Agenda Item F.8.b
GMT Report
June 2013

GROUNDFISH MANAGEMENT TEAM REPORT ON METHODS AND RESULTS THAT MAY BE USED TO EVALUATE ALTERNATIVES FOR STOCK COMPLEX REORGANIZATION

Overview

The Groundfish Management Team (GMT) provided comment on the initial proposal for restructuring groundfish stock complexes (Agenda Item D3a, Attachment 1, April 2013) at the April Council meeting (see Agenda Item D3b, Supplemental GMT Report, April 2013). In that GMT statement, it was noted that the current range of alternatives likely includes complexes that are close to favorable. However, the GMT suggested that this range of alternatives may not yet include all options of interest, and stated that additional tools (i.e., methods) may be needed to further evaluate alternatives. This statement describes additional analyses and results that may be added to the toolbox for evaluating current and new alternatives at the June Council meeting. These additional analyses are intended to supplement, not replace, methods and analyses shown in Agenda Item D3a, Attachment 1, April 2013.

Recommended alternatives for restructuring stock complexes are not presented in this document. The GMT will continue analyses and discussions at the June meeting and will provide a supplemental report that will include recommended alternatives supported by existing analyses (i.e., those shown in Agenda Item D3a, Attachment 1, April 2013) and new analyses that are described herein.

The intent of this report is to provide the Council with descriptions of new methods and examples of recent results that the GMT will use to evaluate current and additional alternatives. As such, figures and tables provided herein were included only as examples to help with proper interpretation of results. The full suite of tables and figures generated by these analyses can be found on the Council ftp site by using the following link: ftp://ftp.pcouncil.org/pub/Stock Complex Materials/.

A GMT webinar, which was open to the public, took place on May 22, 2013 to discuss analyses to date. A brief recap of that webinar is provided near the end of this statement.

The GMT thanks the Northwest Fisheries Science Center (NWFSC) and the West Coast Groundfish Observer Program (WCGOP) for providing data analyzed herein and for their help interpreting the dataset variables.

Types of New Analyses Included in this Report

Analyses described in this document will be used to evaluate species co-occurrence, species identification (or difficulty thereof), and potential costs to State sampling programs. Previous analyses described co-occurrence over broad or generally-reported depth ranges and across large areas (e.g., north of 40°10’ N lat.). In the analyses described here, co-occurrence among species was evaluated at a much higher resolution than before (e.g., at the haul level). This level of resolution is needed for identifying stock complexes that are most similar in terms of geographic distribution and vulnerability to fisheries. The degree to which species co-occur in the catch determines how easily they can be managed together. Species that occur together often are more likely to have similar responses to management measures.

Costs to State sampling programs and difficulty discerning among species were only inferred in previous Council documents, with no data or analysis provided for supporting conclusions (e.g., Appendix C of the 2013-2014 FEIS). In this report, we describe a survey developed by the GMT that was intended to ascertain information from state port biologists and managers about species that are often misidentified as well as potential costs of additional sorting requirements. The GMT anticipates that state reports will also be submitted to the briefing book or at the Council meeting that will provide additional information regarding potential costs of stock complex reorganization in terms of expenses for the states and potential impacts to data quality.

This report focuses only on reorganization of slope rockfish and "other fish" complexes, which were designated as a high priority by the Council in April. Similar analyses can be conducted for the remaining stock complexes being considered for reorganization (i.e., nearshore and shelf rockfish) for future meetings, if needed. The analyses and discussion for these other complexes were not included due to time constraints and because they were listed as a lower priority by the GMT and Council in April 2013.

Methods and Data

Five new analyses are being considered by the GMT for evaluating stock complex alternatives at the June meeting. Those analyses are:

(1) Spatial Analysis (haul/set level, or 25 fathom x 1^o lat. blocks, depending on data source)
(2) Species Co-occurrence Tables (haul/set level)
(3) C-scores Derived from the Co-occurrence Tables (haul/set level)
(4) Cluster analysis (haul/set level)
(5) Survey of Port Biologists and State Fishery Managers

Data Sets Analyzed

Alaska Fishery Science Center (AFSC) Survey Data: Data from AFSC surveys (shelf and slope) were obtained for the years 1977-2004. These data are not confidential and therefore can be used to demonstrate spatial analyses at the haul or set level. Survey data are advantageous to fishery data in some cases; for example, survey research sets can be made within rockfish conservation areas (RCAs), as bottom type allows. Therefore, habitats and depths accessible to surveys may provide information that is not possible using recent fishery data (i.e., post-RCAs). In addition, nearly all fish species are identified and enumerated for all survey hauls; therefore, data accuracy and precision are likely higher for survey data than for fishery datasets. On the other hand, minimum and maximum depths for the AFSC survey data are restricted relative to commercial fishery data, which limits our ability to fully evaluate vulnerability of certain species to commercial fisheries. Finally, gear design, towing speeds, towing duration, and seasonality of surveys (e.g., only spring and summer months) result in some disadvantages relative to commercial data when evaluating species co-occurrence and vulnerability to commercial fisheries.

<u>WCGOP Trawl Data</u>: WCGOP trawl data (2002-2011) were used for spatial analysis (25 fm x 1^o latitude blocks) and for co-occurrence analyses (analyses 2-4 listed above) at the haul level. Observer data must be properly filtered when making inference at the haul level; otherwise, false-positive haul locations or false-positive species co-occurrence designations could be prevalent. Use of these data requires clear guidance from the WCGOP program to ensure these haul-level false positive errors are minimized, as we did. Further detail can be provided by the WCGOP or by the GMT if needed.

<u>WCGOP Non-Nearshore Fixed Gear Data</u>: WCGOP non-nearshore fixed gear data (2002-2011) were used for spatial analysis (25 fm x 1^o latitude blocks) and for haul-level co-occurrence analyses (analyses 2-4 listed above). All hook (e.g., longline) and fish pot data were included in most analyses. Note that although most sets in the non-nearshore data base are seaward of the non-trawl RCA, some sets included in that database are shoreward of the RCA and therefore considered shallow. This is due to the definition of "non-nearshore" versus "nearshore", which is based on species and gear type rather than depth. Shallow "non-nearshore" sets are rare in this database. The discussion in the previous WCGOP Trawl Data section regarding the potential of including false-positive locations or species co-occurrence also applies to this database. More detail can be provided by the WCGOP or by the GMT if needed.

