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Author(s)	YAMAMURA, Orio
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20. Demersal Fish Assemblages of the Oyashio Region Ecosystem

Orio YAMAMURA

Hokkaido National Fisheries Research Institute, 116 Katsurakoi Kushiro, 085-8611, Japan
E-mail: orioy@hnf.affrc.go.jp

Abstract

Structure and trophic pathways of demersal fish assemblages were studied using trawl samples collected in the Doto area and off the Sendai Bay area, within the northern and southernmost parts of the Oyashio Current Ecosystem. Each of the areas was separated into a few faunal assemblages along a depth axis, dominated by the gadiform fishes *Gadus macrocephalus, Theragra chalcogramma, Laemonema longipes,* and *Physiculus maximowiczi.* In the southern area, there was marked seasonal and interannual variability in structure, whereas there appeared to be an exclusive competition among the dominant species in the Doto area. Trophic pathways supporting the fish assemblages were assessed using an index which took into account diet and dominance of predator fish. In every assemblage, pelagic prey, such as euphausiids, copepods, pelagic squids, and lantern fish, was more important than benthic prey. According to catch statistics, during the 1950s the fish assemblages in the study area were dominated by benthos-feeding species such as rockfish and flatfishes. These fishes are more substratum-related, dependent upon benthic prey, and more vulnerable to fishing activity than are the present gadiform dominants. Therefore, the fish assemblages and trophic pathways have changed due to the impact of fishing in the study area.

Introduction

The Oyashio Current, the western part of the Subarctic Gyre, flows in a southwesterly direction along the Kuril Islands, southeastern coast of Hokkaido, and the northeastern coast of the Japanese mainland. The Oyashio Current region is one of the most productive areas in the world, accounting for the largest contribution to the catch in the Japanese fishery. As for groundfish, in recent years more than 70% of the total catch has been from this region.

In this paper, I present information on community structure and trophic pathway for demersal fish communities over the lower continental shelves and upper slopes of the northern and southernmost parts of the Oyashio Current ecosystem, Doto (i.e., off the southeastern coast of Hokkaido Island) and off Sendai Bay (SB) areas. Furthermore, the influence of fishing activities on community structure and trophic pathway is discussed using historical data from the 1950s.

Community Structure

Biannual bottom trawling research data were available for May and November, 1989-1992, for the SB area. Depth-related faunal zonation of the demersal fish assemblage has been shown for this area (Fujita et al., 1993; Yamamura et al., 1993a): the demersal fish fauna in this region shows a distinct change across the 300 m contour during May and across the 200 m contour during November (Table 1).

Table 1. Percent species composition of the demersal fish assemblages off Sendai Bay separated according to year, month, and depth off Sendai Bay.

May	Shallow(<300m)				Deep(>300m)			
	1989	1990	1991	1992	1989	1990	1991	1992
Pacific cod	44	52	26	14	4	41	4	4
Walleye pollock	48	38	48	74	4	23	1	1
Threadfin hakeling	-	-	11	4	82	4	83	73
Other fishes	8	10	16	9	10	32	12	22
November	Shallow(<200m)				Deep(>200m)			
	1989	1990	1991	1992	1989	1990	1991	1992
Pacific cod	-	3	-	-	53	29	17	24
Walleye pollock	13	14	11	11	33	58	41	26
Brown hakeling	59	19	62	59	2	3	8	4
Threadfin hakeling	-	-	-	-	2	1	2	17
Other fishes	28	64	27	30	10	10	31	28

The bulk of the demersal fish assemblage was composed of four gadiform fish species: Pacific cod, *Gadus macrocephalus*; walleye pollock, *Theragra chalcogramma*; threadfin hakeling, *Laemonema longipes*; and brown hakeling, *Physiculus maximowiczi*. During May, Pacific cod and walleye pollock were prevalent in the shallow stratum, whereas threadfin hakeling was dominant in the deep stratum. Marked seasonal change in fish fauna occurred in the deep stratum; Pacific cod and walleye pollock replaced threadfin hakeling, reflecting the increase in water temperature in the shallow stratum.

The SB area is characterized by a complicated oceanographic structure incorporating the Oyashio intrusion, current extension, Tsugaru Warm Current, as well as numerous warm-core rings shed by these currents. Consequently, the fish assemblages in the area are subject to substantial physical variability at various temporal scales. For instance, the abrupt decrease in threadfin hakeling within the deep stratum during May, 1990 was attributable to the above-average water temperature caused by the prevalence of the Kuroshio Extension. Such physical variability affects the distribution of not only fish assemblages, but also prey organisms and thus has the potential to alter the structure of entire food webs.

