LETTER

Using folk taxonomies to understand stakeholder perceptions for species conservation

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Keywords
Biodiversity; endangered species; folk taxonomy; perceptions; *Sebastes*; species concept; stakeholder.

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Received
25 March 2011
Accepted
20 July 2011

Editor
Ashwini Chhatre

doi: 10.1111/j.1755-263X.2011.00199.x

Abstract

We used folk biological classification as a framework for understanding stakeholder perceptions of marine species diversity and its potential consequences for conservation in Puget Sound, Washington. Respondents ($N = 99$) classified 46 marine species into folk taxonomies, which diverged substantially from a scientific taxonomy. Variation in folk taxonomy structure was related to respondents' expertise, suggesting that the ways in which people sampled or observed the marine environment led to different perceptions of species diversity within it. Differences in the degree of aggregation among taxa supported the notion that culturally important species are more identifiable. We focused on rockfishes (*Sebastes* spp.), long-lived species of conservation concern, to demonstrate how different views of biodiversity could lead to divergent perceptions of risk to rockfish populations. Understanding the connection between people's values, goals, and experience and their underlying views of species diversity may help to reconcile differences between stakeholder and scientific perspectives.

"No one definition has as yet satisfied all naturalists; yet every naturalist knows vaguely what he means when he speaks of a species" (Darwin 1859).

Introduction

The species concept is central to characterizing biological diversity and is arguably the most salient currency of conservation (Wilcove 1994; Brooks *et al.* 2004). While it is recognized that successful conservation must also consider habitats, landscapes, and whole ecosystems (Franklin 1993), the use of species as a foundation for conservation dominates policy (e.g., U.S. Endangered Species Act, Convention on International Trade in Endangered Species) and many consider species preservation the "heart and soul of ecosystem protection" (Wilcove 1994). Species have remained a conservation focus because they have long been viewed as biologically tractable entities, discrete units on which evolution operates (Mayr 1969). Furthermore, social factors are key determinants of conservation success (Mascia *et al.* 2003) and species are the biological units that resonate most with policy makers and the public (Mace 2004). Concepts such as "evolutionarily significant unit" may be important in technical discussions but are unlikely to capture public interest (Anderson 2001).

Despite the importance of the species unit in biology and conservation, uncertainty in species identities emerges from empirical limitations in the delineation of taxa and semantic arguments about how "species" is defined (Rojas 1992; Hey *et al.* 2003). In essence, species are not "real objective units" (Mayr 1942) but human constructs used to characterize and organize diversity (Raven *et al.* 1971; Levin 1979). Human cognition evolved around the ability to perceive discontinuities in nature and develop classification systems for them (Raven *et al.* 1971; Anderson 2001). Thus, early scientific taxonomies were derived from innate folk biological understanding of how nature is organized (Raven *et al.* 1971). Classification systems developed outside of a scientific framework (folk taxonomies) may correspond with contemporary scientific taxonomies (Raven *et al.* 1971); however, folk taxonomies often reflect an individual's expertise, goals, and values (Medin *et al.* 1997; Bang *et al.* 2007). Consequently, the nature of "species" may vary among individuals or groups with different cultural or economic values (Boster & Johnson 1989; Lopez *et al.* 1997) or social norms (e.g., gender-specific roles in agricultural systems; Boster 1986).

Folk taxonomies not only reflect ways that people observe components of the environment, but also relate to their perceptions and understanding of the natural system as a whole (Atran 1998). People may make biological inductions about an organism based on others they view as similar in nature (i.e., belonging to the same category; Medin *et al.* 1997; Medin & Atran 2004). Therefore, discrepancies between scientific classification schemes and folk perceptions of biodiversity could lead to a disconnect between scientific views and stakeholder perspectives. Understanding the ways in which stakeholders perceive biodiversity may be particularly important in ecosystems that are not observed or observable by most citizens and where successful conservation depends on willing participation by stakeholders. For example, adherence to species-selective harvest regulations and accuracy of harvest data collected by natural resource agencies depends on the ability of fishers and hunters to recognize and identify managed species (e.g., Haw & Buckley 1968). Furthermore, species that are named, classified, and recognizable elicit stronger support for conservation from the public (Crozier 1997; Agapow *et al.* 2004). As a result, it may be difficult to garner widespread support for recovery of a species that is morphologically similar to others and unfamiliar to stakeholders.

While simple cognitive models of how people view species do not fully characterize folk biological knowledge that arises from dynamic experiences in nature, they provide a useful system for linking environmental perception with resource management practices (Nazarea 2006). We used folk biological classification as a framework for understanding stakeholder perceptions of marine species diversity and its potential consequences for conservation in Puget Sound, Washington. Puget Sound is home to nine endangered and threatened species and 21 state-listed marine and anadromous fish species of concern (WDFW 2011). Among these are 13 rockfish (*Sebastes* spp.) species of concern, three of which are federally protected under the Endangered Species Act (NOAA 2010). Rockfishes are morphologically similar (Love *et al.* 2002), not favored by most recreational and commercial fishers (Williams *et al.* 2010), and commonly aggregated for management purposes (Palsson *et al.* 2009). These issues pose challenges to conservation efforts aimed at recovery of rockfish populations.

Table 1 Summary of respondent experience. In-person interviews were conducted with 99 individuals with specialized knowledge of the marine environment acquired through fishing, diving, research, and other activities in Puget Sound, Washington. *N* is the number of respondents who reported participation in each activity type and *Npri* is the number of respondents whose principal expertise was determined to be a given activity type based on estimated lifetime days of participation (see the Appendix). Total experience-years was calculated for each activity as the lifetime years of participation summed across respondents

	Participants		
Activity type	*N*	*Npri*	Total Experience-years
Fishing, recreational	92	56	3,627
Fishing, commercial	33	10	637
Fishing, charter	13	1	161
Diving	46	16	1,057
Research	36	14	833
Other	24	4	234

In this study, we characterized folk taxonomies of individuals with knowledge of Puget Sound marine species acquired through commercial, recreational, and scientific activities and examined structural attributes of these taxonomies. We first determined differences between folk taxonomies and a scientific taxonomy. Second, we evaluated whether variation among folk taxonomies was related to the ways in which respondents gained knowledge of the marine environment (i.e., their expertise). We then quantified the frequency with which respondents identified different species as identical and the extent to which this varied among taxa. Finally, we used rockfishes as a focal group to examine whether differences in species identification could lead to different perceptions of risk for members of this group.

