Metazoan parasites as potential markers for selected Gulf of Alaska rockfishes

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Rockfishes (family Scorpaenidae) of the genus *Sebastes* constitute some of the most important groundfish resources in the northeastern Pacific Ocean. In Alaska waters, shortraker rockfish, *S. borealis*, and rougheye rockfish, *S. aleutianus*, are especially prized because their large size and red color make them valuable on the Asian market. Both species reside in offshore waters of the upper continental slope, and they often co-occur. Commercial catches of these two species in the Gulf of Alaska (GOA) have averaged 1700 metric tons per year during this period, and the estimated exvessel value of the fishery in 1991 (the most recent year with good economic data) was $3 million.

Knowledge of stock structure and the degree of mixing among populations is important for the rational management of commercially important marine species. At present, such information is lacking for shortraker and rougheye rockfish, and questions, such as whether these species perform lengthy migrations or whether discrete populations exist, are unanswered. Traditional tag-and-release experiments, which are often used to investigate stock structure, are not feasible for physoclistic fish such as rockfish because they cannot survive the barotrauma of initial capture. One alternative to human-implanted tags is the use of parasites as naturally occurring tags. Because necropsies of rockfishes are time consuming, we examined 100 fish of each species from the GOA to identify the feasibility of targeting selected parasites as tags for these species.

Methods

Adult shortraker and rougheye rockfish were captured in the GOA in summer 1990 during an annual longline survey conducted on the upper continental slope by the National Marine Fisheries Service. Sampling covered five statistical management areas established by the International North Pacific Fisheries Commission (Zenger and Sigler, 1992): Shumagin, Chirikof, Kodiak, Yakutat, and Southeast (Fig. 1). The survey area extended from the Island of the Four Mountains (52°50'N, 170°W) eastward to Dixon Entrance (54°29'N, 134°W). Forty-five stations were sampled along the upper continental slope at depths from 150 to 1000 m. Of the 7836 rockfishes of various species caught in the cruise, a subsample of 20 rougheye and 20 shortraker rockfish (21 from Shumagin) from each management area were frozen on board for later necropsy. Total sample size was 101 shortraker and 100 rougheye rockfish from 21 stations.

In the laboratory, we conducted complete necropsies for metazoan parasites on an initial sample of 54 shortraker and 69 rougheye rockfish. As a result of preliminary analysis of the parasite data from these fish, we restricted the necropsies on the remaining 47 shortraker and 31 rougheye rockfish to examinations for the presence of gill and fin copepods, monogenetic gill trematodes, and visceral acanthocephalans. Identities of representative parasite specimens were verified by D. J. Whitaker of the Canadian Department of Fisheries and Oceans. Both prevalence (the proportion of fish with a given parasite) and intensity (the mean number of parasites per infected fish) were calculated for each management area.

Geographic trends were examined by grouping samples into the five management areas. Categorical analysis of variance (SAS procedure CATMOD; SAS Inst., 1989) was used to determine whether parasite prevalence differed among areas. For this analysis, the prevalence of a particular parasite was used as the dependent variable, and area and fish size as independent variables. For each fish species, median fork length was used to divide the areawide sample into two groups, hereafter referred to as large and small. Data on parasite intensity for each fish were divided by fish length to account for the possible influence of fish size on parasite intensity. Distribution of the intensity data was highly nonnormal, even after transformation. Therefore, intensity data were analyzed by using the nonparametric Mann-Whitney U test. These analyses allowed us to account for differences in fish size by area while test-

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ing for dependence of parasite prevalence and intensity by area. Fish size was chosen as a variable because the size of fish sampled in some areas differed, and fish size may influence parasite prevalence and intensity (Sekerak, 1975). A probability of 0.10 or less was judged to be statistically significant.

