THE FOOD DIET CONTENT OF THE GRAY WHALE *ESCHRICHTIUS ROBUSTUS* IN MECHIGMENSKY BAY, WESTERN BERING SEA

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ABSTRACT
Food compositions in 82 individuals of the gray whale *Eschrichtius robustus* from Mechigmensky Bay in the Bering Sea were analyzed in 2007—2009. Animals of 12 taxonomic groups were revealed in the food boluses of whales; amphipods and polychaetes prevailed by biomass and frequency of occurrence. The average specific biomass of amphipods was 54.2-71.7% and the frequency of occurrence reached 96.3-100%; those of polychaetes were 19.5-37.2 and 85.2-100%, respectively. The comparison of the feeding of *E. robustus* in 2007-2009 and 1998-1999 displayed that the taxonomic composition of the eaten animals remained the same, but the sizes of the groups changed. In 2007-2009, 68 species of amphipods were recorded in the whale stomachs; the input to biomass was counted for six species, *Anonyx nugax* (31.7%), *Ampelisca macrocephala* (22.3%), *Psammonyx kurilicus* (15.3%), *Ampelisca eschrichti* (9.1%), *Hippomedon denticulatus orientalis* (4.3%), and *Pontoporeia femorata* (4.6%). As in 1998-1999, the first two species prevailed. In percentage terms, the greatest portion of the whale bolus was based on most abundant benthic species.

Key words: Gray whale, food composition, amphipods, polychaetes, frequency of occurrence, specific biomass

Zenkovich [Zenkovich, 1934, 1937] was the first who studied the feeding of the Gray whale *Eschrichtius robustus* in the Bering and Chukchi seas at summer-autumn seasons. He found that the Gray whale is a benthivore, whose food base was amphipods. This aspect of the biology of the Gray whale has been thoroughly studied [Tomilin, 1937, 1957; Sleptsov, 1952; Klumov, 1963; Zimushko, Lenskaya 1970; Blokhin, Pavlyuchkov, 1981, 1996; Bogoslovskaya et al., 1981, 1982; Highsmith, Coyle, 1992]. However most of the published works are devoted to feeding of *E. robustus* in the open coastal waters off the Chukchi Peninsula, while information about its diet in Mechigmensky Bay, a relevant feeding area off the coast of Chukotka, is extremely poor [Blokhin, Pavlyuchkov, 1983, 1999]. This was the reason for our study, which aimed at obtaining information on the food composition of Gray whale in the area.

MATERIAL AND METHODS

In July-September 2007-2009, we took samples of the stomach contents from 82 Gray whales that were captured in the Mechigmensky Bay according to IWC quotas and landed to the Lorino native village. Most of the investigated animals – 41 whose average size did not exceed 8.9 m, were caught in the west shallow area of the bay. We produced boluses weighing about 100 g from each whale stomach; the samples were fixed with 4% formaldehyde solution and were delivered to the Hydrobiology Lab at the Pacific Scientific Research Fisheries Centre (TINRO-Center). The food objects were then sorted into taxonomic groups and weighed in

precision ±0.1 g. The specific biomass of each group of animals or individual species was calculated as a percentage from the total of the studied bolus.

RESULTS AND DISCUSSION

Twelve taxonomic groups of animals were revealed in the stomachs of Gray whales. Amphipods and polychaetes prevailed in biomass. The specific biomass of amphipods in the boluses varied in different years (**Table 1**) from 54.2 to 71.7 %% (average – 61.5 %); the biomass of polychaetes altered from 19.5 to 37.2 %% (average – 30.3 %). The contribution of aquatic organisms from other taxonomic groups in the diet of the whales was much lower and did not exceed 3.9 %. Besides the animals, macrophytes were found in the stomachs of whales (**Table 1**). Clams, sand ascidians, cumaceans, layings of gastropods (usually of *Neptunea lyrata, Buccinum ochotense, Tectonatica alaskanus),* and isopods were the permanent component of the food. However, their specific biomass in the samples was low (**Table 1**).