Methods

We used a stratified chain referral approach (Bernard 2006) to identify individuals with specialized knowledge of Puget Sound species acquired through fishing, diving, and research activities (Table 1). Fishing experience was categorized as recreational fishing, commercial fishing, and charter operation. Additional information on respondent characteristics and interview methodology is in the appendix. Respondents completed a pile sort and identification task (e.g., Boster & Johnson 1989; Lampman 2007), in which they were given 46 color photos of

Table 2 Species used in pile sort and identification tasks ($N = 46$). The percentage of respondents who grouped each species with at least one other at the lowest sorting level is shown as percent frequency. Species are ranked from the highest (rank = 1) to lowest (rank = 33) percent frequency of grouping and those grouped by more than 50% of respondents are in bold type. Note that some species are tied in rank

Accepted common name[a]	Scientific name	% Frequency	Rank
Black rockfish	*Sebastes melanops*	35%	17
Bocaccio	***Sebastes paucispinis***	**56%**	**7**
Brown rockfish	***Sebastes auriculatus***	**65%**	**2**
Cabezon	*Scorpaenichthys marmoratus*	10%	30
California sea lion	*Zalophus californianus*	8%	31
Canary rockfish	*Sebastes pinniger*	42%	13
Chinook salmon	*Oncorhynchus tshawytscha*	24%	24
Chum salmon	*Oncorhynchus keta*	36%	16
Coho salmon	*Oncorhynchus kisutch*	30%	21
Comb jelly	*Mnemiopsis leidyi*	43%	12
Copper rockfish	*Sebastes caurinus*	48%	9
Dover sole	***Microstomus pacificus***	**63%**	**4**
Dungeness crab	*Cancer magister*	3%	32
English sole	***Parophrys vetulus***	**63%**	**4**
Greenstriped rockfish	***Sebastes elongatus***	**71%**	**1**
Harbor seal	*Phoca vitulina*	8%	31
Kelp greenling	*Hexagrammos decagrammus*	15%	27
Lingcod	*Ophiodon elongatus*	13%	28
Lion's mane jellyfish	*Cyanea capillata*	29%	22
Moon jellyfish	*Aurelia aurita*	47%	10
Northern anchovy	*Engraulis mordax*	39%	14
Orca	*Orcinus orca*	0%	33
Pacific cod	*Gadus macrocephalus*	13%	28
Pacific hake	*Merluccius productus*	29%	22
Pacific halibut	*Hippoglossus stenolepis*	36%	16
Pacific herring	*Clupea pallasii*	20%	26
Pacific sand lance	*Ammodytes hexapterus*	11%	29
Pacific sanddab	***Citharichthys sordidus***	**64%**	**3**
Pacific staghorn sculpin	*Leptocottus armatus*	22%	25
Pile perch	*Rhacochilus vacca*	44%	11
Pink salmon	*Oncorhynchus gorbuscha*	32%	19
Puget Sound rockfish	***Sebastes emphaeus***	**65%**	**2**
Quillback rockfish	*Sebastes maliger*	49%	8
Red rock crab	*Cancer productus*	3%	32
Redstripe rockfish	***Sebastes proriger***	**71%**	**1**
Rock sole	***Lepidopsetta bilineata***	**57%**	**6**
Sablefish	*Anoplopoma fimbria*	31%	20
Sockeye salmon	*Oncorhynchus nerka*	38%	15
Spiny dogfish	*Squalus acanthias*	0%	33
Spotted ratfish	*Hydrolagus colliei*	3%	32
Starry flounder	*Platichthys stellatus*	28%	23
Striped seaperch	*Embiotoca lateralis*	44%	11
Surf smelt	*Hypomesus pretiosus*	31%	20
Walleye pollock	*Theragra chalcogramma*	34%	18
Yelloweye rockfish	*Sebastes ruberrimus*	35%	17
Yellowtail rockfish	***Sebastes flavidus***	**59%**	**5**

[a] Accepted U.S. common names for fish species (Nelson *et al.* 2004).

marine mammal, fish, and invertebrate species in Puget Sound (Table 2) and asked to "group these according to what belongs together using any criteria you wish" (Bernard 2006). No species was represented more than once. The sorting task was repeated for each group individually until no further subdivisions could be made (i.e., the lowest folk-taxonomic level had been achieved). At this final sorting step, the respondent was asked to identify each organism by name (if any). If multiple species were not separated at the final sorting stage, the respondent was asked to verify whether they were identified as the same organism. We constructed a scientific taxonomy from the literature (Myers *et al.* 2006) for comparison with folk taxonomies derived from pile sort tasks.

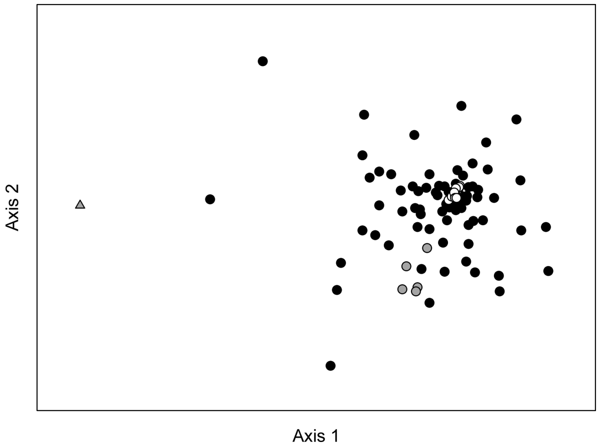

Figure 1 Nonmetric multidimensional scaling ordination (Kruskal stress = 0.16) of respondents' folk taxonomies (points; $N = 99$) and scientific taxonomy (triangle; $N = 1$). Hierarchical cluster analysis revealed 20 significant clusters ($P < 0.05$) of respondents; the two largest clusters are indicated by open points (Respondent Group A; $N = 18$) and shaded points (Respondent Group B; $N = 5$).

The pile sort results were translated into a respondent by species-pair data matrix, in which the elements are folk-taxonomic distances (sensu Lopez *et al.* 1997) calculated according to

$$\frac{S_r - \sum_{s=1}^{S_r} x_s}{S_r}$$

where S_r is the total number of sorting steps undertaken by a given respondent r and x_s is equal to 1 if the species pair was grouped or 0 if it was not grouped in each sorting step s. For example, the scientific taxonomy represented in Figure 2 shows seven levels of taxonomic organization, from phylum (highest level) to species (lowest level). If the tree were derived from a pile sort task, it would have been constructed in a total of $S =$ 6 sorting steps (i.e., subdivisions). In our formulation, folk-taxonomic distance is scaled between 0 (species are identical) and 1 (species are unrelated). Thus, low folk-taxonomic distance corresponds to high folk biological relatedness and the folk-taxonomic distance between a species and itself is 0 (Lopez *et al.* 1997).

