Long-term dynamics of species composition and abundance of flatfish in waters off Primorye (the Sea of Japan)

Article in Journal of Ichthyology · March 2007

DOI: 10.1134/S0032945207020038

Dmitriy Valer'evich Antonenko
Pacific Scientific Research Fisheries Center

ISSN 0032-9452, Journal of Ichthyology, 2007, Vol. 47, No. 2, pp. 154–161. © Pleiades Publishing, Ltd., 2007.
Original Russian Text © D.V. Antonenko, 2007, published in Voprosy Ikhtiologii, 2007, Vol. 47, No. 2, pp. 188–195.

Long-Term Dynamics of Species Composition and Abundance of Flatfish in Waters off Primorye (the Sea of Japan)

D. V. Antonenko

Pacific Fisheries Research Center (TINRO-Center), tupik Shevchenko 4, Vladivostok, 690600 Russia
e-mail: vdovin@tinro.ru

Received March 22, 2006

Abstract—Based on the data of trawl surveys, changes in the structure of species composition and flatfish abundance (Pleuronectidae) in waters off Primorye are shown in the period embracing over 20 years (1983 to 2004). In waters off Primorye, 14 flatfish species were recorded in catches. At the present time, the structure of the flatfish part of the fish community in waters off Primorye has undergone considerable changes in comparison with the 1980s: the proportion of deepwater flatfish has considerably increased against the background of a decrease in the abundance of coastal species. A general decrease in the numbers and biomass of flatfish in waters off Primorye is recorded, which is caused by natural reasons against the background of an inconsiderable fishery intensity.

DOI: 10.1134/S0032945207020038

Representatives of the family Pleuronectidae by the number of species, abundance, and biomass occupy a dominant place in the bottom ichthyofauna of the shelf of Far East seas, and many flatfish species form large aggregations and are traditional objects of coastal fishery (Borets, 1997; Fadeev, 2005). In waters off Primorye, 24 fish species of the family Pleuronectidae were recorded (Novikov et al., 2002), but only 13 species may be related to permanent inhabitants (Borets, 1997). Due to some ecological and biological features (the settled mode of life and staying in local regions of habitation, comparatively slow growth, and a long life cycle), the change in the numbers of flatfish populations depends to a certain degree on the fishery intensity (Moiseev, 1953). At the present time, under conditions of a long-term commercial impact on traditional items of fishery, constant monitoring of the state of their resources becomes important. In the northwestern part of the Sea of Japan, flatfish have been intensively seined beginning from the 1930s (Ivankova, 2004). During this time, their biology, distribution, and spawning and wintering migrations were rather comprehensively studied; however, the causes of changes in the composition of flatfish population remain unexplained (Vdovin, 2005). A widespread opinion concerning a decrease in the stock and changes in the species composition of flatfish in Peter the Great Bay exclusively because of a commercial impact (Moiseev, 1946, 1953; Ivankova, 1975; Fadeev, 1987; et al.) is subjected to question by several authors (Shuntov et al., 1990; Borets, 1997; Vdovin, 2005).

The purpose of this study was the analysis of the dynamics of the species composition of flatfish, as well as of their abundance in waters off Primorye during the last two decades.

MATERIALS AND METHODS

The study is based on results of 28 trawl surveys performed in waters off Primorye from 1983 to 2004; of them, 17 in Peter the Great Bay and 11 in northern Primorye. Altogether, results of 3437 trawlings (1934 in the first region and 1503 in the second region) were processed. Trawling in the bay was performed on board the MRS-type vessels (small seiners) mostly in the summer during the active feeding of flatfish when the dislocation of their aggregations is relatively stable (Moiseev, 1953). In waters off northern Primorye, trawl surveys were performed on board the SRTM- and MRTK-type vessels (medium refrigerated side-trawler and small trawler) mainly in spring during the active migration of most flatfish to the coast. In general, the survey zones in Peter the Great Bay and northern Primorye almost completely embraced the distribution range of flatfish during studies. Trawlings were performed using a soft ground rope of various lengths. For obtaining comparable results in using trawls of various sizes, the value of catch per 1 h of trawling was recalculated per specific biomass (t/km^2).

Latin names of flatfish in the paper are cited according to the latest revision of the family Pleuronectidae (Cooper and Chapleau, 1998) and the Catalog of Fish by Eschmeyer (2005). Russian names of flatfish are borrowed from the Dictionary of Animal Names in Five Languages (Reshetnikov et al., 1989). By the present time, *P. schrenki* is recognized as a junior synonym of the species *P. yokohamae* (Vinnikov et al., 2006).

Table 1. Average values of relative abundance in catches (% of mass) of flatfish (Pleuronectidae) in Peter the Great Bay in various periods

Flatfish species	Periods, yr				Abundance in catches
	1984–1989	1990–1999	2001–2004	1984–2004	
Acanthopsetta nadeshnyi	4.2	4.5	9.2	6.0	**
Glyptocephalus stelleri	11.3	10.0	16.4	12.6	***
Hippoglossoides dubius	5.4	3.8	7.8	5.7	**
Cleisthenes herzensteini	8.6	8.3	8.9	8.6	**
Kareius bicoloratus	+	+	0	+	*
Platichthys stellatus	4.1	4.1	1.7	3.3	**
Limanda aspera	8.7	4.7	4.3	5.9	**
Pseudopleuronectes herzensteini	10.5	14.8	16.0	13.7	***
Lepidopsetta mochigarei	+	0.3	+	+	*
Liopsetta pinnifasciata	2.2	4.9	7.7	5.0	**
Limanda punctatissima	10.9	13.3	5.6	9.9	**
Sakhalin flounder	+	+	0	+	*
Pleuronectes yokohamae	34.1	31.2	22.4	29.2	***

Note: ***, mass species (over 10% in flatfish catch); **, common species (1 to 10%); *, rare species (less than 1%); +, less than 0.1%.