By the frequency of occurrence in the samples, amphipods, from 96.3 to 100 %%, and polychaetes, from 85.2 to 100 %%, also prevailed. A high occurrence of bivalves in boluses *Yoldia seminude* and *Serripes groenlandicus* (52.9 – 63.2 %%) was recorded, but their specific biomass did not exceed 2.5 % in 2007-2008. In 2009 the mollusks (Mollusca) occurred in the samples much less frequently (3.7 %) and their specific biomass was in hundredths of a percent. Despite the fact that the frequency of occurrence of cumaceans was high (47.4 – 70.4 %) all 3 years, the specific biomass of this group was of any significant value (3.9 %) only in 2009, mostly due to the presence of *Lamprops quadriplicata krasheninnikovi.* In 2007 and 2008, the specific biomass of cumaceans did not exceed 0.6 % (**Table 1**) and was composed of other species, *Diastylis bidentata* and *D. alaskensis.* Isopods were represented by *Synidotea muricata* and *Gnorimosphaeroma noblei* in the samples; their occurrence ranged from 44.1 – 73.7 %% and their specific biomass was less 1.0 %. The comparison of the food spectra of whales from Mechigmensky Bay in 1998-1999 [Blokhin, Pavlyuchkov, 1999] and in 2007-2009 revealed some differences, although the major groups in the diet of whales were amphipods and polychaetes. However, in 2007-2009, the average specific biomass of amphipods in the boluses increased 2 times and the one's of polychaetes decreased from 41.6 to 30.3 %%. The percentage of cumaceans in the food masses significantly decreased; these were one of the major groups, up to 22.8 %, in 1999. The biomass of *Diastylis alaskensis,* which was dominant in 1998-1999, also significantly decreased in 2007-2009. No significant change was recorded in the parameters of other taxonomic groups.

Our studies confirmed that amphipods remained a favorite food of Gray whales in Mechigmensky Bay, although the species composition and weight in the bolus changed. A total of 68 species of amphipods belonging to two suborders, 19 families and 30 genera were recorded in the stomachs of whales that were killed in 2007-2009 (**Tables 2 and 3**), but only 6 species were of significant specific biomass and 3 of them, *Anonyx nugax* (31.7 %) and *Ampelisca macrocephala* (22.3 %), always prevailed. *Psammonyx kurilicus* (15.3 %), *Ampelisca eschrichti* (9.1 %), *Hippomedon denticulatus orientalis* (4.3 %) and *Pontoporeia femorata* (4.6 %) yielded somewhat to those species for this parameter. The first four of these species of amphipods prevailed in frequency of occurrence as well **(Table 2**).

In 1998-1999, 17 species of amphipods from the stomachs of whales from Mechigmensky Bay were identified. *A. nugax* and *A. macrocephala* also prevailed by specific biomass and frequency of occurrence, but their percentage in 1999 was significantly different from that in 1998. Two species, *Atylus carinatus* and *Melita formosa* were recorded in the 1990s but did not make a significant input to the diet of whales; they were not revealed in 2007-2009.

The qualitative and quantitative indicators of all species of amphipods in the bolus changed somewhat during the period of our research, 2007-2009. For example, 55 species of amphipods were recorded in the stomachs of whales in 2007; 26 species were found in 2008 and 34 species were recorded in 2009 (**Table 3**), which could be related to the unequal numbers of whales that were produced in those years.

The specific biomass of individual species of amphipods also did not remain stable in various years. Thus, the specific biomass of *A. nugax* ranged from 24.9-41.1 % and the highest value was reached in 2009 (**Table 2**). *A. macrocephala* led by biomass (32.9 %) and frequency of occurrence (94.7 %) in 2008, in 2009 the biomass of this species decreased by 2 times, although the frequency of occurrence was high, from 84.6 to 94.7 %% (**Table 3**). *P. kurilicus* was the leader in the frequency of occurrence (100 %) in 2008 and its biomass in 2008-2009 was more than 2 times higher than in 2007 (**Table 2**). Long-term parameter variation was also recorded in other species. For example, the biomass of *H. denticulatus orientalis* was extremely low in 2008, as well as that of *P. femorata* in 2009 (**Table 2**). Such species as *Atylus bruggeni, Photis fischmanni, Orchomenella minuta* and *Byblis erythrops* were permanent components of the gray whale diet but their specific biomass was low in the boluses (**Table 2**).