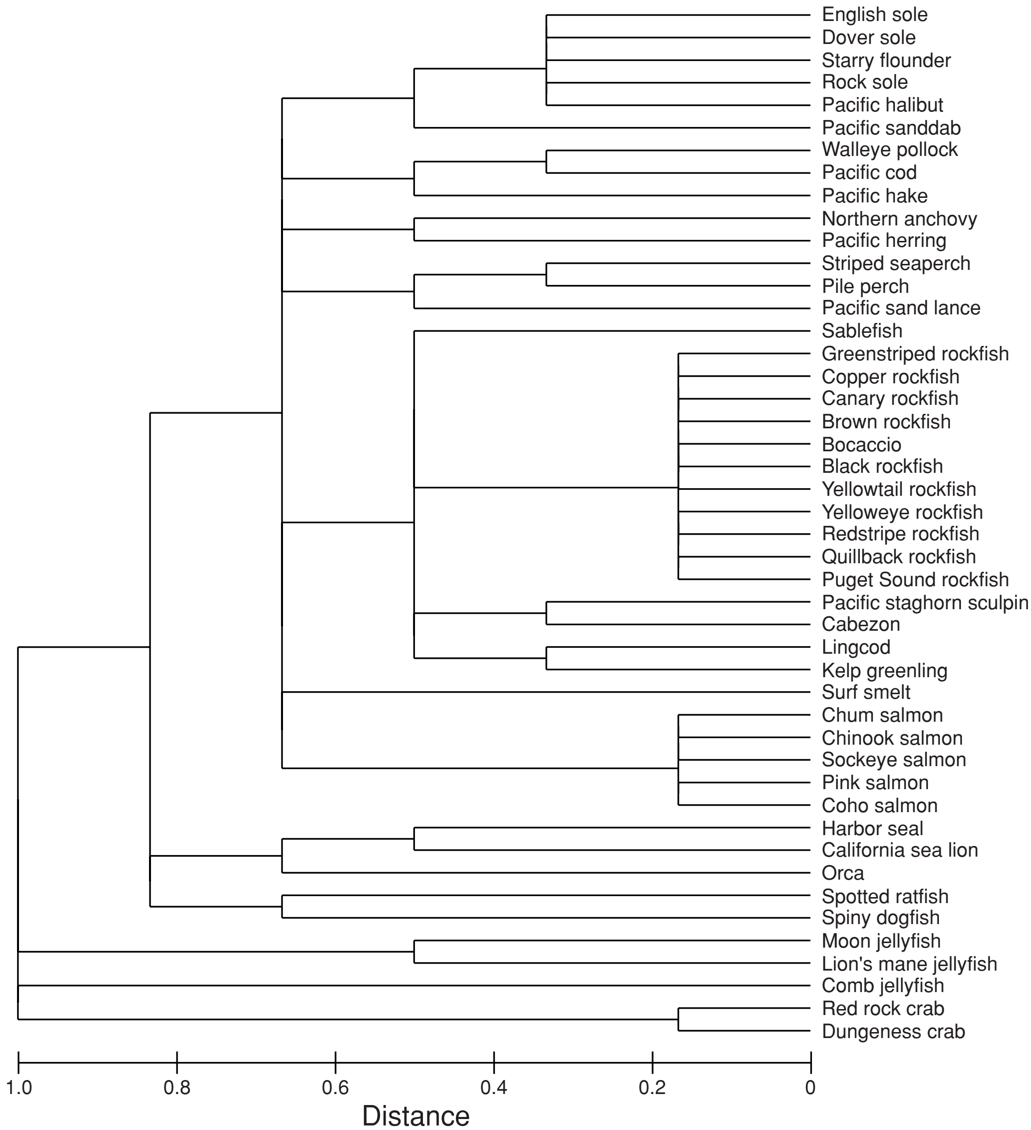

Figure 2 Scientific taxonomy of all species used in pile sort task.

Variation in the structure of scientific and folk taxonomies was evaluated by performing a nonmetric multidimensional scaling on a Euclidean distance matrix calculated from the respondent by species-pairs data (Primer 6 ver. 6.1.11, PRIMER-E Ltd., Plymouth, UK). Groups of respondents with similar folk taxonomies were identified using a hierarchical cluster analysis with group average linking, followed by a similarity profile test (SIMPROF, Primer 6 ver. 6.1.11) to test for significant ($P < 0.05$) differences among groups (Clarke & Gorley 2006). A separate cluster analysis with SIMPROF was performed to test for differences between the scientific and folk taxonomies. Aggregate folk-taxonomic trees were constructed for groups of respondents whose taxonomies did not differ significantly by performing a hierarchical cluster analysis on a species by species distance matrix calculated for multiple respondents as

$$\frac{\sum_{r=1}^{R} S_r - \sum_{r=1}^{R} \sum_{s=1}^{S_r} x_{r,s}}{\sum_{r=1}^{R} S_r}$$

where R is the total number of respondents, S_r is the total number of sorting steps undertaken by a given respondent r, and $x_{r,s}$ is equal to 1 if the species pair was grouped or 0 if it was not grouped in sorting step s by respondent r.

To evaluate the degree to which variation in folk-taxonomic structure was related to respondents' expertise in the marine environment, we performed a canonical analysis of principal coordinates (canonical correlation-type CAP routine, Primer 6 ver. 6.1.11; Anderson & Willis 2003). In this procedure, an unconstrained ordination (principal coordinates analysis, PCO) was first performed on the respondent by species-pairs matrix. Next, a canonical correlation analysis was used to draw axes through the PCO ordination (i.e., the multivariate cloud of points) that have the strongest correlation with respondents' relative expertise (see the Appendix). We calculated correlations (loadings) between the canonical axes and two variables—relative expertise and species-pair similarity—and considered loadings with absolute values >0.3 relevant to interpretation of the results (Tabachnick & Fidell 1996).

The extent to which species are distinguishable and identifiable has potential consequences for public perception of their conservation value (Crozier 1997). Therefore, we calculated the percent frequency of occurrence of respondents who grouped each species with at least one other at the lowest level of folk-taxonomic organization (i.e., identified different species as identical). Species were ranked from most to least frequently aggregated (Table 2).