Owing to the unclear taxonomic status (Vinnikov and Ivankov, 2002; Kartavtsev et al., 2002; Vinnikov et al., 2004) and considerable difficulties involved in the determination in the field, *Pseudopleuronectes obscurus* was also regarded as a synonym of *P. yokohamae*. The separation of flatfish into ecological groups (coastal, conventionally coastal, and deepwater) was made according to the paper by Vdovin and Shvydkii (2000).

RESULTS AND DISCUSSION

The study of the flatfish part of the fish community in Peter the Great Bay has been performed since the initiation of trawl fishery in the 1920s (Moiseev, 1946). According to the data by Moiseev (1946, 1953), 20 flatfish species (20 in Peter the Great Bay and 14 in waters of northern Primorye) inhabited waters of Primorye in this period. Dominant flatfish in catches were the yellow-finned sole *Limanda aspera* and the pinewood flounder *Cleisthenes herzensteini* whose total proportion in catches of flatfish in some years was over 80%. However, over 10 to 15 years, the species ratio in catches considerably changed, and the basic proportion was now made by species that were rather insignificant previously such as *Glyptocephalus stelleri*, the scaly-eyed plaice *Acanthopsetta nadeshnyi*, the yellow-banded flounder *Pseudopleuronectes herzensteini*, *P. yokohamae*, and the long-snouted flounder *Limanda punctatissima* (Tychkova, 1946; Moiseev, 1953). By the moment of banning flatfish fishery in Peter the Great Bay in 1968, the bulk of catches was formed by *G. stelleri* (34%); however, in the early 1970s, *L. aspera* ranked first (Ivankova, 1975). In the 1980s, in waters of the bay, the bulk of commercial catches was formed by *L. aspera* and *G. stelleri* (Ivankova, 1998, 2000). Off the coasts of northern Primorye, no specialized flatfish fishery was developed, and published data on the species composition of flatfish in this region are based on the results of trawl surveys performed in the early 1980s. According to data by Borets (1990), of 11 flatfish species recorded on the shelf of northern Primorye from 1983 to 1984, dominant species in catches included *A. nadeshnyi* (54%), *G. stelleri* (21%), and *Hippoglossoides dubius* (16%), and the total proportion of the remaining species did not exceed 9%.

According to the data of our surveys, 14 flatfish species were recorded in trawl catches off the coasts of Primorye over the 20-year period (1983 to 2004) (Tables 1 and 2). In Peter the Great Bay, 13 species were recorded, of them, 11 constantly occurring (in each survey); stone flounder *Kareius bicoloratus* and white-bellied flounder *Lepidopsetta mochigarei*, episodically occurring; and *Pleuronectes quadriturberculatus* was lacking altogether, although there are data on the presence of this species in waters of Peter the Great Bay (Antonenko et al., 2003). In waters of northern Primorye, 12 flatfish species were recorded, of them 10 were constantly occurring; *Platichthys stellatus* and *P. quadrituberculatus* occurred incidentally and *Liopsetta pinnifasciata* was lacking in catches. As is known, *L. pinnifasciata* is the most shallow-water species of all flatfish inhabiting waters of Primorye (Vdovin and Shvydkii, 1993, 2000; Novikov et al., 2002), and its aggregations in the period of maximum distribution do not occur at depths larger than 20–30 m. It may be assumed that this flatfish was absent in catches due to its habitation in shallow waters, thereby

Table 2. Average values of relative abundance in catches (% of weight) of flatfish (Pleuronectidae) in waters of northern Primorye in various periods

Flatfish species	Periods, yr				Abundance in catches
	1983–1989	1990–1998	2000–2004	1983–2004	
Acanthopsetta nadeshnyi	69.4	51.6	51.2	57.4	***
Glyptocephalus stelleri	18.9	32.3	24.3	25.2	***
Hippoglossoides dubius	7.2	2.8	6.5	5.5	**
Cleisthenes herzensteini	0.6	0.3	0.8	0.6	*
Platichthys stellatus	0.1	0.1	0.1	0.1	*
Limanda aspera	0.2	0.3	1.1	0.5	*
Pseudopleuronectes herzensteini	2.4	3.9	7.1	4.5	**
Lepidopsetta mochigarei	+	0.3	0.2	0.3	*
Limanda punctatissima	+	+	+	+	*
Pleuronectes quadrituberculatus	+	+	+	+	*
Sakhalin flounder	+	+	0	+	*
Pleuronectes yokohamae	0.9	8.4	8.6	6.0	**