<u>Species included in the Analyses</u>: The species included in the analyses provided in this report were based on those shown in slope rockfish and "other fish" alternatives in Agenda Item D.3.a, Attachment 1, April 2013. Species analyzed for slope rockfish alternatives include:

- Aurora rockfish, bank rockfish, blackgill rockfish, darkblotched rockfish, Pacific ocean perch, redbanded rockfish, rougheye/blackspotted rockfish, sharpchin rockfish, shortraker rockfish, splitnose rockfish, and yellowmouth rockfish.

Species or species groups analyzed for the "other fish" complex were:

- Cartilaginous species – Aleutian skate, Bering/sandpaper skate, big skate, black skate, California skate, longnose skate, all other skates, spiny dogfish shark, leopard shark, brown cat shark, soupfin shark, and spotted ratfish;

- Roundfish – Giant grenadier, Pacific grenadier, all other grenadiers, California slickhead, Pacific flatnose (=finescale codling), California scorpionfish, cabezon, kelp greenling, and all other greenlings.

Methods and Examples of Results

Spatial Analysis

Spatial distribution by depth and latitude for roundfish are shown in Figure 1 and for slope rockfish in Figure 2. The WCGOP data for observed bottom trawl trips were used to create these figures. Similar plots for all other species (i.e., within the "other fish" and slope rockfish complex alternatives) and gear types (i.e., WCGOP non-nearshore fixed gear data; WCGOP trawl data; AFSC trawl survey) can be found at the ftp site (ftp://ftp.pcouncil.org/pub/Stock Complex Materials).

In Figure 1 and Figure 2, catch per unit effort (CPUE) is shown by blocks measuring 25 fm x 1^{o} latitude. CPUE was calculated as the sum of all catch per block divided by the sum of all effort (as towing hours; as number of hooks or pots), across all years. This quantity was then divided by the maximum value across blocks within each species and shaded so that the darkest cells correspond with the highest CPUE (see legends in Figure 1 and Figure 2). The CPUE shown in these figures should only be used to look at the distribution of each species and not as a measure of the relative density across species because the scaling eliminates all information about relative abundance. Empty cells represent areas where 3 or more vessels fishing with a given gear carried observers, but no fish of the species in question were caught. Diagonally-hatched cells represent areas where two or fewer vessels were observed while operating with a given gear (i.e. less than 3 vessels carried observers in these areas). The CPUEs for these areas did not satisfy data confidentiality requirements.

Figure 1 and Figure 2 clearly illustrate the spatial distribution by latitude and depth; both are important considerations for managing groundfish. In one sense, many of the inferences that can be drawn from these figures are self-evident (e.g., species that are typically caught shallow or deep; species that are typically found in the north or south). These figures do, however, provide a visual scale from which one can infer the degree of overlap either among species, or overlap across management lines. The amount of overlap among species (more overlap = more likely to co-occur) is one important attribute for grouping "like" species within complexes. For example, Pacific flatnose, California slickhead, and all grenadiers show a great deal of overlap by depth (deep) and area (north and south of 40º10' N lat.; Figure 1). The amount of overlap across regulatory lines (i.e., equally distributed versus unequally distributed north and south of regulatory lines) may also be considered when restructuring complexes. For example, shortraker rockfish (Figure 2) is caught mostly north of 40º10' N lat., whereas a relatively small amount is caught south of 40º10' N lat.

Species Co-occurrence Tables

Co-occurrence of species is shown in Table 1 (roundfish) and Table 2 (slope rockfish) for observed bottom trawl trips (WCGOP trawl data). Only hauls where these species were present are included. Values in these tables represent occasions where two species were present during the same haul. Shading ranges from no shading (= no to low co-occurrence in like hauls) to dark (= frequent co-occurrence in like hauls). Percentages are based on the following premise: given species A is present in a subset of hauls (= columns), what is the percent co-occurrence with species B (= rows) within the same hauls. To illustrate this relationship, refer to Table 1 and the column header “Giant Grenadier”. The number of hauls encountering giant grenadier in the WCGOP database is 7,032 hauls. Thirty seven percent (or 2,629) of these hauls also encountered Pacific flatnose. On the other hand, of 4,120 hauls encountering Pacific flatnose, 64% those hauls (the same 2,629 hauls) also encountered giant grenadier.

Another way to interpret these co-occurrence tables is illustrated in Figure 3. This figure demonstrates that giant grenadier were caught in 7,032 trawl hauls in the WCGOP database, whereas Pacific flatnose were caught in 4,120 hauls. These species were caught together in the same haul 2,629 times, which represented 37% of the “giant grenadier” hauls and 64% of the “Pacific flatnose” hauls.

It is important to note that these examples are shown across all areas (coastwide). Results may be different if shown by area, such as north and south of 40°10’ N lat. This analysis is forthcoming and will be uploaded to the Council ftp site.

C-scores

As another metric of pairwise species co-occurrence, we are also exploring the C-score metric (Table 3 and Table 4). This measure of species overlap is normalized so that a value of 1 indicates perfect segregation between the two species and 0 complete overlap (Stone and Roberts 1990, Gotelli and Ulrich 2010). The GMT is exploring the C-score as a possible, first-level filter to identify which species might be highly segregated. As examples, we provide the C-scores (Table 3 and Table 4) calculated from the WCGOP bottom trawl data for roundfish and slope rockfish. The information used to calculate the C-score is the same as that used to calculate the species co-occurrence tables above. One advantage of the C-score metric is that it allows a species pair to be compared with a single score instead of the two-way look provided in the species occurrences tables described above. It also allows a relative comparison to other species pairs.