The biomass and frequency of occurrence in the dominant species of amphipods also varied in 1998-1999; the biomass of *A. nugax* decreased from 7.7 to 2.9 %, while the frequency of occurrence decreased from 44.4 to 20.6 %%. In *A. macrocephala* these parameters changed from 22.6 to 1.6 %% and from 48.1 to 15 %% at respectively [Blokhin, Pavlyuchkov, 1999].

The comparison of the diets of male and female gray whales in Mechigmensky bay in 2007-2009 did not reveal any significant differences. This could be explained by the fact that males and females feed together within the bay. No significant differences were revealed in the diets of young and adult whales, although most of the young whales preferred to feed in the shallow part of the bay, because of their physiological capabilities for foraging.

The comparison of our data to that obtained previously showed that amphipods and polychaetes were the main groups in the diet of the Gray whales, although their proportion, specific biomass, and frequency of occurrence varied. The dominant species of amphipods in the diet of Gray whales in Mechigmensky Bay in 2007-2009 did not differ from those in 1998-1999, with a slight variation of their proportion in the total biomass of the bolus. The qualitative and quantitative characteristics of the amphipods in 1980 were different, *P. femorata* prevailed in the diet of whales from Mechigmensky Bay; its proportion sometimes reached 93.3 % in the total biomass of the bolus. This parameter was significantly lower in *A. macrocephala* and *A. bruggeni* [Blokhin, Pavlyuchkov, 1983]. In 1998-1999, the specific biomass of *A. macrocephala* was 12.1 %; that of *A. nugax* was 5.3 % and it was 4.5 % in *P. femorata* [Blokhin, Pavlyuchkov, 1999]. Based on the data we obtained in 2007-2009, the ratio of the biomass of the dominant species changed somewhat and the role of *P. femorata* in the nutrition of Gray whales in the bay significantly decreased compared to the 1980s – 1990s.

In percentage terms, the most abundant benthic species should have the greatest proportion in the bolus of the gray whales. *A. nugax* and *A. macrocephala* were obviously such species in Mechigmensky Bay in 2007-2009. Other species dominated in the food of the Gray whales in the waters of Sakhalin Isl., viz., *P. femorata, Anisogammarus pugettensis, Eohaustorius eous eous, Eogammarusschmidti,* and *Grandifoxus longirostris* [Sobolewsky et al., 2000]. In Sakhalin coastal waters these species probably prevailed at the depths of 7-12 meters at which the whales fed, and *A. nugax* and *A. macrocephala*, although occurring in the area, formed a greater biomass only at depths of about 50 m.

It is known that the gray whale obtained many tons of food objects that were on the surface of the sand-silt bottom or were buried in its surface layers. Therefore it is natural that most of the amphipod species that were dominant in the diet of whales in Mechigmensky Bay were suspension feeders, which built leathery houses in the soft bottoms, while the remainder was necrophages or polyphages.

During their summer feeding the whales fed at the same locations for many years with an increased biomass of major food objects. The Mechigmensky Bay is one of those areas. It may be assumed that the stocks of food organisms were fairly stable. Some changes in the parameters of food objects of the whale (both of taxonomic groups as a whole and of individual amphipod species) various years were caused due to several reasons. Perhaps this was a reflection of natural long-term variations in the biomass and population density of benthic animals. Beyond

this, the discrepancies of various food components in biomass in different years may be caused by the patchy distribution of the benthos and migrations of whales within the feeding areas. The difference in quantitative and qualitative assessments of food objects of whales in different times may be affected by methodological errors as well, since the entire bolus was not studied, but only a small part of it. To some extent, this change may be caused by feeding on food organisms by whales, which, however, did not lead to the destruction of benthic communities. According to Bogoslovskaya [Bogoslovskaya, 1996], the gray whale itself provides food for future seasons. Only large adult amphipods remained in the baleen, while small ones were squeezed out by the tongue with the water jet and returned to the sea. Thus, strictly speaking, the whales "seeded" the upturned bottom with juvenile amphipods and provided them with food; concurrently with sediments that rise during feeding, buried formerly organic matter entered the water, thus stimulating plankton growth, which is the main food source of coastal amphipods. Amphipods reproduce rapidly and the most abundant species (for example, from the Family Ampeliscidae) also reinforce the broken sections of the bottom with their tubular houses. In time the whales can "harvest" them again. The permanent "plowing" of bottom by feeding whales does not deteriorate the ecosystem of the north Bering Sea and does not affect the sustainability of the favorite feeding grounds of the gray whale.