not getting into the trawl survey zone (deeper than 20 m). However, according to data by Kolpakov (2004) during surveying in 1997–2002 the coastal waters of northern Primorye at depths of up to 20 m, *L. pinnifasciata* was never found in catches. It should be noted that species such as barfin flounder *Verasper moseri*, spotted halibut *V. variegatus*, round-nosed flounder *Eopsetta grigorjewi*, fine-spotted flounder *Pleuronichthys cornutus*, *Microstomus achne*, rough-skinned sole *Clidoderma asperrimum*, Kamchatka flounder *Atheresthes evermanni*, and Pacific halibut *Hippoglossus stenolepis*, that according to published data are found in waters of Primorye, were not recorded in our catches throughout the observation period. This may be explained by considerable climatic and oceanological changes that took place in Far East seas during the 20th century. It is known that warming was observed from 1920 to 1930, and this period is called the first “sardine epoch” of the 20th century when an intense expansion of subtropical and even tropical fish and other southern marine animals to Far East temperate waters occurred (Shuntov, 2001). During these years in Peter the Great Bay, *K. bicoloratus* was caught in considerable amounts, and *L. mochigarei* was a commercial species (Taranets, 1938; Moiseev, 1946). At the present time, these species occur singly in the bay. According to data by Moiseev (1946), in 1935 and 1936, 5 ind. of *V. variegatus* were caught in Ussuriisk Bay. Respectively, in periods of cooling, cold-water species penetrate into waters of Primorye from northern regions (Antonenko et al., 2003).

As a result of the analysis of long-term data, it was found that, in Peter the Great Bay from 1980 to 1990, the dominant species in flatfish catches was *P. yokohamae* whose proportion in some years exceeded 45%. However, after 2001, the tendency formed for a considerable decrease in the proportion of this species in catches (Fig. 1a). The relative number of *P. herzensteini* and *L. punctatissima* in the 1980s was at a stable level (10–13%); however, then the proportion of *L. punctatissima* began to decrease and of *P. herzensteini*, to increase. The total proportion of *P. stellatus* and *L. pinnifasciata* in catches in the study period was insignificant and varied in the range of 10%; the index of the relative abundance of *P. stellatus*—a species not subjected to considerable population fluctuations (Vdovin et al., 1997) was characterized by high stability. The proportion of deepwater and conventionally coastal species in Peter the Great Bay throughout the study period was, in general, noticeably lower than that of coastal species. Some exceptions were made by *G. stelleri* whose proportion in catches in some years reached 28%. *A. nadeshnyi* and *H. dubius* in the 1980s to the first half of the 1990s comprised an insignificant part of caches, but, by the present time, the proportion of these species noticeably increased (Fig. 1b). The relative amount of *L. aspera* that, according to published data, formed the bulk of commercial catches in the mid-1980s did not exceed 10% and in the second half of the 1990s, declined to 5%. The proportion of *C. herzensteini* throughout the study period was at a rather stable level—in the range of 10%. The data on the species composition of flatfish in Peter the Great Bay averaged according to three periods indicate a considerable increase during the last years (2001–2004) of the relative numbers of *A. nadeshnyi*, *G. stelleri*, *H. dubius*, *P. herzensteini*, and *L. pinnifasciata* and a decrease of this index for *P. stellatus*, *L. aspera*, *L. punctatissima*, and *P. yokohamae* (Table 1). According to the relative abundance in catches, flatfish of the bay may be classified as numerous, common, and rare. The first group includes three species: *G. stelleri*, *H. dubius*, and

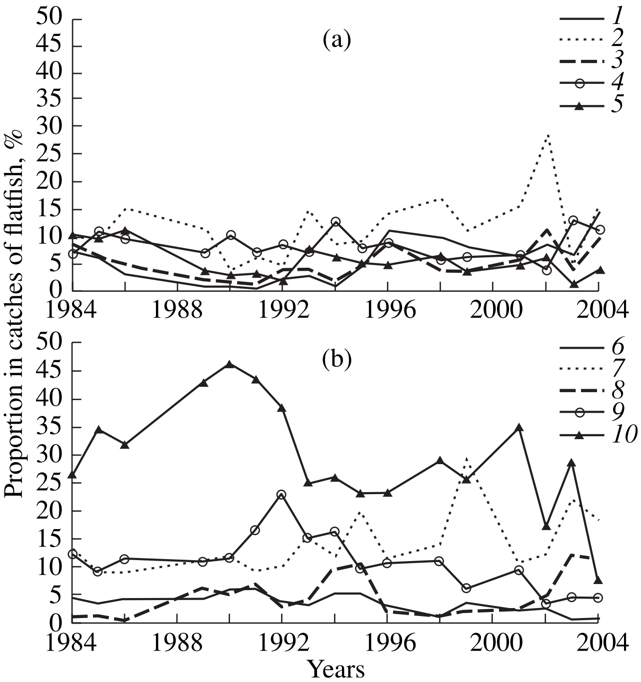

Fig. 1. Dynamics of species composition of flatfish (Pleuronectidae) in Peter the Great Bay from 1984 to 2004: (a) coastal species; (b) deep-water and conventionally coastal species. (*1*) *Platichthys stellatus*; (*2*) *Pseudopleuronectes herzensteini*; (*3*) *Liopsetta pinnifasciata*; (*4*) *Limanda punctatissima*; (*5*) *Pleuronectes yokohamae*; (*6*) *Acanthopsetta nadeshnyi*; (*7*) *Glyptocephalus stelleri*; (*8*) *Hippoglossoides dubius*; (*9*) *Cleisthenes herzensteini*; (*10*) *Limanda aspera*.