Results

Differences between scientific and folk taxonomy structure

Folk taxonomy structure diverged substantially from the scientific taxonomy (Figure 1). A hierarchical cluster analysis of taxonomy structure showed that the intercluster distance was maximized between the scientific taxonomy and all folk taxonomies (SIMPROF: $\pi = 0.92$, $P = 0.01$). Scientific and folk taxonomies differed in their structural complexity (i.e., number of sorting levels, number of groups per level) and characteristics of species groupings. The maximum number of taxonomic levels created by respondents in the pile sort task ranged from 4 to 6 (median = 4), while the scientific taxonomy included seven levels of organization (Figure 2). Particular species were grouped by respondents in ways that differed consistently from the scientific taxonomy. For example, Pacific herring (*Clupea pallasii*), northern anchovy (*Engraulis mordax*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus prettiosus*) are members of different taxonomic orders but were grouped by 90% of respondents into a "forage fish" or "bait fish" category (e.g., Figures 3 and 4).

Differences among folk taxonomies

Folk taxonomies varied among respondents ($N = 99$), as illustrated by a nonmetric multidimensional scaling (MDS) ordination that shows a scatter of individuals with unique taxonomies diverging from a tight central cluster of respondents whose taxonomies were similar in structure (Figure 1). A hierarchical cluster analysis provided statistical support for this observed pattern, with 69 respondents grouped into 20 significant clusters (similarity profile test: $\pi = 0.85$, $P = 0.001$) and 30 respondents with folk taxonomies that differed from all others. The positions of the two largest clusters (Group A: $N = 18$ respondents; Group B: $N = 5$) are shown on the MDS ordination (Figure 1) and aggregate folk taxonomies were constructed for these two groups (Figures 3 and 4). Focusing on rockfishes (*Sebastes* spp.), Group A showed a greater degree of differentiation among species and species groups than Group B. Group A was composed of respondents whose experience in the marine environment was derived from a range of activities: 46% of the respondents' lifetime days of experience were attributed to recreational fishing, 21% to research, 16% to diving, 7% to commercial fishing, 5% to charter fishing, and 5% to other activities. Group B was more homogeneous in terms of expertise, with 66% of lifetime experience-days engaged in commercial fishing, 28% in recreational fishing, and 6% in research. Respondents classified organisms according to a range of criteria, including taxonomic relatedness, morphology, ecological factors, behavior, recreational value, and commercial value.

Variation in folk taxonomy structure was significantly related to respondents' expertise in the marine environment (canonical correlation-type CAP: $m = 12$, $\delta_1 = 0.71$, $\delta_2 = 0.44$, $P = 0.002$; Figure 5). The first canonical axis primarily described differences between folk taxonomies of respondents with diving (loading = −0.61) and research (−0.22) experience and those of individuals engaged in recreational fishing (0.43) and other activities (0.25). Folk taxonomy structure showed less separation along the second canonical axis, which correlated weakly with research (0.25), commercial fishing (0.22), diving (−0.21), and other activities (−0.20). Separation of folk taxonomies along the canonical axes was also related to differences in particular species-pair groupings among respondents (Figure 5). For example, the second canonical axis was negatively correlated with eight salmon species-pair groupings (loadings < −0.3) and positively correlated with 13 rockfish species-pair groupings (>0.3), suggesting that structural differences among folk taxonomies could be partly explained by the degree to which respondents grouped salmon versus rockfishes. Species-pair

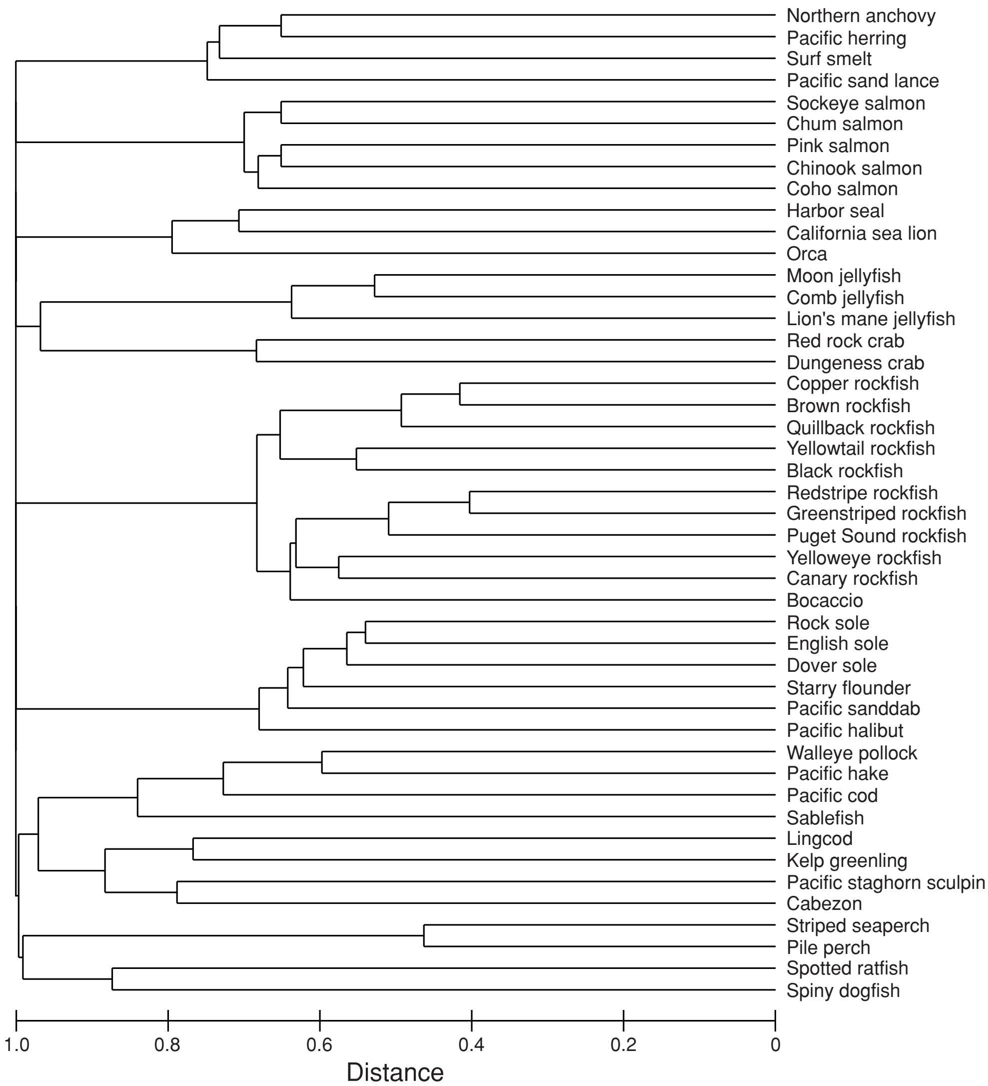

Figure 3 Folk taxonomy calculated from aggregated pile sort data for Respondent Group A.

similarities with loadings that had absolute values >0.3 are shown in Figure 5.