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Table 1 — The average frequency of occurrence (%) and specific biomass (%) of various representatives of benthic fauna in the samples of Gray whale boluses that were produced in Mechigmensky Bay in July-September, 2007-2009

No.	Groups	Frequency of Occurrence, %			Specific Biomass, %		
		2007	2008	2009	2007	2008	2009
1	Amphipoda	100.0	100.0	96.3	58.6	71.7	54.2
2	Polychaeta	91.2	100.0	85.2	34.1	19.5	37.2
3	Bivalvia	52.9	63.2	3.7	2.5	2.4	<0.01
4	Ascidiacea	55.9	89.5	70.4	1.9	2.3	2.5
5	Isopoda	44.1	73.7	44.4	1.0	0.5	0.3
6	Cumacea	50.0	47.4	70.4	0.5	0.6	3.9
7	Gastropoda	5.9	0	0	0	0	0
8	Gastropoda (egg sets)	23.5	47.4	63.0	0.2	2.7	2.0
9	Hydroidea	2.9	0	0	0	0	0
	Decapoda:						
10	Macrura	8.8	31.6	3.7	0.4	0.2	0.02
11	Paguridae	2.9	0.0	0.0	0.2	0.0	0.0
12	Leptostraca	0	0	7.4	0	0	<0.01
13	Algae	29.4	5.3	7.4	0.4	0.1	0.1

Table 2 — The average frequency of occurrence (%) and specific biomass (%) of various species of amphipods in the samples of boluses of Gray whales landed in Mechigmensky Bay, 2007-2009

No.	Species	Frequency of occurrence, %			Specific biomass, %		
		2007	2008	2009	2007	2008	2009
1	*Anonyx nugax*	82.4	84.2	96.2	29.1	24.9	41.1
2	*Ampelisca macrocephala*	85.3	94.7	84.6	19.0	32.9	15.0
3	*Ampelisca eschrichti*	52.9	31.6	65.4	11.2	31.0	13.1
4	*Psammonyx kurilicus*	64.7	100.	69.2	7.4	20.0	18.5
5	*Hippomedon denticulatus orientalis*	35.3	10.5	26.9	10.5	<0.01	2.5
6	*Pontoporeia femorata*	32.4	26.3	3.8	8.9	5.0	<0.01
7	*Atylus bruggeni*	29.4	21.1	50.0	1.4	1.2	1.8
8	*Photis fischmanni*	35.3	21.1	50.0	1.3	0.1	0.3
9	*Orchomenella minuta*	17.6	26.3	53.8	0.4	2.0	2.5
10	*Byblis erythrops*	26.5	31.6	19.2	1.3	3.8	2.0

Table 3 — The species list of amphipods found in the boluses of whales produced in Mechigmensky Bay in 2007-2009