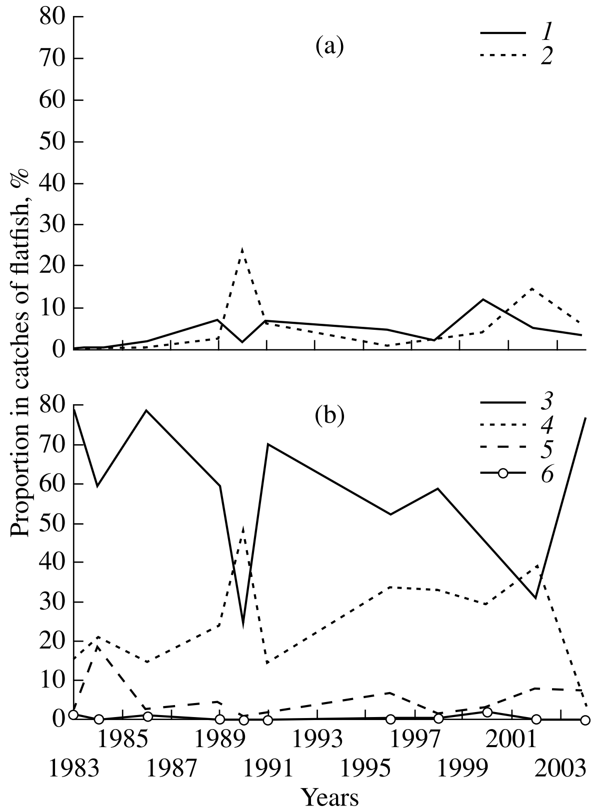

Fig. 2. Dynamics of species composition of flatfish (Pleuronectidae) in waters of northern Primorye from 1983 to 2004: (a) coastal species; (b) deepwater and conventionally coastal species. (*1*) *Pseudopleuronectes herzensteini*; (*2*) *Pleuronectes yokohamae*; (*3*) *Acanthopsetta nadeshnyi;* (*4*) *Glyptocephalus stelleri*; (*5*) *Hippoglossoides dubius*; (*6*) *Cleisthenes herzensteini*.

P. yokohamae. The second group includes seven species: *A. nadeshnyi*, *H. dubius*, *C. herzensteini*, *P. stelatus*, *L. aspera*, *L. pinnifasciata*, and *L. punctatissima*. Rare species include *K. bicoloratus*, *L. mochigarei*, and *Sakhalin flounder.*

In waters of northern Primorye, of the group of coastal species, only *P. herzensteini* and *P. yokohamae* had an appreciable proportion in catches in the study period; the relative number of the remaining coastal flatfish did not exceed 1% (Fig. 2a, Table 2). Catches primarily consisted of two deepwater species—*A. nadeshnyi* and *G. stelleri*; the proportion of *A. nadeshnyi* in catches in some years reached 80%, and *G. stelleri*, on the whole, was considerably inferior by this index. The proportion of *H. dubius* was insignificant and, on average, did not exceed 5.5%. The conventionally coastal *C. herzensteini* and *L. aspera* that make up a considerable portion in catches of Pleuronectidae in Peter the Great Bay are rare species in waters of northern Primorye. According to relative abundance in catches, only *A. nadeshnyi* and *G. stelleri* were mass species off the coasts of northern Primorye. *H. dubius*, *P. herzensteini*, and *P. yokohamae* were common species; the remaining species occurred rarely (Table 2).

Thus, there are considerable differences in the structure of the species composition of flatfish between the waters of Peter the Great Bay and northern Primorye, which, without doubt, is determined by physicogeographic and hydrological differences of these subregions. In catches made in the bay, coastal flatfish dominate, which is explained by the presence here of vast shallow waters, while a narrow band of the shelf and the drop-off near the coast off the coasts of northern Primorye determine optimum conditions for habitation of deepwater species. This explains the absence of shallow-water *L. pinnifasciata* in catches in northern Primorye (Izmyatinskii and Sviridov, 2000; Kolpakov, 2004). The warm-water *K. bicoloratus* that episodically enters Peter the Great Bay from adjacent Korean waters no longer occurs in colder waters of northern Primorye, and cold-water *P. quadrituberculatus* is almost absent in waters of Peter the Great Bay.

The abundance of Pleuronectidae in the study period in waters of Peter the Great Bay and northern Primorye is clearly demonstrated by the dynamics of their average specific biomass. This index in the bay from 1984 to 1992 insignificantly varied in the range of

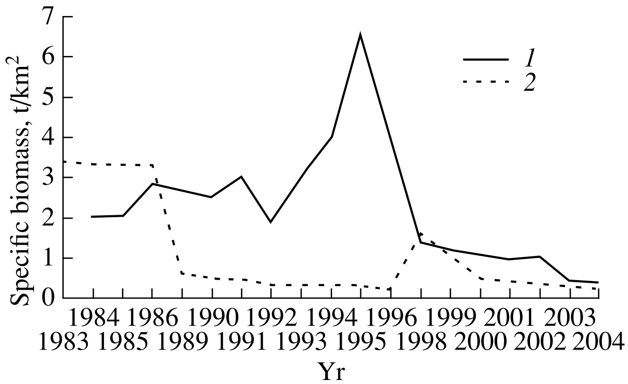

Fig. 3. Dynamics of average density of flatfish (Pleuronectidae) in Peter the Great Bay (*1*) and northern Primorye (*2*) from 1983 to 2004.