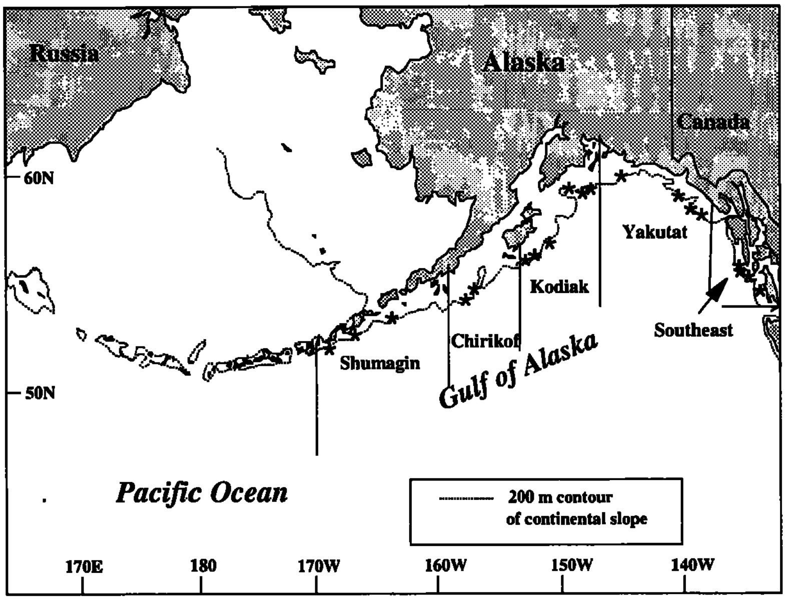

Figure 1

Northeastern Pacific Ocean, showing management areas of the Gulf of Alaska. Asterisks show sampling stations along the continental slope.

Results

Seventeen species of parasites were found in our preliminary examinations: six species of copepod on the gills and fins and in the cephalic canal and nasal cavities; two species of monogenetic trematodes on the gills; three species of digenetic trematodes, two species of acanthocephalans, one species of cestode, and three species of nematodes in the viscera and mesenteries. All these species had been described previously from northeastern Pacific rockfishes, although parasites of shortraker and rougheye rockfishes in the western GOA had not been described previously. Many of the fish contained both larval nematodes *Contracaecum* spp. and *Hysterothylacium* spp. Because it is time consuming to separate these two genera, they were lumped together as a single species as *Contracaecum*-type spp. On the basis of these preliminary results, nematodes, digenes, and cestodes were eliminated from further examination. These helminths were infrequent in the samples or showed no difference between management areas. Further examinations focused on enumeration of copepods, acanthocephalans, and monogenes.

Prevalence (Table 1) and intensity (Table 2) of several parasite species differed distinctly among shortraker and rougheye rockfish populations in the GOA; they varied between areas, rather than being present in one area and absent in another. Three of these—*Neobrachiella robusta* (copepod), *Trochopus trituba* (monogenetic trematode), and *Corynosoma* sp. (acanthocephalan)—had the most distinctive changes in prevalence between areas. For shortraker rockfish, the highest prevalence of *N. robusta* and *T. trituba* parasites was in Kodiak samples. In rougheye rockfish, prevalence of all three parasites was significantly reduced in the Southeast. Several species of parasites were scarce in some areas and absent in others.

Of the six species of copepods in our survey, the gill copepod *N. robusta* was sufficiently prevalent to be potentially useful in stock discrimination studies. Prevalence of *N. robusta* differed significantly between areas for both shortraker (P=0.076) and rougheye (P=0.087) rockfish. *Neobrachiella robusta* was present in 80% of the Kodiak shortraker rockfish sampled as opposed to 35–55% of those sampled in the other four areas. Larger rougheye rockfish also had a significantly (P=0.028) greater prevalence of *N. robusta* than smaller specimens. Among shortraker rockfish, intensities ranged from a mean of 2.4 in Shumagin to 7.6 in Chirikof; the differences were also significant between areas (P=0.029), especially when corrected for the size of the fish (P=0.016). Among rougheye rockfish, however, intensity of *N. robusta* infection did not differ between areas (P=0.667). Mean infection levels were lower among rougheye rockfish than among shortraker rockfish for *N. robusta* but still averaged 1–5 parasites per fish.