Years*	Sub/Ord. Gammaridea
	Sup/Fam. Ampeliscoidea
	Fam. Ampeliscidae
1	*Ampelisca birulai* Brüggen, 1909
1, 2, 3	*Ampelisca eschrichti* Kroyer, 1842
1, 2, 3	*Ampelisca macrocephala* Lilljeborg, 1852
1, 2, 3	*Byblis erythrops* G. Sars, 1882
1, 3	*Byblis* sp.
	Sub/Fam. Corophioidea
	Fam. Ampithoidae
3	*Ampithoe* sp.
	Fam. Aoridae
1	*Arctolembos arcticus* (Hansen, 1887)
	Fam. Ischyroceridae
1	*Ischyrocerus anquipes* Kroyer, 1838
3	*Ischyrocerus dezhnevi* Gurjanova, 1951
1	*Ischyrocerus latipes* Kroyer, 1842
1	*Ischyrocerus pachtusovi*, Gurjanova, 1933
1, 2, 3	*Ischyrocerus* sp.
	Fam. Photidae
1, 3	*Photis fishmanni* Gurjanova, 1951
1	*Photis reinhardi* Kroyer, 1842
1, 2	*Photis* sp.
1	*Protomedeia coeca* Bulytcheva, 1952
1	*Protomedeia epimerata* Bulytcheva, 1952
1	*Protomedeia fasciata* Kroyer, 1842
2	*Protomedeia microdactyla* Bulytcheva, 1952
1, 3	*Protomedeia* sp.
1	*Protomedeia stephenseni ochotensa* Kudrjaschov, 1965
	Fam. Podoceridae
3	*Podoceridae* gen. sp.
	Sup/Fam. Dexaminoidea
	Fam. Atylidae
1, 2, 3	*Atylus bruggeni* (Gurjanova, 1938)
1	*Atylus collingi* (Gurjanova, 1938)
	Sup/Fam. Eusiroidea
	Fam. Eusiridae
3	*Pontogeneia ivanovi* Gurjanova, 1951
	Sup/Fam. Gammaroidea
	Fam. Anisogammaridae
3	*Eogammarus kygi* (Derzhavin, 1923)
	Fam. Melitidae
3	*Melita* sp.
	Sup/Fam. Haustorioidea
	Fam. Haustoriidae
1, 2, 3	*Priscillina armata* (Boeck, 1861)
	Fam. Phoxocephalidae
1, 2, 3	*Grandifoxus longirostris* (Gurjanova, 1938)
1	*Grandifoxus nasuta* (Gurjanova, 1936)

1	*Grandifoxus* sp.
1	*Phoxocephalidae gen. sp.*
	Fam. Pontoporeidae
1	*Monoporeia ekmani* (Bulycheva, 1936)
1, 2, 3	*Pontoporea femorata* (Kroyer, 1842)
	Sup/Fam. Iphimedioidea
	Fam. Iphimediidae
3	*Paramphithoe concinna* Gurjanova, 1972
	Sup/Fam. Lysianassoidea
	Fam. Lysianassidae
1, 3	*Hippomedon denticulatus orientalis* Gurjanova, 1962
1	*Hippomedon granulosus* Bulytcheva, 1955
1	*Hippomedonpacificus* Gurjanova, 1962
1, 2, 3	*Hippomedon punctatus* Gurjanova, 1962
1	*Orchomenella japonica* Gurjanova, 1962
1	*Orchomenella minuta* Kroyer, 1846
1, 2	*Orchomenella pinguis* (Boeck, 1861)
1	*Orchomenella* sp.
1, 2, 3	*Psammonyx kurilicus* Gurjanova, 1962
1, 3	*Psammonyx* sp.
	Fam. Uristidae
1	*Anonyx epistomicus* Kudrjaschov, 1965
3	*Anonyx laticoxae* Gurjanova, 1962
1, 2, 3	*Anonyx lilljeborgi* Boeck, 1871
1, 2, 3	*Anonyx nugax* (Phipps, 1774)
1	*Anonyx ochoticus* Gurjanova, 1962
1, 2	*Anonyx* sp.
1, 2, 3	*Onisimus derjugini* Gurjanova, 1929
1	*Onisimus krassini* Gurjanova, 1951
1, 2, 3	*Onisimus plautus* (Kroyer, 1845)
	Sup/Fam. Oedicerotoidea
	Fam. Oedicerotidae
1, 2, 3	*Acanthostepheia beringiensis* (Lockington, 1877)
1	*Acanthostepheia* sp.
1, 2, 3	*Bathymedon langsdorfi* Gurjanova, 1951
2, 3	*Bathymedon obtusifrons* (Hansen, 1887)
1, 2	*Bathymedon* sp.
1	*Bathymedon tilesii* Gurjanova, 1951
1, 2, 3	*Paroediceros lynceus* (M. Sars, 1858)
3	*Westwoodilla* sp.
	Sup/Fam. Leucotoidea
	Fam. Pleustidae
2	*Parapleustes* sp.
1	*Pleustespanoplus occidentalis?* (Stimpson, 1864)
2, 3	*Pleustes* sp.
	Sub/Ord. Caprellidea Fam. Caprellidae
1	*Caprella angulosa*? Mayer, 1903
1, 3	*Caprella carina*? Mayer, 1903
2	*Caprella* sp.
1	*Metacaprella horrida*? (G. Sars, 1877)

* 1 — 2007, 2 — 2008, 3 — 2009.

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