The C-score metric derives from the “checkerboardness” concept in biogeography (i.e., a presence-absence dataset of two species that were perfectly segregated would form a checkerboard of 1s and 0s). The C-score is calculated from presence-absence data, where a “1” is used to mark the presence of a species in a sampling unit and a “0” to mark absence. With the WCGOP and trawl survey data, the sampling unit is an individual haul or set. For the examples here we have not stratified the dataset so that the C-scores are calculated over all years, areas, and depths. Because it is based only on presence-absence data, the C-score does not take into account the magnitude of catch.

The equation for the C-score is:

$$\mathrm{C}ij = \frac{(\mathrm{K}i - \mathrm{S}ij) * (\mathrm{K}j - \mathrm{S}ij)}{\mathrm{K}i * \mathrm{K}j}$$

K_i = # of occurrences of species i
K_i = # of occurrences species j
S_{ij} = # of co-occurrences of species i and j
C_{ij} = C-score for species i and j

The denominator represents the maximum value that the C-score can take for two species. The maximum occurs when the species are perfectly segregated in the dataset. For example, a species that occurs 6 times in a dataset and species that occurs 7 times could have a maximum value of 42. The numerator then factors in the number of common occurrences between the species and the resulting C-score is normalized as a ratio of the maximum value. If two species that occurred 6 and 7 times each had 3 common occurrences, the numerator takes a value of 12 and the normalized C-score is 12/42 = 0.29. If they had no common occurrences, their normalized C-score would be 1.

In interpreting the C-scores, it is important to note that the metric is multiplicative and thus non-linear. A C-score of 0.5 does not indicate that the species pair co-occurs in 50 percent of the tows/hauls in the data. To illustrate, two species that occurred 100 times each and had 50 common occurrences would receive a C-score of 0.25. The C-score will also differ between species pairs that have similar and disparate number of occurrences in the data. The score becomes more linear in nature where the discrepancy in total presence of the two species being compared becomes large.

To date, the GMT has considering C-scores above 0.70 as strong indication that two species are segregated and scores less than 0.30 as a having a relatively high degree of aggregation worth further exploration. It is important to note that these examples (Table 3 and Table 4) are shown across all areas (coastwide). Species pairs with intermediate C-scores could be explored to see how their scores may change in subsets of the data, such as north and south of 40°10' N lat.

Cluster analysis

Two clustering approaches were used to evaluate the co-occurrence of species within a proposed complex, based on fishery data collected by WCGOP: 1) partitioning analysis (k-medoids; Figure 4) and 2) agglomerative hierarchical clustering analysis (Figure 5). Each follows the methods outlined in Cope and Haltuch (2012) and differ in their approach. Partitioning analysis uses cluster validity diagnostics (in this specific case, silhouettes and Hubert's gamma) to indicate how many groups are most supported by the data. Cope and Punt (2009) demonstrated how different cluster validity diagnostics have a propensity for indicating less (silhouette; Figure 4a) and more (Hubert's gamma; Figure 4b) groups, hence the reason for using multiple diagnostic measures. Significant clustering are then interpreted using silhouette plots, wherein the silhouette value >0.75 indicates a very strong group, >0.5 indicates a strong group, and >0.25 indicates a weak, but notable association. Values <0.25 are not considered significantly part of a group. Agglomerative clustering (Figure 5) does not specify how many groups, and thus puts together a variable number of groups that minimizes the average distance of the inter- and intra-group dissimilarities. This approach necessitates a way to evaluate the significance of the resultant groupings. Following Cope and Haltuch (2012), we randomly assigned the presence-absence of 3 "fake" species to each haul (i.e., each species has a 50-50 chance of being in any haul). The clustering of these fake species gives a reference point at which species groupings more similar than the "fake" species are interpreted to occur significantly different than random. Three resultant groupings, two partitioning analyses based on the number of groups identified by either silhouette or Hubert's gamma validity diagnostics and one based on hierarchical clustering using “fake” species for relative significance, are provided for each complex considered (see the Council ftp site).

The results of the cluster analyses are given in Figure 4 and Figure 5. Both cluster validity diagnostics in the partitioning analysis (Figure 4a and Figure 4b) identified a similar notable grouping of species: yellowmouth, bank, shortraker, sharpchin, blackgill, and rougheye rockfishes. The remaining species did not significantly cluster with each other or any other species. The hierarchical analysis (Figure 5), while identifying the same grouping, considered the whole slope complex as being more associated than random.

Port Biologist and State Fishery Manager Surveys

A subgroup of the GMT is designing two surveys to be implemented prior to the June Council meeting. The intent of both surveys are to collect information about which groundfish species in existing stock complexes are difficult to identify, and to gain a better understanding of potential costs to state port sampling programs if additional sorting requirements are applied. The intended recipients of the surveys are port biologists and other port samplers, and state sampling program managers. As of the June 2013 briefing book deadline, both surveys were being finalized by the subgroup. Once finalized, the GMT’s state commercial representatives intend to implement the survey prior to the June meeting, with enough time to provide results from these surveys at that meeting. The surveys were focused only on groundfish composition sampling; biological sampling protocols (i.e., age, sex, and length data) were excluded.

The primary information of interest to be collected from the Port Biologist Survey includes the following: which pairs of species are difficult to distinguish within the slope rockfish and other fish complexes, how often are these species encountered, and how difficult are these species to distinguish (i.e., are visual or tactile cues used). Other information such as waiting time prior to a port biologist commencing their composition sampling protocols, will also be collected. Gaining a more specific understanding from state agency personnel about which pairs of species are difficult to discern (or are often misidentified by those who sort landed catch), may help to inform the composition of currently proposed stock complexes. That is, if two species are often misidentified, separating them into two different stock complexes may decrease the accuracy of data collected from either species. This understanding would argue the necessity of maintaining these two species within one complex.