Differentiation and identification of species

The pile sort results revealed a high degree of species aggregation at the lowest level of taxonomic organization. The majority of respondents (93%) did not distinguish between at least two species at the lowest taxonomic level. For instance, Respondent Group B differentiated two rockfish species (yelloweye *Sebastes ruberrimus* and quillback *S. maliger*) and grouped the remaining nine rockfishes (*Sebastes* spp.) into a single identifiable group described as "rockfish," "rock cod," or "red snapper" (Figure 4). Respondents formed an average (±SD) of 5.5 ± 2.3 groups, each composed of 3 ± 0.8 species at the lowest level of organization. The degree to which respondents aggregated the organisms varied by taxa. Among the least aggregated taxa (grouped by <10% of respondents) were marine mammals, cartilaginous fishes, and crustaceans; in contrast, more than 50% of respondents grouped 4 of 5 flatfishes (Pleuronectiformes) and 6 of 11 rockfishes with at least one other species at the lowest sorting level (Table 2).

Discussion

Systems for classifying species are found across cultures and serve as guides for interpreting the natural world (Medin *et al.* 1997; Medin & Atran 2004). In this study,

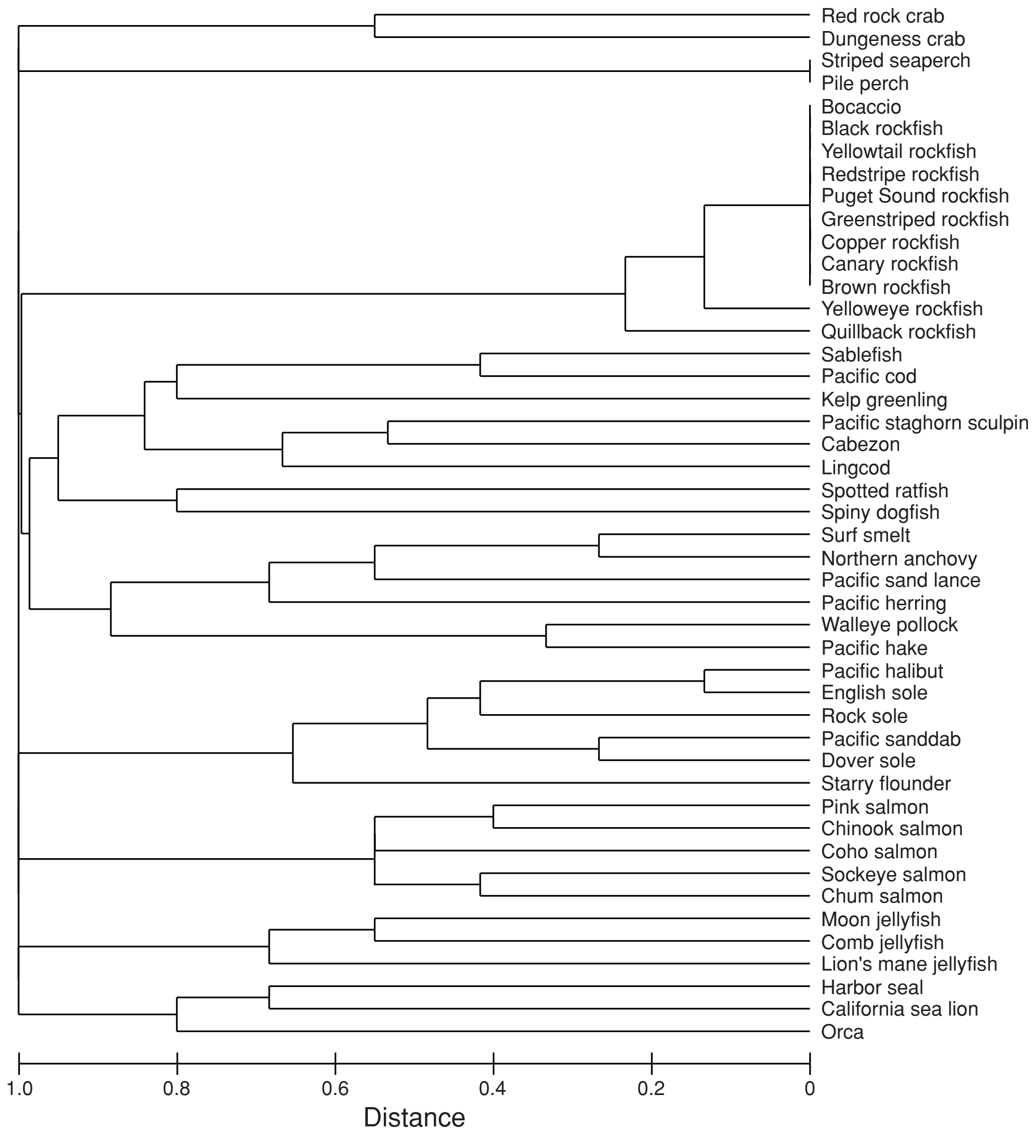

Figure 4 Folk taxonomy calculated from aggregated pile sort data for Respondent Group B.

people demonstrated diverse ways of organizing species into taxonomies that differed from a scientific taxonomy. Our results are consistent with studies of folk biological classification systems around the world that have found significant variation in taxonomy structure related to both the type and amount of knowledge people possess (e.g., Boster & Johnson 1989; Medin *et al.* 1997; Shafto & Coley 2003; Bang *et al.* 2007). Variation among folk taxonomies was related to respondents' expertise, suggesting that the ways in which people observed the marine environment led to different perceptions of species diversity within it. Among expert types, the greatest separation of folk taxonomy structure occurred between divers and recreational fishers (Figure 5). Discrepancies in the ways individuals grouped organisms might be explained by their goals and observation methods. For example, recreational fishers distinguished among salmon species more often than divers (Figure 5). The majority of recreational fishers (92%) described salmon as primary target species and, therefore, are likely to have a greater familiarity with them than divers, who infrequently observe salmonids underwater. These differences show that the structure of folk taxonomies alone cannot reveal all aspects of how folk biological knowledge is constituted, how it translates into inferences about broader ecological processes, and how it might affect an individual's decisions in the real world. Furthermore, folk taxonomies are an imperfect representation of how people view species