Other copepods were prevalent in the GOA samples. *Naobranchia occidentalis* was found in shortraker rockfish from Chirikof, Kodiak, and Yakutat in low prevalence (10%) and in rougheye rockfish from Yakutat (20%), but not from other areas. Prevalence of *Chondracanthus pinguis* was above 40% in Yakutat and Southeast rougheye rockfish, but below 10% in all other samples. This difference, however, was a function of size rather than area. Prevalence was significantly greater (P=0.069) in large rougheye rockfish than in small ones. *Colobomatus kyphosus* was present in one shortraker rockfish from Yakutat and in two rougheye rockfish from Yakutat and Southeast. *Chrondracanthus triventri-*

Table 1

Comparison of parasite prevalence (proportion of fish having the parasite) by area for shortraker and rougheye rockfish in the Gulf of Alaska, 1990. The number of fish examined in each area is given in parentheses. Significance probability is given for a categorical analysis of variance model with area and fish size as main effects. Asterisks indicate $P < 0.10$.

	Parasite prevalence					Significance probability	
	Shumagin	Chirikof	Kodiak	Yakutat	Southeast	Area	Size
Shortraker rockfish	(*n*=21)	(*n*=20)	(*n*=20)	(*n*=20)	(*n*=20)		
Neobrachiella robusta	0.48	0.55	0.80	0.35	0.40	0.076*	0.724
Naobranchia occidentalis	0.00	0.10	0.10	0.10	0.00	0.980	0.493
Chondracanthus pinguis	0.10	0.05	0.10	0.10	0.10	0.971	0.301
Colobomatus kyphosus	0.00	0.00	0.00	0.05	0.00	0.954	0.583
Trochopus trituba	0.62	0.60	0.86	0.55	0.45	0.081*	0.262
Microcotyle sebastis	0.14	0.10	0.00	0.00	0.00	0.927	0.655
Corynosoma sp.	0.81	0.75	0.60	0.65	0.65	0.606	0.914
Echinorhynchus gadi	0.10	0.00	0.00	0.05	0.00	0.929	0.633
Clavella parva	0.62	0.80	0.90	0.30	0.20	0.013*	0.370
Rougheye rockfish	(*n*=20)	(*n*=20)	(*n*=20)	(*n*=20)	(*n*=20)		
Neobrachiella robusta	0.25	0.40	0.30	0.50	0.10	0.087*	0.028*
Naobranchia occidentalis	0.00	0.00	0.00	0.20	0.00	0.897	0.823
Chondracanthus pinguis	0.10	0.00	0.00	0.40	0.50	0.152	0.069*
Colobomatus kyphosus	0.00	0.00	0.00	0.10	0.10	0.960	0.165
Trochopus trituba	0.70	0.60	0.55	0.50	0.20	0.045*	0.822
Microcotyle sebastis	0.15	0.00	0.00	0.15	0.00	0.906	0.895
Corynosoma sp.	0.80	0.75	0.75	0.75	0.20	0.001*	0.283
Echinorhynchus gadi	0.00	0.00	0.15	0.00	0.05	0.674	0.356
Clavella parva	0.48	0.10	0.10	0.70	0.55	0.105	0.704

cosus, a common parasite in the nasal cavities of Canadian rockfishes, was largely absent from our samples, occurring in only a single specimen. The fin copepod *Clavella parva* was present in all areas, with increased prevalence among shortraker rockfish in the western GOA; this difference was significant (P=0.013) between areas. Although we examined all parasites in our sample, *C. parva* was never a candidate for separation, because fin parasites could be lost in capture and sampling.