The “Program Manager” Survey is intended to collect information that fleshes out and identifies the full range of potential costs to state sampling programs if new stock complex configurations require additional sorting requirements. There is current understanding that costs in either data quality, State sampling goals, port coverage levels, and/or resources (e.g., personnel and time) will be incurred. However, it is not currently clear to many on the GMT whether these costs will be incurred to the same degree, or if some balancing between these costs will be made out of necessity. For example, if resources currently available to State sampling programs remain static, will state sampling goals be adjusted downward to ensure that a certain level of data quality is maintained. The GMT also recognizes that specific costs may only be clear once the Council identifies their preliminary preferred alternatives (PPAs) at the June meeting and state programs have time to respond to these alternatives. Despite this, the survey was intended as a first pass at engaging State program managers and gaining a greater understanding of the full range of costs that may be incurred, even if these costs are initially listed in general and qualitative terms. More information about specific costs to State programs could be collected at a later date once PPAs are decided.

GMT Webinar

A GMT webinar, which was open to the public, took place on May 22, 2013 to discuss analyses to date. The following points were discussed:

- Whether to provide all figures and tables in this briefing book document, on an ftp site, or as an appendix to this document. It was decided to include only examples of results in this document but provide a link to the ftp site to enable others to download and evaluate results from all analyses.

- Additional analyses by the GMT using methods described here are expected after the briefing book deadline passes. For example, we expect to provide separate analyses north and south of 40º10' N lat. In some cases, certain species will be excluded from these analyses to demonstrate the impact on co-occurrence results for the remaining species. One example is to perform cluster analyses for slope rockfish south of 40º10' N lat. (a) with all slope rockfish species included, and (b) with redbanded, rougheye, shortraker, and yellowmouth rockfish removed. We anticipate other variations of data combinations for analyses to be discussed and/or presented at the June Council meeting. All relevant analyses will be uploaded to the ftp site accompanied by readme files that will include information needed to understand the output.

- One discussion not resolved during the webinar regarded those cases where a complex-component species crossed management lines, and specifically one where the OFL/ABC/ACL contribution of that component species is much lower in one area than the other (e.g., < 5% of the coastwide OFL/ABC/ACL for rougheye rockfish, Figure 2). The following questions arose: if there is no biological reason for splitting a stock-complex species into separate stocks, then is it necessary and prudent to provide OFLs for each area? If not, would some other solution both protect the stock from overfishing and provide less burden to fishermen and communities in the area where the component OFL is low relative to the coastwide value? The GMT concluded that this situation needs to be fully discussed before potential solutions could be offered.

Literature Cited

Cope, J.M. and M.A. Haltuch. 2012. Temporal and spatial summer groundfish assemblages in trawlable habitat off the west coast of the USA, 1977-2009. *Marine Ecology Progress Series,* 451: 187-200.

Cope, J.M. and A.E. Punt. 2009. Drawing the lines: resolving fishery management units with simple fisheries data. *Canadian Journal of Fisheries and Aquatic Sciences*, 66: 1256-1273.

Gotelli, N. J. and W. Ulrich. 2010. The empirical Bayes approach as a tool to identify non-random species associations. *Oecologia*, 162: 463-477.

Stone, L. and A. Roberts. 1990. The checkerboard score and species distributions. *Oecologia*, 85: 74-79.