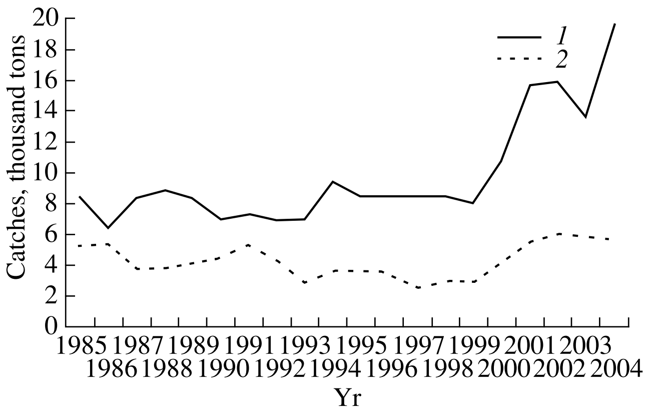

Fig. 4. Recommended (*1*) and actual (*2*) catch of flatfish (Pleuronectidae) in waters of Primorye from 1985 to 2004 according to data of Primorrybvod.

2 to 3 t/km^2; then, in the mid-1990s, it increased to 6.5 t/km^2 and, in the late-1990s, declined to 1.5 t/km^2 (Fig. 3). In the subsequent years, the specific biomass of flatfish in Peter the Great Bay gradually decreased to 0.5 t/km^2. In waters of northern Primorye, on the contrary, a noticeable decrease in specific biomass of flatfish occurred in the mid-1990s in comparison with the 1980s. After a certain increase in 1998 to 1.7 t/km^2, this index decreased to a value comparable to that in Peter the Great Bay (less than 0.5 t/km^2).

The results of long-term observations demonstrated that the total numbers of flatfish in waters of Primorye that were at a sufficiently high and stable level in the 1980s, underwent considerable changes in the 1990s: in Peter the Great Bay, they increased for a short period (which is possibly the result of errors in count in a particular survey) and decreased off the coasts of northern Primorye. In the subsequent years, a general tendency for a decline in the numbers of flatfish in waters of Primorye formed, which is apparently first related to changes in hydrological conditions rather than to the fishery load. The intensity of fishery off the coasts of Primorye over the last ten years even slightly decreased; this is supported by long-term data on the forecast and catch of flatfish in Primorye (Fig. 4). Beginning from the second half of the 1980s, the level of realizing the forecasts of catch of flatfish gradually decreased and by the mid-1990s comprised less than 50%, which was mainly accounted for by economic factors.

The conclusion about the decrease in the flatfish numbers is indirectly confirmed by comparison of the dynamics of catches of a group of fish close to them by the mode of life—Cottidae that parallel to the greenling *Pleurogrammus azonus*, wall-eyed pollack *Theragra chalcogramma*, and flatfish traditionally occupy a dominant place in catches of bottom fish by numbers and biomass in waters of Primorye (Gavrilov, 1998; Vdovin et al., 2004). *T. chalcogramma* and *P. azonus* that lead a near-bottom-pelagic mode of life and are not always fully considered in bottom surveys were excluded from comparison. The proportion of Cottidae in both Peter the Great Bay and northern Primorye in the study period was at a relatively stable level while the flatfish proportion varied in far greater range (Fig. 5). Beginning from the second half of the 1990s, the proportion of flatfish in catches in Peter the Great Bay successively decreased, having reached in 2004 the value lower than the index of Cottidae for the first time over the observation period (Fig. 5a). Comparison of the composition of catches of trawl surveys in waters of Primorye over the study period demonstrated a very weak negative correlation between Pleuronectidae and Cottidae ($r = -0.094$ in Peter the Great Bay and $r = -0.178$ in waters of northern Primorye). It should be noted that a considerable increase (up to 20% and over) of the proportion of gobies in commercial catches on the shelf of Far East seas was also recorded in the 1960s (Fadeev, 1971a, 1971b), which was first related to the increase in the fishery load on bottom fish.

The retrospective analysis of the dynamics of species composition of flatfish in Peter the Great Bay based on published data showed certain trends. For instance, in the first years of fishery, *L. aspera* and *C. herzensteini* formed the bulk of catches (Moiseev, 1946; Tychkova, 1946); however, in the 1950s to 1960s when the total numbers of flatfish were at a low level, the bulk of catches was formed by four flatfish species: *G. stelleri*, *H. dubius*, *A. nadeshnyi*, and *P. yokohamae* (Mineva, 1967). In the 1970s to early 1980s, the proportion in catches of *L. aspera* increased again (Ivankova, 1975). At the present time, the structure of the species composition of flatfish in the bay is close to that of the 1950s to 1960s. A similar pattern is recorded on the shelf of western Kamchatka where, beginning from the late 1990s and up to the present time, considerable changes in the species composition of flatfish are observed against the background of a low intensity of fishery. The present-day ratio of flatfish species has not been observed here since overfishing in the 1960s (Il'inskii et al., 2004).