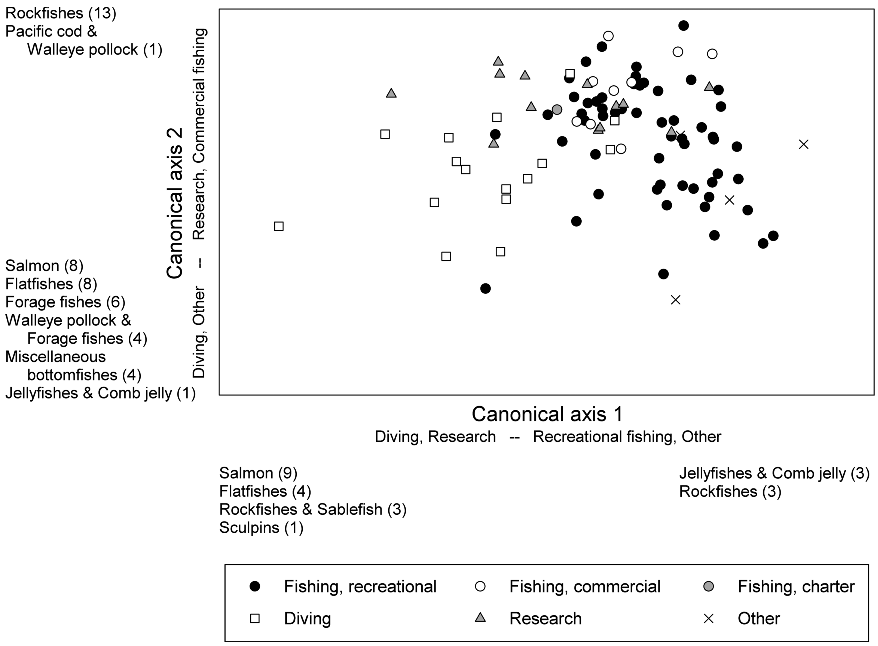

Figure 5 Results of a canonical analysis of principal coordinates describing the relationship between folk taxonomy structure and characteristics of respondent experience in the marine environment. Points represent individual folk taxonomies coded according to respondents' principal activity types, determined from their total lifetime days of participation in each activity. Species-pair similarities were correlated with the canonical axes; the number of species pairs with loadings that had absolute values >0.3 is shown in parentheses for each species group. For presentation purposes, species pairs were generalized into species groups according to taxonomic membership and/or functional group: flatfishes (Pleuronectiformes), forage fishes (Clupeidae, Osmeridae, Ammodytidae), jellyfishes (Cnidaria), miscellaneous bottomfishes (Anoplopomatidae, Gadidae, Hexagrammidae, Scorpaenidae), rockfishes (Scorpaenidae), salmon (Salmonidae), and sculpins (Cottidae).

in practice because individuals may use a host of features to identify organisms in nature, including size, texture, and behavior, that are inadequately represented by static images in the pile sort task.

Local ecological knowledge is derived from practical experience and situated in a broader sociocultural context (Sillitoe 1998; Lauer & Aswani 2009). Thus, differential opportunities for acquiring knowledge (Boster 1986; Nazarea 2006) and cultural attitudes toward nature can play a role in the way people perceive biodiversity (Boster & Johnson 1989; Bang *et al.* 2007). This was reflected in the criteria respondents used to classify species, which included biological characteristics of the organisms (e.g., taxonomic relatedness, morphology, food habits, behavior) and also sociocultural attitudes toward them (e.g., sport value, food value, desirability). For instance, "salmon-eaters" such as dogfish and harbor seals were viewed as competitors by many fishers and, therefore, classified as undesirable. Ecological knowledge, and categorizations of nature therein, may therefore respond to changing cultural attitudes toward species and the environment.

Importantly, knowledge of folk taxonomies is of more than academic interest—it provides information about stakeholder perceptions that can inform the communication of conservation science and policy. The structure of people's folk taxonomies extends to their understanding of patterns in nature (Lopez *et al.* 1997) and different views of how diversity is organized could lead to differences in perception of species extinction risk. Two components of risk are addressed in policy processes: magnitude (i.e., extinction probability) and acceptable level of risk (Tietenberg 2005). Conflict in natural resource management can emerge because stakeholders have different goals and values and, therefore, different degrees of risk tolerance (Stankey & Shindler 2006). Disagreement among stakeholders in their perceptions of extinction risk may not only reflect differing values, but also fundamental differences in how individuals organize diversity. As an illustration, we summarized relative abundance data for two rockfish species based on how they were classified in folk taxonomies. Greenstriped rockfish (*Sebastes elongatus*) and bocaccio (*S. paucispinis*) were viewed as the same species by 40% of respondents. Yet, their populations have undergone very different trajectories along the U.S. west coast: greenstriped rockfish increased 7.9% from 1977 to 2001, while bocaccio declined 16.9% over the same period (Levin *et al.* 2006). To respondents

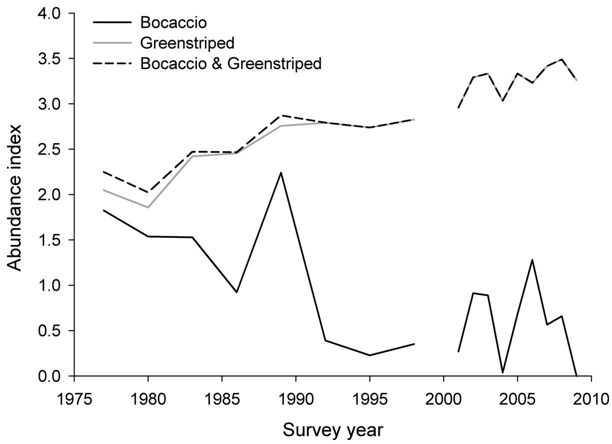

Figure 6 Abundance indices for bocaccio (*Sebastes paucispinis*), greenstriped rockfish (*S. elongatus*), and both species combined from 1977 to 2009, calculated as the log-transformed mean catch per unit effort ($\log_{10}(\bar{x}+1)$) from bottom trawl surveys along the U.S. west coast.

who did not differentiate between the two species (i.e., they are both "rockfish"), the decline of bocaccio would be masked by an increase in the much more abundant greenstriped rockfish (Figure 6). These individuals might conclude that extinction risk to rockfish is quite low, in contrast to those who perceived bocaccio as a distinct species. Thus, stakeholders may perceive risk in different ways because they are using fundamentally different information to assess it. This could lead to divergent beliefs about the need for conservation of particular species.