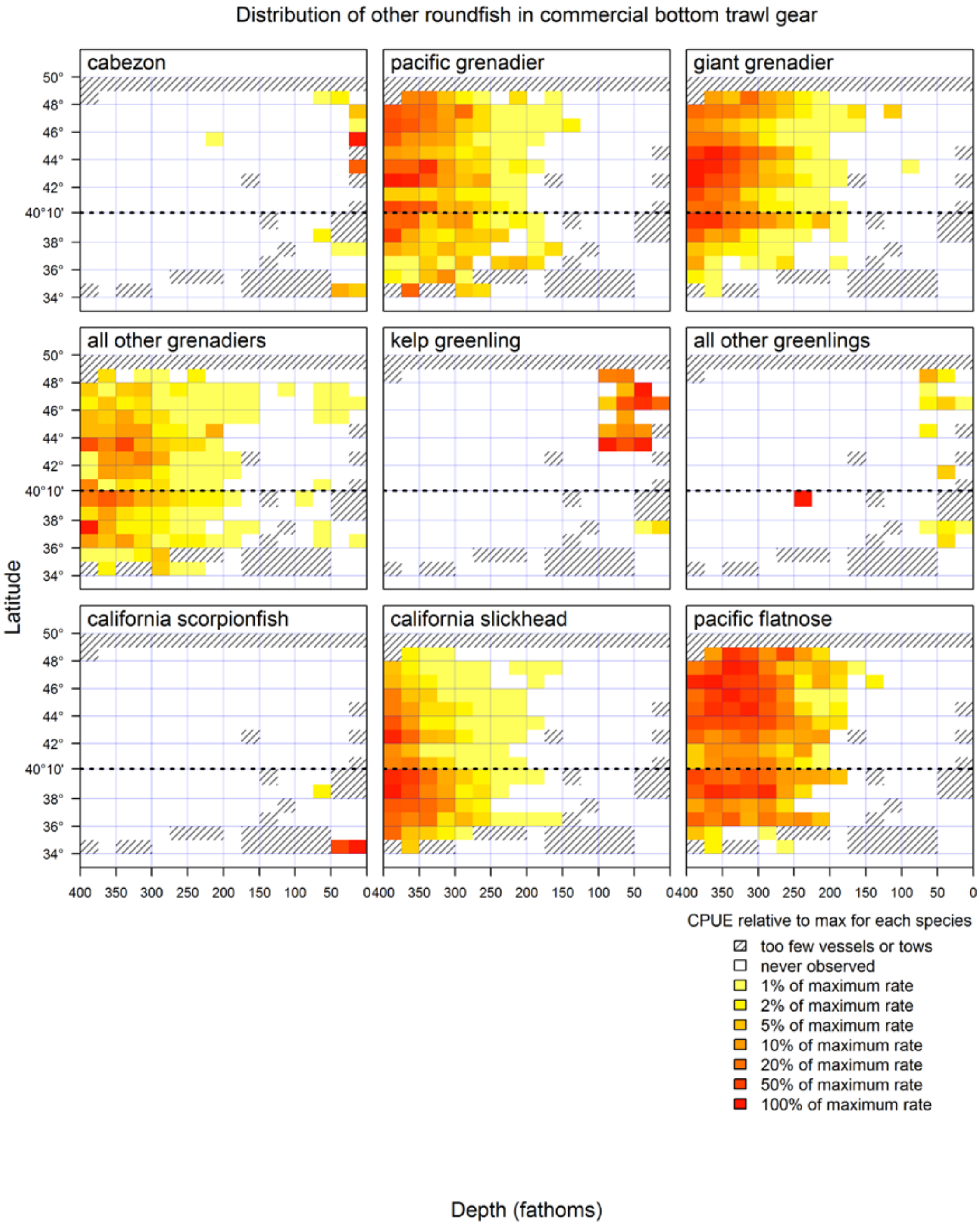


Figure 1. Spatial distribution of roundfish in WCGOP trawl data (2002 – 2011) for alternatives shown in Agenda Item D3a, Attachment 1, April 2013. Colors represent CPUE relative to the maximum within each species (see the legend below). Darkest red = highest CPUE; lightest yellow = lowest CPUE. Data for hatched boxes could not be displayed because of confidentiality (only 1 or 2 vessels carrying observers fished in the area) or because no vessels carrying observers fished in the area. White areas are places where 3 or more vessels fished and carried observers, but the species in question was not caught.

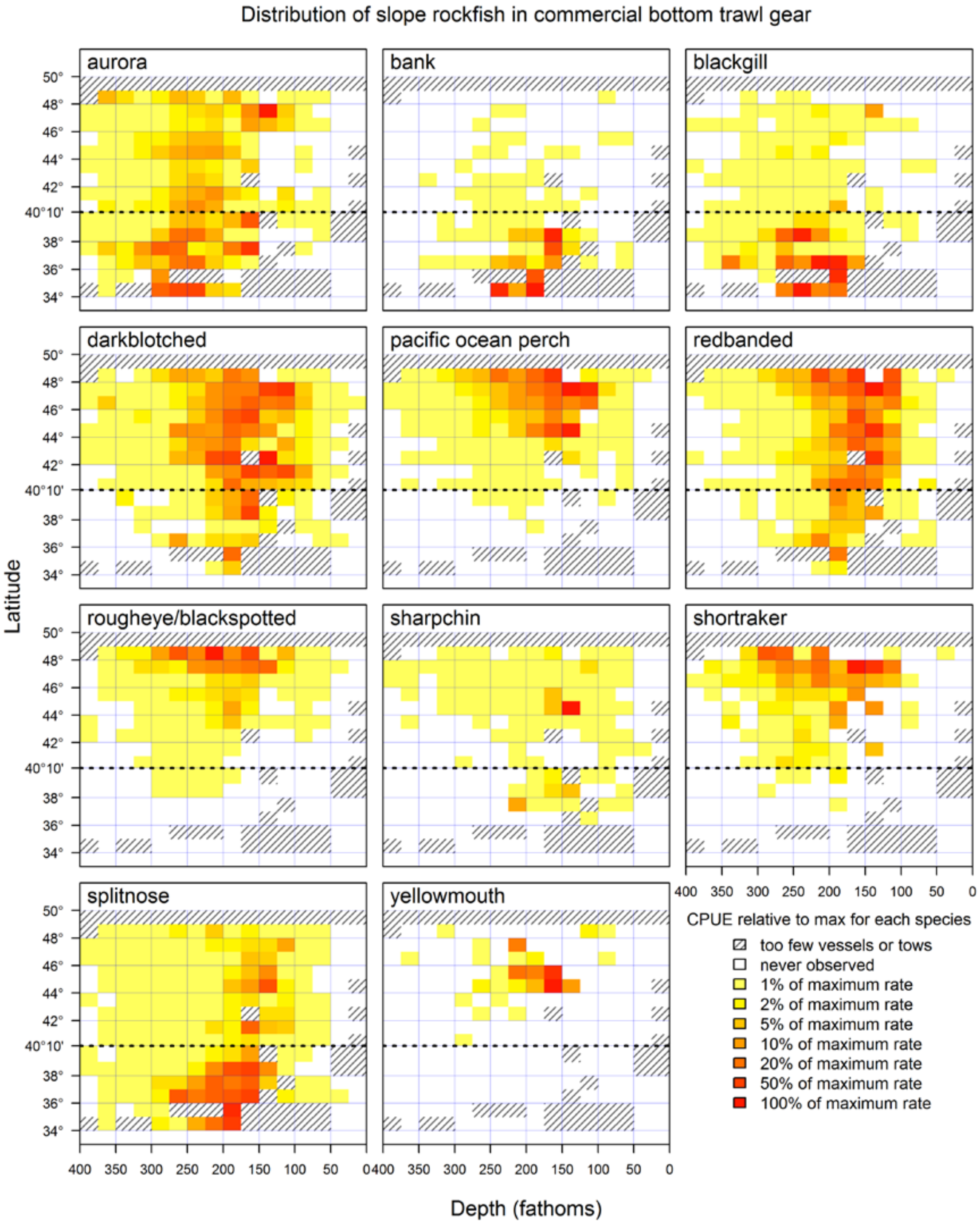


Figure 2. Spatial distribution of slope rockfish in WCGOP trawl data (2002 – 2011) for alternatives shown in Agenda Item D3a, Attachment 1, April 2013. Colors represent CPUE relative to the maximum within each species (see the legend below). Darkest red = highest CPUE; lightest yellow = lowest CPUE. Data for hatched boxes could not be displayed because of confidentiality (only 1 or 2 vessels carrying observers fished in the area) or because no vessels carrying observers fished in the area. White areas are places where 3 or more vessels fished and carried observers, but the species in question was not caught.