The parasites showing the most potential for providing insights into the population structure for both species of rockfishes were the monogenetic trematodes *T. trituba* and *Microcotyle sebastis*, because of their high and low prevalences, respectively. Prevalence and intensity of *T. trituba* were significantly lower for rougheye rockfish in the Southeast (20% prevalence, mean intensity of 1.8) than in other management areas (50–70% prevalence, mean intensity of 2–9). For shortraker rockfish, prevalence and intensity of *T. trituba* were highest in Kodiak (86%, intensity of 16) and declined farther southward (45% and 8 in the Southeast, 62% and 4 in Shumagin). Both prevalence and intensities of *T. trituba* differed significantly among areas and did not depend on fish size. *Microcotyle sebastis*, common among many species of British Columbia rockfishes, was rare in the GOA.

The only internal parasite showing potential as a tag was *Corynosoma* sp., which, with the less common acanthocephalan *Echinorhynchus gadi*, infected nearly every Shumagin shortraker rockfish (90% infected with an acanthocephalan at an average of three *Corynosoma* sp. per fish). Most other shortraker rockfish were also infected (60–75%). Although prevalences of *Corynosoma* sp. in shortraker rockfish did not differ among areas, intensities and intensities/cm differed significantly (P=0.024 and 0.019, respectively) by area, largely owing to high numbers of *Corynosoma* sp. among Yakutat fish. Rougheye rockfish were also infected with *Corynosoma* sp. at 75–80%, except in the Southeast (20%; significantly lower [P=0.001] than in other areas).

Discussion

Williams et al. (1992) proposed six criteria to assess the value of a parasite as a marker for stock separation. The parasite should differ in levels of infection across geographic regions, not be detached easily with handling, be easily assessed, have no harmful effect

Table 2

Comparison of mean parasite intensity by area for shortraker and rougheye rockfishes in the Gulf of Alaska, 1990. Range of intensity is in parentheses. Significance probability for differences in intensity and for intensity per cm fish length between areas is also given (Mann-Whitney U test). Asterisks indicate $P < 0.10$. Dash means insufficient number of infected fish to perform statistical tests. Int = intensity.

	Mean parasite intensity (no. of parasites per infected fish)					Significance probability	
	Shumagin	Chirikof	Kodiak	Yakutat	Southeast	Intensity	Int/cm
Shortraker rockfish							
Neobrachiella robusta	2.4 (1–9)	7.6 (1–18)	4.9 (1–12)	4.4 (1–17)	3.8 (1–8)	0.029*	0.016*
Naobranchia occidentalis	0	1 (1)	1 (1)	4.5 (4–5)	0	0.333	0.156
Chondracanthus pinguis	1 (1)	3 (3)	3.5 (3–4)	1 (1)	1.5 (1–2)	0.131	0.189
Colobomatus kyphosus	0	0	0	1 (1)	0	—	—
Trochopus trituba	3.8 (1–9)	4.8 (1–9)	16 (1–106)	17 (2–89)	8.3 (1–15)	0.001*	0.002*
Microcotyle sebastis	1.3 (1–2)	2.5 (2–3)	0	0	0	0.133	0.083*
Corynosoma sp.	3.3 (1–6)	2.3 (1–12)	2.7 (1–7)	5.6 (1–26)	3.7 (1–7)	0.024*	0.019*
Echinorhynchus gadi	1 (1)	0	0	3 (3)	0	—	0.221
Clavella parva	1.2 (1–2)	1.5 (1–5)	1.5 (1–3)	1.5 (1–2	1.3 (1–2)	0.259	0.357
Rougheye rockfish							
Neobrachiella robusta	2.6 (1–4)	2.7 (1–7)	1.8 (1–4)	5.2 (1–32)	1 (1)	0.667	0.478
Naobranchia occidentalis	0	0	0	1 (1)	0	—	—
Chondracanthus pinguis	1 (1)	0	0	9.6 (1–61)	2.7 (1–5)	0.235	0.211
Colobomatus kyphosus	0	0	0	3 (2–4)	1.5 (1–2)	0.333	0.121
Trochopus trituba	4.6 (1–19)	1.7 (1–3)	2.1 (1–8)	9.1 (1–50)	1.8 (1–3)	0.023*	0.069*
Microcotyle sebastis	1 (1)	0	0	1 (1)	0	—	—
Corynosoma sp.	6 (1–17)	5.1 (1–15)	4.6 (1–8)	5 (1–17)	3.8 (1–7)	0.973	0.916
Echinorhynchus gadi	0	0	1 (1)	0	1 (1)	1.000	0.180
Clavella parva	1.4 (1–3)	1 (1)	1 (1)	1.8 (1–3)	2.2 (1–5)	0.427	0.443