There are often practical challenges to garnering public support for the conservation of "rare and little-known species" (Stankey & Shindler 2006); however, efforts aimed at increasing stakeholder awareness of these species could improve interest in their conservation. Folk taxonomies reflect people's expertise, goals, and values and can therefore serve as useful tools for gaining insight into the relative knowledge and importance of species to stakeholders. In a study of manioc farmers, respondents provided more specific names and showed more consistent recognition of plants they viewed as familiar and important (Boster 1986). Here, differences in the degree of species aggregation among taxa provide support for the notion that culturally important species are more identifiable. Pacific salmon, a primary target of fisheries and cultural icon in the Pacific Northwest (Montgomery 2003), were less frequently grouped with other species compared to flatfishes and rockfishes, which are of lower value to anglers (Williams *et al.* 2010). This relative degree of importance is reflected in the local media: over a 10-year period (2000–2010), the Seattle Times published 796 articles related to Chinook salmon (*Oncorhynchus tshawytscha*) compared to only 22 for bocaccio rockfish (*Sebastes paucispinis*), both of which are federally listed endangered species. Chinook salmon were among the most and bocaccio the least distinguishable fishes (grouped at the lowest taxonomic level by 24% and 56% of respondents, respectively; Table 2).

The practical problem of species identification becomes increasingly complex when variation in nomenclature is considered (Table A1). Inconsistency in naming may reflect respondents' uncertainty in species identities (Boster 1986), and the number of different names given by respondents was generally higher for species that were more frequently grouped with others at the lowest taxonomic level ($r = 0.41$, Table A1). Rockfishes were viewed by many respondents as morphs or varieties of the same species and the dominant name provided for 6 of the 11 rockfishes was the generic "rockfish" or "rockcod" (Table A1). If "a shared understanding of the referential meaning of words seems to be essential to most other forms of human communication," as Boster (1986) posited, then understanding how people identify and name organisms is critical for effectively communicating regulations to stakeholders and resource use data back to management agencies.

Conservation relies on a common understanding of species identities, but the fundamental nature of species can vary with people's knowledge, goals, and values. If conservation is to proceed from a common ground of biological understanding, it is important to consider the influence of cultural frameworks on the way people organize ecological knowledge (Bang *et al.* 2007). Furthermore, to the extent that folk taxonomies reveal something about the way people experience the natural system, they may also help to reconcile differences between what science shows and what stakeholders perceive. A species does not have to be charismatic to be preserved: the melding of social and ecological science provides a road into identifying the cultural salience of rare and little-known species and improving the public discourse on their conservation.

Acknowledgments

This research was supported by the Fidalgo Chapter of the Puget Sound Anglers Association, the U.S. Environmental Protection Agency, and NOAA Fisheries. We are grateful to the study participants who volunteered their time and knowledge to this research. We thank the editor and two anonymous reviewers for their insightful contributions to the manuscript. The study was conducted in compliance with the University of Washington Human Subjects Division and adhered to the ethical standards established by the American Sociological Association for social science research.

Appendix

Interview methodology and respondent characteristics

Following a chain referral (snowball sampling) approach (Bernard 2006), each interview respondent was asked to identify other potential study participants. Initial contacts were made with university and agency scientists working in Puget Sound, recreational fishing and diving club members, and fisheries coordinators for the Northwest Indian Tribes to disseminate information about the study and recruit participants. Respondents were stratified into three broad areas of expertise (fishing, diving, and research) and we interviewed a minimum of 30 respondents (aged 18 + years) per group. This sample size is typical of ethnographic and folk classification studies (e.g., Boster & Johnson 1989; Lopez *et al.* 1997; Lampman 2007). In-person interviews were conducted individually with each respondent by the same interviewer (A. Beaudreau). Respondents were asked to report the average number of days per year and total years of participation in five activity types (Table 1). Respondents also provided basic demographic information (age, race, and city or town of residence).

Pile sort tasks were completed by 99 individuals residing in 12 counties bordering Puget Sound in western Washington State. Interview respondents ranged in age from 24 to 90 years, with a median age of 60. Respondents demonstrated a wide range of expertise, including commercial and recreational fishing, charter operation, commercial and recreational diving, research, and other professional experience, which included environmental journalism and fishing- or diving-related entrepreneurship. A majority of respondents (84%) indicated that they had experience in two or more of these categories (Table 1). Relative expertise across categories was determined by normalizing the lifetime days of participation in each activity (average days per year × total years) by the total lifetime days in all activities. The category of highest relative expertise was determined to be the principal activity type for each individual. Recreational fishing was the principal activity type for the majority of respondents (55%), followed by recreational diving (16%), research (14%), and commercial fishing (10%; Table 1).

Table A1 Names provided by respondents for species used in pile sort and identification tasks (*N* = 46). The number of respondents who used each name is indicated in parentheses; total number of respondents varies across species because some individuals provided more than one name. Names given by fewer than five respondents were categorized as "Other."

Scientific name	Accepted common name[a]	Respondent-given names
Ammodytes hexapterus	Pacific sand lance	Candlefish (49); Pacific sand lance/Sand lance (40); Needlefish (15); Other (23)
Anoplopoma fimbria	Sablefish	Sablefish (30); Black cod (22); Lingcod/Ling (9); Pacific cod/Cod (8); Other (24); No name provided (27)
Aurelia aurita	Moon jellyfish	Jellyfish/Jelly (49); Moon jellyfish/jelly (14); White jellyfish (7); *Aurelia aurita*/*Aurelia* (5); Other (14); No name provided (13)
Cancer magister	Dungeness crab	Dungeness crab/Dungeness (81); Dungie (10); Other (12)
Cancer productus	Red rock crab	Red rock crab/Rock crab (89); Crab (5); Other (8)
Citharichthys sordidus	Pacific sanddab	Pacific sanddab/Sanddab (29); Flatfish (28); Flounder (26); Sole (14); Halibut (8); Other (15); No name provided (2)
Clupea pallasii	Pacific herring	Pacific herring/Herring (88); Other (15)
Cyanea capillata	Lion's mane jellyfish	Jellyfish/Jelly (32); Red jellyfish/jelly (22); Lion's mane jellyfish/jelly (15); Man o' war (9); *Cyanea capillata*/*Cyanea* (6); Stinging jellyfish (5); Other (10); No name provided (11)
Embiotoca lateralis	Striped seaperch	Perch/Surfperch/Seaperch (42); Striped perch/surfperch/seaperch (19); Pile perch (14); Blue striped perch/Blue perch (9); Rainbow perch (7); Other (15); No name provided (7)
Engraulis mordax	Northern anchovy	Northern anchovy/Pacific anchovy/Anchovy (52); Baitfish (14); Herring (12); Smelt (12); Food/Feed fish (6); Sardine (5); Other (16)
Gadus macrocephalus	Pacific cod	True cod (48); Pacific cod/P cod (22); Cod/Codfish (18); Pacific tomcod/Tomcod (6); Other (9); No name provided (12)
Hexagrammos decagrammus	Kelp greenling	Greenling (41); Kelp greenling (34); Kelp cod (11); Other (17); No name provided (13)
Hippoglossus stenolepis	Pacific halibut	Pacific halibut/Halibut (77); Flatfish (15); Flounder (9); Sole (5); Other (8)
Hydrolagus colliei	Spotted ratfish	Spotted ratfish/Ratfish (89); Chimaera (6); Other (5); No name provided (6)
Hypomesus pretiosus	Surf smelt	Smelt (46); Surf smelt (13); Baitfish (12); Food/Feed fish (7); Anchovy (6); Sardine (6); Herring (5); Hooligan (5); Other (15); No name provided (6)

