard Study – Proposed Field Data Sheet

PAGE #		OF	

SAMPLER NAME:	SAMPLE DATE:
VESSEL NAME:	TRIP START DATE:
USCG NUMBER:	HAUL NUMBER:
GEAR TYPE:	HAUL START TIME:

Fish #	SPECIES NAME	SPECIES CODE	LENGTH (CM)	WEIGHT (LBS)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
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28				
29				
30				

Fish #	SPECIES NAME	SPECIES CODE	LENGTH (CM)	WEIGHT (LBS)
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
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58				
59				
60				

Fish #	SPECIES NAME	SPECIES CODE	LENGTH (CM)	WEIGHT (LBS)
61				
62				
63				
64				
65				
66				
67				
68				
69				
70				
71				
72				
73				
74				
75				
76				
77				
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82				
83				
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85				
86				
87				
88				
89				
90				

Fish #	SPECIES NAME	SPECIES CODE	LENGTH (CM)	WEIGHT (LBS)
91				
92				
93				
94				
95				
96				
97				
98				
99				
100				
101				
102				
103				
104				
105				
106				
107				
108				
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110				
111				
112				
113				
114				
115				
116				
117				
118				
119				
120				

#	SPECIES ID	BASKET WEIGHT (LBS)	COUNT
1			
2			
3			
4			
5			

#	SPECIES ID	BASKET WEIGHT (LBS)	COUNT
6			
7			
8			
9			
10			

Appendix D: Published length-weight regressions; $W = \alpha L^{\beta}$, where W is weight in kgs and L is length in cm. Fish length was recorded as fork length (FL) or total length (TL) or unknown (U).

				Female Only		Male Only		
Species		α	β	α	β	α	β	**Source**
Arrowtooth Flounder	U			3.79E-06	3.246	3.49E-06	3.256	Kaplan and Helser. 2007
Bocaccio Rockfish	U	7.36E-06	3.11359					Field, J. 2010
Canary Rockfish	U	1.55E-05	3.03					Stewart, I. 2009
Cowcod Rockfish	U	1.01E-05	3.09332					Dick and MacCall. 2013
Darkblotched Rockfish	U			1.110E-05	3.1351	1.205E-05	3.122	Gertseva and Thorson. 2013
Dover Sole	U			2.805E-09	3.345	2.231E-09	3.412	Hicks and Wetzel. 2011
English Sole	TL			5.47E-06	3.15447	7.28E-06	3.0728	Stewart, I. 2005
Lingcod	FL			1.760E-06	3.3978	3.953E-06	3.2149	Hamel et al. 2009
Longspine Thornyhead	TL	4.30E-06	3.352					Fay, G. 2005
Greenblotched Rockfish	U	1.103E-05	3.10572					Love et al. 1990
Greenspotted Rockfish	U	1.323E-05	3.108					Dick et al. 2011
Greenstriped Rockfish	U	7.930E-06	3.12745	9.670E-06	3.0756	8.840E-06	3.1097	Love et al. 1990
Halfbanded Rockfish	U			1.520E-05	2.93761	1.270E-05	3.01568	Love et al. 1990
Rosy Rockfish	U	5.200E-06	3.38573					Love et al. 1990
Speckled Rockfish	U			5.430E-06	3.1371	5.210E-06	3.21742	Love et al. 1990
Squarespot Rockfish	U	1.464E-05	2.96355					Love et al. 1990
Starry Rockfish	U	8.670E-06	3.15979					Love et al. 1990
Stripetail Rockfish	U			2.479E-05	2.80487	3.759E-05	2.81864	Love et al. 1990
Swordspine Rockfish	U	1.320E-05	2.97021					Love et al. 1990
Vermilion Rockfish	U	1.744E-05	2.995					MacCall, A. 2005
Aurora Rockfish	U			1.000E-05	3.14	1.000E-05	3.15	Hamel et al. 2013
Bank Rockfish	U	7.790E-06	3.14685					Piner et al. 2000
Blackgill Rockfish	U	1.132E-05	3.1005904					Field and Pearson. 2011
Blackspotted Rockfish	U	9.600E-06	3.123					Hicks et al. 2013
Rougheye Rockfish	U	9.600E-06	3.123					Hicks et al. 2013
Pacific Sanddab	U			5.117E-08	3.214	7.419E-08	3.081	He et al. 2013
Pacific Hake	U	9.17E-06	2.901411					Stewart et al. 2011
Pacific Ocean Perch Rockfish	U			1.065E-05	3.08	1.395E-05	3	Hamel and Ono. 2011
Petrale Sole	U			2.083E-09	3.473703	3.050E-09	3.360544	Haltuch et al. 2012
Sablefish	U			3.449E-06	3.26681	3.672E-06	3.250904	Stewart et al. 2011b
Shortspine Thornyhead	U	4.77E-06	3.263					Taylor and Stephens. 2013
Splitnose Rockfish	FL			2.00E-05	3.0139	2.00E-05	2.9684	Gertseva et al. 2009
Starry Flounder	U	1.474E-05	2.973					Ralston, S. 2005
Widow Rockfish	U			5.450E-06	3.28781	1.188E-05	3.06631	He et al. 2011
Yelloweye Rockfish	U			9.770E-06	3.17	1.700E-05	3.03	Stewart et al. 2009
Yellowtail Rockfish	U	2.140E-05	2.92					Tagart et al. 1997