It is of interest that in the 1950s and 1960s, in Peter the Great Bay, deepwater flatfish species—*G. stelleri*, *H. dubius*, and *A. ndeshnyi* comprised the bulk of catches (Fadeev, 1971a). However, if previously (in the 1930s) these usually scarce species always stayed at depths larger than 100 m, in the mid-1940s, they began to occur in catches of low-tonnage vessels. From 1965 to 1968, fishery was mainly performed at depths 70–80 m; however, deepwater flatfish species dominated in catches.

The general decrease in flatfish resources in waters of Primorye, in our opinion, is not directly related to the anthropogenic impact and has a temporary pattern. It is known that the numbers of commercial objects are first dependent on the conditions and efficiency of their natural reproduction, as well as on the state of communities they dwell in. Fishery, depending on its intensity, affects only additionally, sometimes considerably, the natural course of events (Shuntov et al., 2002). Marine ecosystems exist under conditions of natural rhythms of various durations that directly affect the resources of hydrobionts. According to the opinion of Shuntov et al. (Shuntov, 2001; Shuntov et al., 2002), the long-term dynamics of the structure of bioresources and fish productivity of seas is mostly affected by the 40–60-year cyclicity of cosmogeophysical, climatic, and oceanological factors. During the 20th century in Far East seas, two relatively warm periods were observed: the 1920s to 1930s and the second half of the 1970s to the first half of the 1990s that were replaced by relatively cold periods: the 1940s to 1960s and the period that began in the second half of the 1990s and continues up to now (Ponomarev et al., 2000; Shuntov, 2001; Zuenko, 2002). Comparison of this cyclicity with the flatfish abundance in Peter the Great Bay shows the following regularity: the maximum numbers of flatfish in the bay coincide with periods of warming and, in periods of cooling, flatfish numbers decline to a minimum. The processes taking place in Peter the Great Bay (and in Far East seas, in general) in the late 1930s, when the structure of the species composition of flatfish considerably changed over a rather short period, highly resembles a situation observed since the late 1990s. At this time, considerable rearrangements in the composition and structure of nekton and plankton communities of Far East seas were observed (Shuntov, 2001). Some authors consider that the origin of changes in the composition and structure of bottom communities should be searched for in the pelagial, where the development of the early stages of bottom fish takes place (Bocharov and Shuntov, 2004; Dulepova et al., 2004). Most of them have pelagic eggs and larvae concentrating in the upper layers of the sea together with larvae of pelagic species and entering various forms of interspecific relations with them. In all likelihood, the main cause of changes in the species composition and numbers of flatfish is a decrease in the survival of larvae and juveniles of these fish as a result of the destabilization of plankton communities caused by climatic–oceanological changes occurring recently in Far East seas (Il'inskii et al., 2004). As is known, the dates of the outbreak of phyto- and zooplankton are affected by a host of factors: abnormal temperatures and air pressure, the sum of atmospheric precipitation, wind velocity, anomalies of surface temperature and salinity of sea water, duration of the ice period, etc. For instance, the active mixing of the surface layer of water in the northwestern part of the Sea of Japan because of wind intensification leads to its cooling and the shift of the dates of spring blossoming by more than a month (Davydova, 2004). Not a small role is possibly played by predatory zooplankton whose proportion in plankton communities is periodically increased, which affects the survival of pelagic larval flatfish.

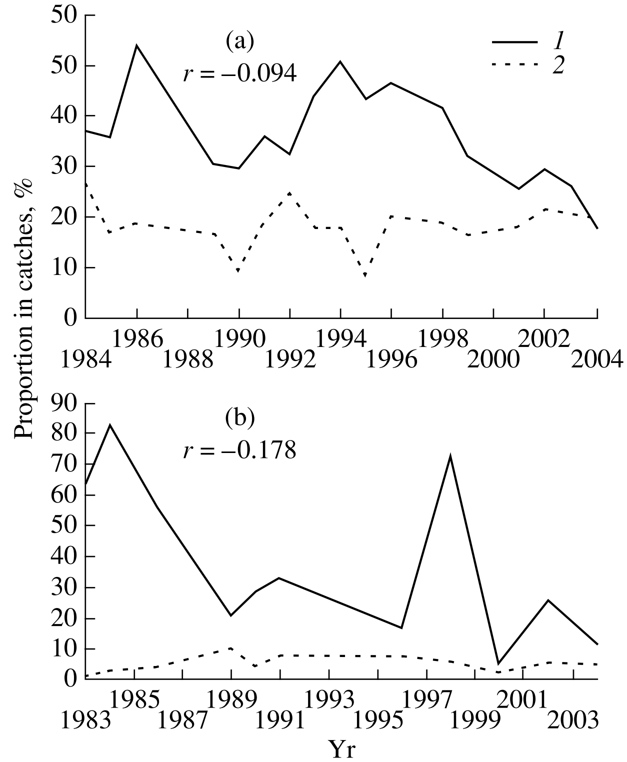

Fig. 5. Long-term dynamics of proportion in catches of flatfish (Pleuronectidae) (*1*) and sculpins (Cottidae) (*2*) in Peter the Great Bay (a) and off the coasts of northern Primorye (b).