on the host, have a long life span, and be present in only one part of the host. Based on coincident samples, it is clear that the monogenetic trematodes and copepods on the gills of the rockfishes in our study meet all these criteria, as do the visceral acanthocephalans. Gill parasites are protected by the operculum during capture, are sampled easily, and can be identified aboard ship. Notably, Leaman and Kabata (1987) previously proposed using *N. robusta* as a marker for separating stocks of *S. alutus* in British Columbia. Acanthocephalans, such as *Corynosoma* sp., also serve as excellent markers because they can be easily enumerated with a pepsin enzyme. In contrast, the lack of digenes and cestodes in the preliminary survey (probably due to regurgitation through barotrauma) makes these parasites poor candidates as tags for deepwater rockfishes. The nematodes are difficult to identify and their prevalences were similar throughout the Gulf of Alaska.

In addition to their potential use in determining stock structure, differences in prevalence between areas among the parasites in this study also give insight on differences in diet and parasite distributions. *Corynosoma* sp. is widely distributed in the northeastern Pacific Ocean as a parasite of marine mammals, birds, and fishes (Margolis, 1958); thus the different prevalences of Corynosoma sp. in our study were likely due to differences in diet rather than to parasite distribution. The intermediate hosts for *Corynosoma* sp. are amphipods; hence, the percentage of amphipods in the diet may be higher in the western part of the GOA than in the eastern part. Alternatively, rougheye and shortraker rockfishes may be more likely to consume infected amphipods than other prey items. In contrast, both copepods and monogenes have no intermediate host stage, and differences in parasitism between management areas probably reflect differences in parasite distribution or host habitat, rather than differences in diet.

Some of the parasite species reported in this study had very different prevalences than those reported for other species or locations of rockfishes. For example, *Corynosoma* sp. was less prevalent (<10%) in most species of British Columbia rockfishes (Sekerak, 1975; Stanley et al., 1992) than in our study. *Corynosoma* sp. may be more common in the GOA than in Canada or simply more prevalent in shortraker and rougheye rockfishes than in some other species. Sekerak (1975) examined 536 rockfishes of

26 species from British Columbia waters and the GOA: of the 40 *Corynosoma* sp. recovered, 12 were from rougheye rockfish and 23 were from the GOA.

Size did not appear significant in parasite prevalences except for *N. robusta* and *C. pinguis* infection in rougheye rockfish. Prevalences of several species of parasites, including *N. robusta*, differed significantly among fish of the same size. Nor was size a factor in parasite intensities, despite the observation of Sekerak (1975) that intensities of copepods and monogenetic trematodes increase with increasing fish size, largely due to increased gill surface area. Although the value of parasite tags would be enhanced by sampling similar-size fish, the statistically significant differences among areas, despite size variation, provide an indication of the potential power of parasite markers for these species.

In summary, the prevalence or intensity of *N. robusta*, *T. trituba*, and *Corynosoma* sp. may prove to be useful markers for population studies of GOA shortraker and rougheye rockfishes. It is interesting to note the major reduction in prevalence of all three parasites among Southeast rougheye rockfish. Possibly these fish may constitute a separate stock and support a localized fishery. More studies are needed to evaluate the effects of temporal and spatial variability on parasite prevalence and intensity, particularly among GOA rougheye rockfishes.

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