Bottom trawls were conducted in the Doto area in June, 1988-1992. The two demersal fish assemblages, each dominated by walleye pollock and threadfin hakeling, were separated by the 200 m isobath (Table 2). However, the boundary between these assemblages changed in accordance with the abundance of the dominants but not with environmental variability. This suggests that this boundary reflects an exclusive competition between these species.

Trophic Pathways

The trophic pathways supporting the fish assemblages in the SB area were studied based on a total of 8,650 samples of stomach contents of fish. Food web structure was described for a total of 16 assemblages, determined by cluster analyses based on species composition of trawl samples. As a relative importance of prey types (i.e., pelagic prey, benthic prey, and fishing discards), an index considering diet and dominance of predator was calculated:

$$D_{ij} = 100 \sum d_i w_{ij}, \quad \ldots\ldots (1)$$

where di is the percent relative abundance of the predator in an assemblage and *wij* is the percent contribution of prey *j* in the diet of predator *i*. In every assemblage, each dominated by a gadiform species, the importance of pelagic prey such as *Euphausia pacifica* (Yamamura *et al.*, in press), *Neocalanus cristatus*, pelagic squid *Watasenia scintillans* (Yamamura *et al.*, 1993b), and myctophid fishes, was high (Table 2). Although its importance was uniformly high during May (88-100%), it decreased during November (55-83%) when benthic prey such as shrimp and octopus and fishing discard, Pacific saury *Cololabis saira* (Yamamura, 1997), contributed up to 34% and 24%, respectively. The decrease in the contribution of the pelagic prey reflects the decrease in primary production from May through November. It is therefore concluded that benthic prey and fishing discards compensate for the decline of pelagic prey during the less productive times of year.

Table 2. Percent contribution of prey categories calculated by formula (1) for each faunal assemblage separated by cluster analyses.

May			November			
Assemblage	Pelagic	Benthic	Assemblage	Pelagic	Benthic	Discards
1989S	87	13	1989S	65	34	1
1989M	99	1	1989D	56	21	23
1990D	100	-	1990A	74	22	4
1990A	88	12	1991D	83	13	4
1991D	100		1991S	68	29	3
1991S	97	3	1991M	83	8	9
1992S	97	3	1992D	81	19	-
1992D	100	-	1992S	63	24	13

Data on diet was available for the dominant species, walleye pollock and threadfin hakeling, for the Doto area. Although both species showed ontogenetic and seasonal dietary shifts, a constant portion of their diets included similar pelagic organisms such as *Neocalanus cristatus, Euphausia pacifica, Thysanoessa* spp., and myctophid fishes. This fact also supports the hypothesis that these dominants compete exclusively on the boundary between shelf and upper-slope assemblages.

3. Influence of Fishing Activity

The greatest portion of the bottom fish assemblages in the Oyashio Region was composed of benthopelagic gadiform fishes primarily dependent on pelagic food resources. To determine whether the structure of the community and food web resulted from the influence of fishing activities, the species compositions of the fish assemblages were compared with the catch compositions in these areas during the 1950s (Anonymous, 1952; Anonymous, 1956). The available data included catch composition of the trawl fishery from 1953 to 1955 in the Miyagi and Fukushima prefectures, which included the present study area, and at Urakawa and Kushiro in the Doto area (Table 3).

Table 3. Catch composition of the bottom trawl fishery during the 1950s.

Location	Year	Rockfish	Flatfishes	Spiny dogfish	Gadid fishes	Other fishes
Miyagi Pref.	1953	22	8	27	3	40
	1954	32	12	22	3	31
	1955	19	10	27	3	31
Fukushima Pref.	1953	23	26	12	14	25
	1954	26	20	21	10	23
	1955	24	22	12	10	32
Urakawa (Doto)	1950	5	31	1	52	11
Kushiro (Doto)	1950	9	47	1	32	12

In Miyagi and Fukushima prefectures, more than half of the catch had been composed of rockfish, flatfishes, and spiny dogfish *Squalus acanthias.* The proportion of gadid fishes in the catch from the Doto area was higher than in the SB area, but rockfish and flatfishes accounted for a higher proportion than in the present study. The dominants from the 1950s were more substratum-related, dependent upon benthic prey, and more vulnerable to the impact of fishing activities than are the present gadiform dominants. I can therefore conclude that the historic fish fauna and trophic pathways in the study area have been altered in response to fishing activities.

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