CONCLUSIONS

Thus, it may be concluded that at the present time the structure of the flatfish population in waters of Primorye has underwent considerable changes in comparison with the 1980s: the proportion of deepwater flatfish has considerably increased against the background of a decrease in the abundance of coastal species. A general decrease in the numbers and biomass of flatfish off the coasts of Primorye is noted, which is caused by natural factors against the background of an insignificant fishery intensity. In all probability, changes in the structure of species composition and numbers of flatfish in waters of Primorye have a cyclic pattern and recur with an interval of about 50 yr.

REFERENCES

1. D. V. Antonenko, P. V. Kalchugin, D. V. Izmyatinskii, and L. N. Kim, "On the Occurrence of Cold-Water Species of Fish, Rare for Peter the Great Bay (the Sea of Japan)," Vopr. Ikhtiol. **43** (1), 54–57 (2003) [J. Ichthyol. **43** (1), 50–53 (2003)].
2. L. A. Borets, "Composition and Biomass of Bottom Fish on the Shelf of the Sea of Japan," in *Biology of Shelf and Migratory Fish* (IBM DVO RAN, Vladivostok, 1990), pp. 59–65.
3. L. N. Bocharov and V. P. Shuntov, "The State and Tasks of the Modern Stage of Ecosystemic Studies of Biological Resources of Far East Seas of Russia," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **137**, 3–15 (2004).
4. L. A. Borets, *Bottom Ichthyocenoses of the Russian Shelf of Far East Seas: Composition, Structure, Elements of Functioning, and Commercial Significance* (TINRO-Tsentr, Vladivostok, 1997) [in Russian].
5. J. A. Cooper and F. Chapleau, "Monophyly and Intrarelationships of the Family Pleuronectidae (Pleuronectiformes), with a Revised Classification," Fish. Bull. **96** (4), 686–726 (1998).
6. S. V. Davydova, "Population Dynamics of the Main Mass Epipelagic Fish Species in the Sea of Japan in the Second Half of the 20th Century and the Factors Responsible for It," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **137**, 119–143 (2004).
7. E. P. Dulepova, A. F. Volkov, V. I. Chuchukalo, et al., "Modern Status of Biota in Far East Seas," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **137**, 16–27 (2004).
8. W. N. Eschmeyer, *The On-Line Catalog of Fishes* (January 14, 2005). *http://www.calacademy.org./research/ichthyology/catalog/fishcatmain..*
9. N. S. Fadeev, *Biology and Fishery of Pacific Flatfish* (Dal'izdat, Vladivostok, 1971a) [in Russian].
10. N. S. Fadeev, "Changes in the Composition of Bottom Ichthyofauna during Trawl Fishery," Zool. Zh. **50** (4), 532–536 (1971b).
11. N. S. Fadeev, *North Pacific Flatfish: Distribution and Biology* (Agropromizdat, Moscow, 1987) [in Russian].
12. N. S. Fadeev, *Guide on Biology and Fishery of Fish in the Northern Part of the Pacific Ocean* (TINRO-Tsentr, Vladivostok, 2005) [in Russian].
13. G. M. Gavrilov, "Composition, Population Dynamics, and Fishery of Fish in the Economic Zone of Russia and Adjacent Waters of the Sea of Japan," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **124**, 271–319 (1998).
14. E. N. Il'inskii, A. Yu. Merzlyakov, A. V. Vinnikov, et al., "Modern Tendencies in the State of Ichthyotcenoses of Bottom Fish from the Western Kamchatka Shelf," Biol. Morya **30** (1), 79–82 (2004).
15. Z. G. Ivankova, "Changes in the Population Structure of Flatfish in Peter the Great Bay under Controlled Fishery," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **96**, 149–159 (1975).
16. Z. G. Ivankova, "Modern State of Resources and Prospects of Flatfish Fishery in Peter the Great Bay," in *Variation in the Composition of Ichthyofauna, Yield of Generations, and Methods of Forecasting Fish Resources in the Northern Part of the Pacific Ocean* (TINRO, Vladivostok, 1988), pp. 56–63.
17. Z. G. Ivankova, "Biology and State of Resources of Flatfish in Peter the Great Bay. 1. Yellow-Finned Sole (*Limanda aspera*)and Pole Flounder (*Glyptocephalus cynoglossus*)," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz.Okeanogr. **127**, 188–202 (2000).
18. Z. G. Ivankova, "Distribution, Migration, and Population Dynamics of Flatfish in the Northwestern Part of the Sea of Japan," in *Hydrometeorology and Hydrochemistry of Seas, Vol. 8: The Sea of Japan*, Issue 2: Hydrochemical Conditions and Oceanological Foundations of Biological Productivity (2004), pp. 202–210.
19. D. V. Izmyatinskii and V. V. Sviridov, "Some Aspects of Variation of Ichthyofauna in Kievka Bay (the Sea of Japan) in the Autumn Period," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **127**, 161–165 (2000).
20. Yu. F. Kartavtsev, A. Yu. Chichvarkhin, O. V. Svin'ina, et al., "Genetico-Biochemical Study of Variation and Similarity of Three Flatfish Taxa (Pleuronectidae) from Peter the Great Bay (the Sea of Japan)," in *Proceedings of the Conference of Students, Post-Graduates, and Young Scientists of the Scientific–Educational Center of Far East State University on Fundamental Studies of Marine Biota: Biology, Chemistry, and Biotechnology, Vladivostok, 2002* (DVGU, Vladivostok, 2002), pp. 70–71.
21. N. V. Kolpakov, "Ichthyocenosis of Coastal Waters of Northern Primor'ye: Composition, Structure, and Spatiotemporal Variation. I. Species Composition," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **136**, 3–40 (2004).
22. T. A. Mineva, "Some Changes in the State of Flatfish from Peter the Great Bay under the Impact of Fishery," Tr. Dal'nevost. Tekhn. Inst. Rybn. Prom-st. Khoz., No. 5, 143–155 (1967).
23. P. A. Moiseev, "Some Data on the Biology and Fishery of Flatfish in Peter the Great Bay," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **22**, 75–184 (1946).
24. P. A. Moiseev, "Cod and Flatfish from Far East Seas of the USSR," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **40** (1953)
25. N. P. Novikov, A. S. Sokolovskii, T. G. Sokolovskaya, and Yu. M. Yakovlev, *Fishes of Primor'ye* (Dal'rybvtuz, Vladivostok, 2002) [in Russian].
26. V. I. Ponomarev, E. I. Ustinova, A. N. Salyuk, and D. D. Kaplunenko, "Climatic Changes in the Sea of Japan and Adjacent Regions in the 20th Century," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **127**, 20–36 (2000).