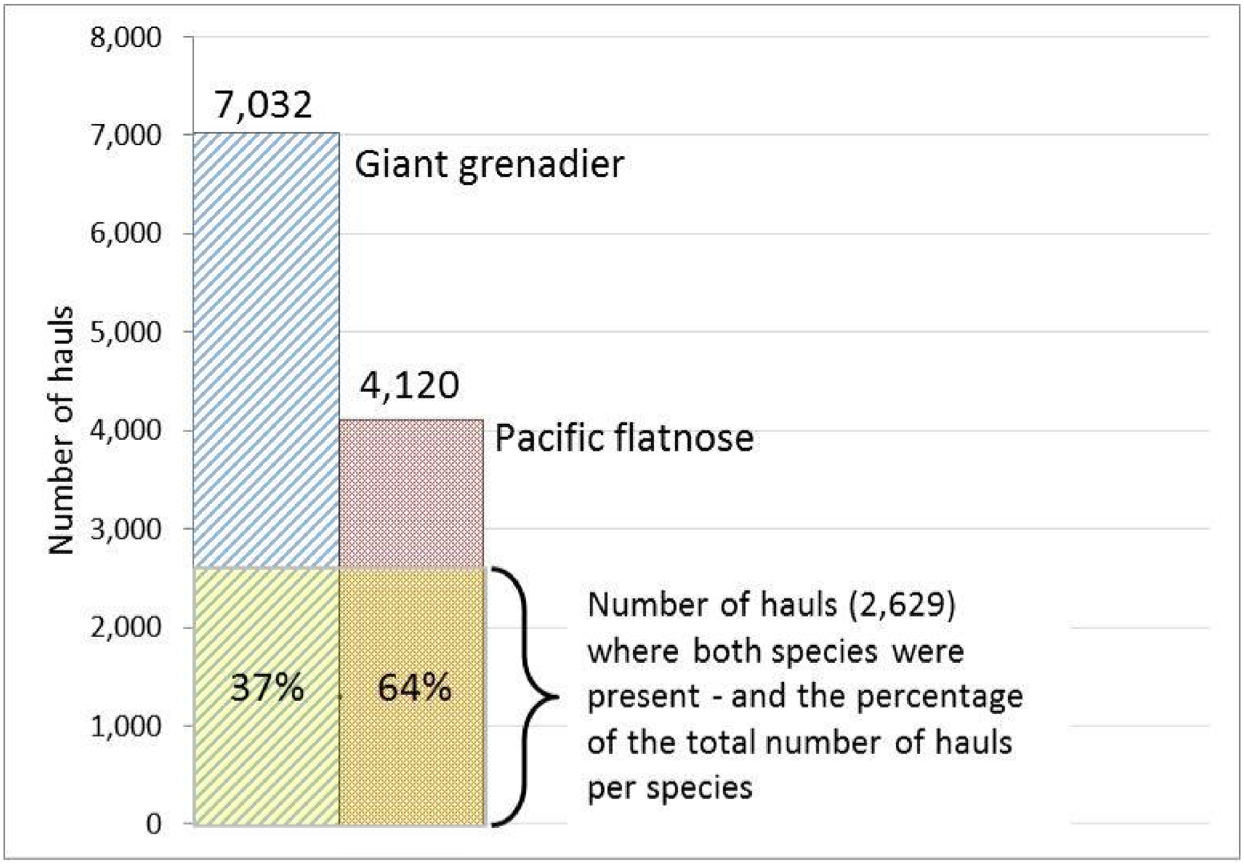
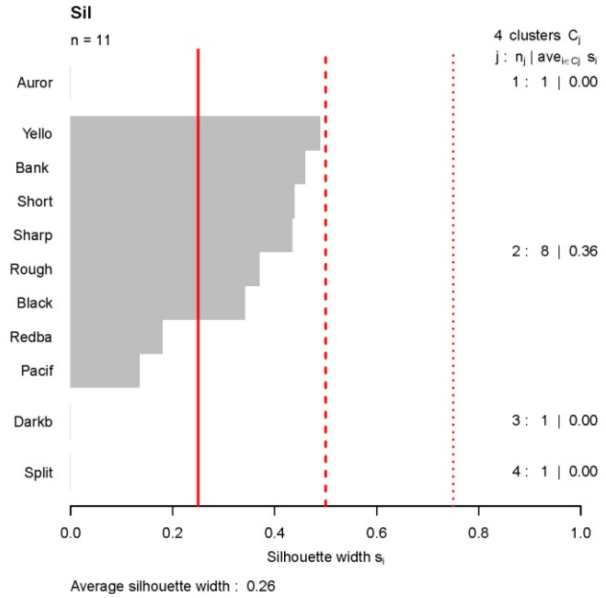


Figure 3. Number of bottom-trawl hauls (WCGOP data, 2002-2011) that caught giant grenadier and Pacific flatnose. Both species were caught during the same haul 2,629 times.

A. Silhouettes



B. Hubert's Gamma

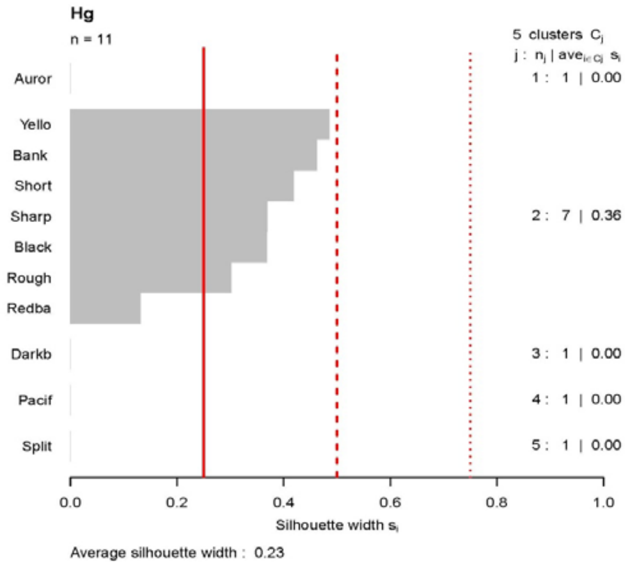


Figure 4. Partitioning analysis (k-medoids) for slope rockfish caught by trawl (WCGOP data, 2002-2011). Two types of validity diagnostics are shown: (A) Silhouettes and (B) Hubert's gamma.