Continued

Table A1 Continued

Scientific name	Accepted common name[a]	Respondent-given names
Lepidopsetta bilineata	Rock sole	Flounder (31); Rock sole (24); Flatfish (22); Sole (17); Halibut (10); Pacific sanddab/Sanddab (5); Other (12)
Leptocottus armatus	Pacific staghorn sculpin	Bullhead (24); Sculpin (22); Pacific staghorn sculpin/Staghorn sculpin (19); Lingcod/Ling (9); Bottomfish (5); Other (22); No name provided (11)
Merluccius productus	Pacific hake	Pacific hake/Hake (51); Pacific whiting/Whiting (7); Stickleback (5); Other (13); No name provided (31)
Microstomus pacificus	Dover sole	Flatfish (28); Flounder (27); Sole (17); Dover sole (15); Pacific sanddab/Sanddab (6); Other (22); No name provided (4)
Mnemiopsis leidyi	Comb jelly	Jellyfish/Jelly (58); Ctenophore (10); Comb jellyfish/jelly (8); Other (12); No name provided (14)
Oncorhynchus gorbuscha	Pink salmon	Pink salmon (41); Salmon (23); Humpback/Humpy (19); King salmon (12); Chinook salmon (8); Chum salmon (7); Other (14)
Oncorhynchus keta	Chum salmon	Chum salmon (46); Salmon (25); Sockeye salmon (10); Dog salmon (8); Coho salmon (7); Silver salmon (6); Pink salmon (5); Other (4)
Oncorhynchus kisutch	Coho salmon	Coho salmon (46); Silver salmon (25); Salmon (23); Chum salmon (6); King salmon (5); Other (10)
Oncorhynchus nerka	Sockeye salmon	Sockeye salmon (51); Salmon (26); Chum salmon (8); Silver salmon (8); Coho salmon (5); Pink salmon (5); Other (7)
Oncorhynchus tshawytscha	Chinook salmon	Chinook salmon (53); King salmon (45); Salmon (15); Blackmouth (9); Other (12)
Ophiodon elongatus	Lingcod	Lingcod (82); Ling (10); Other (9)
Orcinus orca	Orca	Orca (71); Killer whale (47); Blackfish (7); Whale (5); Other (9)
Parophrys vetulus	English sole	Flatfish (27); Flounder (25); English sole (21); Halibut (16); Sole (13); Other (16)
Phoca vitulina	Harbor seal	Harbor seal (70); Seal (20); Other (11)
Platichthys stellatus	Starry flounder	Starry flounder (53); Flounder (20); Flatfish (18); Sole (6); Halibut (5); Other (8); No name provided (4)
Rhacochilus vacca	Pile perch	Perch/Surfperch/Seaperch (46); Pile perch/surfperch/seaperch (34); Shiner perch/surfperch (7); Silver perch/surfperch (6); Other (12); No name provided (6)
Scorpaenichthys marmoratus	Cabezon	Cabezon (67); Irish lord (7); Sculpin (7); Other (15); No name provided (6)
Sebastes auriculatus	Brown rockfish	Rockfish/Rockcod (37); Brown rockfish/rockcod (24); Copper rockfish/rockcod (12); Quillback (10); Other (12); No name provided (14)
Sebastes caurinus	Copper rockfish	Copper rockfish/rockcod (40); Quillback rockfish/rockcod (27); Rockfish/Rockcod (22); China rockfish/rockcod (5); Other (11); No name provided (7)
Sebastes elongatus	Greenstriped rockfish	Rockfish/Rockcod (45); Greenstripe(d) rockfish/rockcod (8); Red rockfish/Red snapper (5); Other (19); No name provided (25)
Sebastes emphaeus	Puget Sound rockfish	Rockfish/Rockcod (36); Puget Sound rockfish/rockcod (20); Bottomfish (5); Red rockfish/Red snapper (5); Other (9); No name provided (26)
Sebastes flavidus	Yellowtail rockfish	Rockfish/Rockcod (34); Yellowtail rockfish/rockcod (14); Black rockfish/rockcod (9); Black bass/seabass (8); Seabass (7); Other (29); No name provided (13)
Sebastes maliger	Quillback rockfish	Quillback rockfish/rockcod (44); Rockfish/Rockcod (28); Copper rockfish/rockcod (19); Other (13); No name provided (7)
Sebastes melanops	Black rockfish	Black rockfish/rockcod (55); Rockfish/Rockcod (16); Seabass (14); Black bass/seabass (13); Blue rockfish (7); Other (12); No name provided (7)
Sebastes paucispinis	Bocaccio	Rockfish/Rockcod (38); Bocaccio (26); Other (21); No name provided (22)
Sebastes pinniger	Canary rockfish	Canary rockfish (41); Rockfish/Rockcod (21); Red snapper (8); Yelloweye (6); Other (20); No name provided (13)
Sebastes proriger	Redstripe rockfish	Rockfish/Rockcod (40); Redstripe rockfish/rockcod (12); Red rockfish/Red snapper (9); Other (22); No name provided (22)
Sebastes ruberrimus	Yelloweye rockfish	Yelloweye rockfish/rockcod (53); Red rockfish/Red snapper (18); Rockfish/Rockcod (17); Other (17); No name provided (9)
Squalus acanthias	Spiny dogfish	Spiny dogfish/Dogfish (73); Mud shark (12); Dog/Dogfish shark (8); Sand shark (6); Shark (6); Other (13)
Theragra chalcogramma	Walleye pollock	Walleye pollock/Pollock (36); Pacific hake/Hake (10); Pacific cod/Cod (9); Baitfish (8); Tomcod (6); Other (16); No name provided (23)
Zalophus californianus	California sea lion	Sea lion (55); California sea lion (20); Seal (11); Steller sea lion (8); Other (7); No name provided (3)

∗ Accepted U.S. common names for fish species (Nelson et al. 2004)

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