27. Yu. S. Reshetnikov, A. N. Kotlyar, T. S. Rass, and M. I. Shatunovskii, *Animal Names in Five Laguages. Fishes* (Rus. Yaz., Moscow, 1989) [in Russian].
28. V. P. Shuntov, *Biology of Far East Seas of Russia* (TINRO-Tsentr, Vladivostok, 2001), Vol. 1 [in Russian].
29. V. P. Shuntov, L. A. Borets, and E. P. Dulepova, "Some Results of Ecosystemic Studies of Biological Resources of Far East Seas," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **111**, 3–26 (1990).
30. V. P. Shuntov, E. P. Dulepova, and I. V. Volvenko, "Modern Status and Long-Term Dynamics of Biological Resources of the Far East Economic Zone of Russia," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **130**, 3–11 (2002).
31. A. Ya. Taranets, "On New Findings of Southern Elements in the Ichthyofauna of the Nothwestern Part of the Sea of Japan," Vestn. Dal'nevost. Fil. Akad. Nauk, No. 28 (1938).
32. M. A. Tychkova, "On the State of Resources of the Flatfish School in Peter the Great Bay," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **22**, 185–194 (1946).
33. A. N. Vdovin, "The Study of the State of Resources of the Main Commercial Fish in Waters of Primor'ye," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **141**, 74–102 (2005).
34. A. N. Vdovin and G. V. Shvydkii, "Seasonal Distribution of Taeniopsetta in Peter the Great Bay," Biol. Morya, No. 4, 52–57 (1993).
35. A. N. Vdovin and G. V. Shvydkii, "Distribution of Flatfish (Pleuronectidae) in Peter the Great Bay During a Hydrological Summer (July–September)," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **127**, 122–136 (2000).
36. A. N. Vdovin, D. V. Antonenko, and T. G. Sokolovskaya, "Distribution of the Starry Flounder *Platichthys stellatus* in Peter the Great Bay," Biol. Morya **23** (4), 227–233 (1997) [J. Ichthyol. **23** (4), 201–206 (1997)].
37. A. N. Vdovin, D. V. Izmyatinskii, and S. F. Solomatov, "Main Results of Studies of Fish from the Marine Coastal Complex off Primorye," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **138**, 168–190 (2004).
38. K. A. Vinnikov and V. N. Ivankov, "On the Validity of Flatfish Species *Pleuronectes yokohamae* and *P. schrenki* (Morphometrical and Genetico-Biochemical Study)," in *Proceedings of V Regional Conference on Urgent Problems of Ecology, Marine Biology, and Biotechnology* (DVGU, Vladivostok, 2002), pp. 24–25.
39. K. A. Vinnikov, V. N. Ivankov, S. Yu. Neznanova, et al., "Taxonomic Status and Generic Status of the Sea of Japan Flatfish (Subfamily Pleuronectinae)," in *Proceedings of VII Regional Conference on Urgent Problems of Ecology, Marine Biology, and Biotechnology* (DVGU, Vladivostok, 2004)), pp. 27–29.
40. K. A. Vinnikov, V. N. Ivankov, and D. L. Pitruk, "Taxonomic Status of *Pseudopleuronectes yokohamae* and *P. schrenki* (Pleuronectidae, cited from Cooper and Chapleau, 1998)," Vopr. Ikhtiol. **46** (3), 316–325 (2006) [J. Ichthyol. **46** (4), 301–310 (2006)].
41. Yu. I. Zuenko, "Seasonal and Interannual Variation of Water Temperature in the Northwestern Part of the Sea of Japan," Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. **96**, 3–21 (2002).

Translated by I.A. Pogosyants