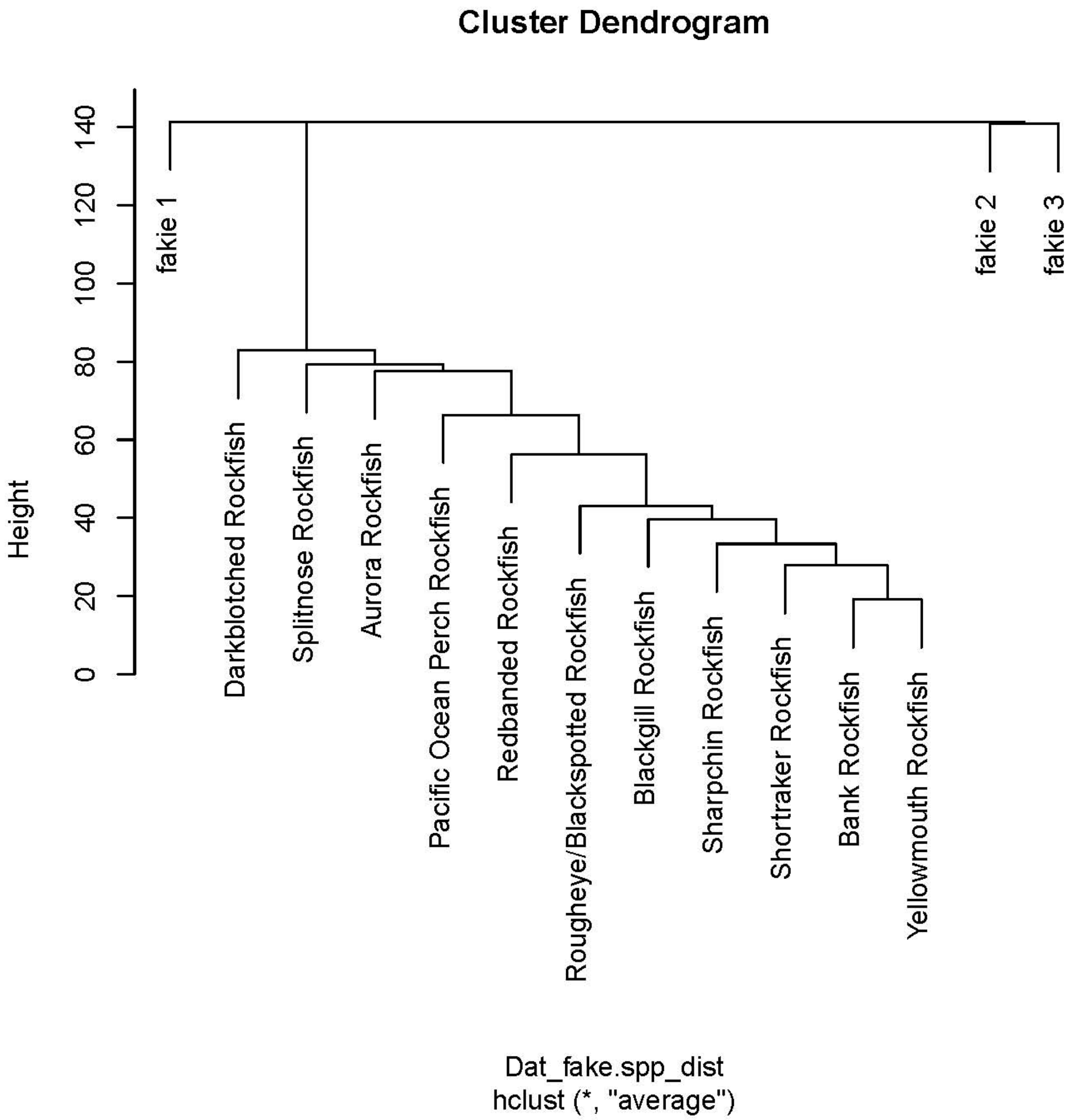


Figure 5. Agglomerative hierarchical clustering analysis for slope rockfish caught by trawl (WCGOP data, 2002-2011).

Table 1. Species co-occurrence in WCGOP trawl data (2002 – 2011) at the haul level for other roundfish alternatives shown in Agenda Item D.3., Attachment 1, April, 2013. This table represents the percentage of all hauls containing the species on a particular column that also have the species on the particular row. Darkest shading = highest co-occurrence.

	Giant Grenadier (7,032)	Pacific Grenadier (6,433)	California Slickhead (4,465)	Pacific Flatnose (4,120)	All Other Grenadiers (3,867)	California Scorpionfish (148)	Kelp Greenling (108)	Cabezon (29)	All Other Greenlings (28)
Giant Grenadier	XXXX	66%	73%	64%	36%	0%	1%	0%	0%
Pacific Grenadier	60%	XXXX	66%	58%	28%	0%	1%	0%	0%
California Slickhead	46%	46%	XXXX	47%	41%	0%	1%	0%	0%
Pacific Flatnose	37%	37%	43%	XXXX	39%	0%	1%	0%	0%
All Other Grenadiers	20%	17%	35%	37%	XXXX	0%	2%	0%	0%
California Scorpionfish	0%	0%	0%	0%	0%	XXXX	0%	3%	0%
Kelp Greenling	0%	0%	0%	0%	0%	0%	XXXX	0%	0%
Cabezon	0%	0%	0%	0%	0%	1%	0%	XXXX	0%
All Other Greenlings	0%	0%	0%	0%	0%	0%	0%	0%	XXXX

Table 2. Species co-occurrence in WCGOP trawl data (2002 – 2011) at the haul level for slope rockfish alternatives shown in Agenda Item D.3., Attachment 1, April, 2013. This table represents the percentage of all hauls containing the species on a particular column that also have the species on the particular row. Darkest shading = highest co-occurrence.

	Darkblotched Rockfish (6,933)	Splitnose Rockfish (6,534)	Aurora Rockfish (5,650)	Pacific Ocean Perch Rockfish (4,358)	Redbanded Rockfish (3,018)	Rougheye/ Blackspotted Rockfish (1,521)	Blackgill Rockfish (1,249)	Sharpchin Rockfish (855)	Shortraker Rockfish (604)	Bank Rockfish (337)	Yellowmouth Rockfish (39)
Darkblotched Rockfish	XXXX	47%	32%	62%	66%	65%	50%	64%	55%	48%	72%
Splitnose Rockfish	45%	XXXX	39%	55%	77%	58%	64%	78%	51%	82%	77%
Aurora Rockfish	26%	34%	XXXX	30%	37%	44%	61%	21%	50%	29%	36%
Pacific Ocean Perch Rockfish	39%	37%	23%	XXXX	53%	55%	25%	63%	52%	8%	67%
Redbanded Rockfish	29%	36%	20%	37%	XXXX	45%	28%	55%	38%	28%	49%
Rougheye/Blackspotted Rockfish	14%	14%	12%	19%	23%	XXXX	15%	21%	45%	5%	44%
Blackgill Rockfish	9%	12%	14%	7%	12%	12%	XXXX	8%	14%	26%	21%
Sharpchin Rockfish	8%	10%	3%	12%	16%	12%	5%	XXXX	8%	8%	41%
Shortraker Rockfish	5%	5%	5%	7%	8%	18%	7%	6%	XXXX	2%	10%
Bank Rockfish	2%	4%	2%	1%	3%	1%	7%	3%	1%	XXXX	15%
Yellowmouth Rockfish	0%	1%	0%	1%	1%	1%	1%	2%	1%	2%	XXXX

Table 3. Normalized C-scores (a), and input data (b) and (c), used to calculate them for Other Fish roundfish presence-absence in the WCGOP bottom trawl observations, 2002-2011. The shading in (a) is darkest for values less than 0.30 and lighter for values between 0.30 and 0.70. Values greater than 0.70 are un-shaded.

(a) Matrix of normalized C-scores

	GREN	CLSK	PFNS	GRDR	SCOR	KLPG	CBZN	UGLG
GGRD	0.14	0.14	0.23	0.51	1.00	0.99	1.00	1.00
GREN		0.19	0.27	0.60	1.00	0.99	1.00	1.00
CLSK			0.30	0.39	1.00	0.99	1.00	1.00
PFNS				0.38	1.00	0.99	1.00	1.00
GRDR					1.00	0.98	1.00	1.00
SCOR						1.00	0.96	1.00
KLPG							1.00	1.00
CBZN								1.00

GGRD = Giant grenadier
GREN = Pacific grenadier
CLSK = California slickhead
PFNS = Pacific flatnose
GRDR = Other grenadiers
SCOR = California scorpionfish
KLPG = Kelp greenling
CBZN = Cabezon
UGLG = Other greenlings

(b) Total occurrences for each species

GGRD	GREN	CLSK	PFNS	GRDR	SCOR	KLPG	CBZN	UGLG
7,032	6,433	4,465	4,120	3,867	148	108	29	28

(c) Matrix of common occurrences

	GREN	CLSK	PFNS	GRDR	SCOR	KLPG	CBZN	UGLG
GGRD	4,239	3,264	2,629	1,400	0	1	0	0
GREN		2,942	2,373	1,079	0	1	0	0
CLSK			1,928	1,566	0	1	0	0
PFNS				1,516	0	1	0	0
GRDR					0	2	0	0
SCOR						0	1	0
KLPG							0	0
CBZN								0

Table 4. Normalized C-scores (a), and input data (b) and (c), used to calculate them for slope rockfish presence-absence in the WCGOP bottom trawl observations, 2002-2011. The shading in (a) is darkest for values less than 0.30 and lighter for values between 0.30 and 0.70. Values greater than 0.70 are un-shaded.

(a) Matrix of normalized C-scores

	SNOS	POP	RDBD	SHRP	ARRA	REYE/BSPT	BLGL	BANK	YMTH	SRKR
DBRK	0.29	0.23	0.24	0.33	0.50	0.30	0.45	0.51	0.28	0.43
SNOS		0.28	0.15	0.20	0.41	0.36	0.31	0.17	0.23	0.47
POP			0.30	0.33	0.54	0.36	0.69	0.91	0.33	0.44
RDBD				0.38	0.50	0.42	0.63	0.70	0.51	0.57
SHRP					0.76	0.69	0.87	0.89	0.58	0.87
ARRA						0.49	0.33	0.70	0.64	0.48
REYE/BSPT							0.75	0.94	0.56	0.45
BLGL								0.69	0.79	0.80
BANK									0.83	0.97
YMTH										0.89

DBRK = darkblotched
SNOS = splitnose
POP = Pacific Ocean Perch
RDBD = redbanded
BLGL = blackgill
BANK = bank
YMTH = yellowmouth
SRKR = shortraker
REYE/BSPT = rougheye/blackspotted

(b) Total occurrences for each species

DBRK	SNOS	POP	RDBD	SHRP	ARRA	REYE/BSPT	BLGL	BANK	YMTH	SRKR
6,933	6,534	4,358	3,018	855	5,650	1,521	1,249	337	39	604

(c) Matrix of common occurrences

	SNOS	POP	RDBD	SHRP	ARRA	REYE/BSPT	BLGL	BANK	YMTH	SRKR
DBRK	3,091	2,706	2,001	551	1,808	983	625	161	28	331
SNOS		2,397	2,321	667	2,187	885	803	276	30	306
POP			1,590	536	1,311	840	317	28	26	316
RDBD				467	1,124	687	353	94	19	231
SHRP					181	181	67	26	16	48
ARRA						669	766	98	14	299
REYE/BSPT							185	17	17	273
BLGL								87	8	87
BANK									6	6
YMTH										4