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On stock size and fishery management of splendid alfonsino (*Beryx splendens*) on the Corner Rise Seamount

by

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Abstract

Fishing concentrations of alfonsino are distributed all year round on the three Corner Rise seamounts, where the fish biomass is estimated at 11,000-12,000 t. The alfonsino may be easily subjected to overfishing but its stock rapidly recovers. The TAC should not exceed 9% (F=0.1) of the spawning stock size. The stock assessment should be based on the results from the annual trawl-acoustic surveys. The temporary measures of fishery management involving the TAC of 400 t for each separate seamount, the prohibition to use pelagic trawls at the depths less than 600 m, a full ban of bottom fishery and the presence of observers onboard fishing vessels should be established in the nearest future. The limitation of fishing efforts is reasonable to be applied as an additional measure.

Introduction

In 2006, the Fishery Commission (FC) of NAFO established a ban to use bottom fishing gear on the Corner Rise seamounts. The mentioned restriction is aimed at the protection of vulnerable marine ecosystems (VMEs) and, by now, it has been the only fishery management measure in the area. Special measures of splendid alfonsino stocks management are not applied here which is mainly caused by the lack of appropriate scientific justification. The issue on the catch limitation of this species had been already raised at the NAFO annual meetings (NAFO, 2013a; NAFO, 2014) however, due to the lack of the necessary data, its consideration was postponed to 2015.

In the Corner Rise area, the most intensive research was carried out by Russian Federation in the 1970-1990s. In that period, exploratory, research and fishery vessels (EV, RV, FV respectively) conducted 26 cruises (Vinnichenko, 1997b), by the results of which about two tens of publications on different aspects of biology, habitat and fishery of splendid alfonsino were prepared.

In the latest two decades the interest in study and fishery development on the Corner Rise has been shown by some other NAFO Contracting Parties, notably Canada and Spain. The vessels of those countries carried out several cruises, collected a great amount of research and fishing data, which has become the basis for a several scientific papers.

Overall, the investigations of the Corner Rise area was comprehensive and they were conducted in several ways. However, the size and status of the alfonsino stocks as main target species were poorly studied, and there was the only publication considering that problem (Vinnichenko, 1995). To certain extent, that has been caused by the lack of data on research and fishery of alfonsino (NAFO, 2013b).

This paper aims at summarizing the available research and fishery information and estimating the stock status on this basis as well as at preparing the advice on fishery management of splendid alfonsino in the Corner Rise area.

Materials and Methods

The following were used during the preparation of that paper:

- Russian and other countries' publications;
- cruise reports of Russian EVs, RVs and FVs in 1976-2009;
- response made by the Scientific Council (SC) to the FC's request for advice on the Corner Rise;
- reports of NAFO FC.

The statistics on Russian fishery for splendid alfonsino has been formed on the basis of different sources of information without using the official data.

Behavior and distribution of the fish were studied using the results from the hydro-acoustic observations, check tows and the ichthyologic investigations.

In order to assess the stock status were used:

1. The data collected in the cruises by EVs in 1980-1987 and FV in 1995.
2. Results from the trawl-acoustic surveys (TAS) conducted by Russian RVs:
   - in 1978 using the hydro-acoustic informative and measuring system on the basis of HAG-432 echosonar and HAG-331 echosounder;
   - in 1987 with applying EK-400 echosounder and SIORS echointegrator;
   - in 2001 and 2009 using the scientific EK60 echosounder.

When using the materials from EVs and FVs the alfonsino biomass was estimated by the data of hydroacoustic observations with the help of the vessel standard equipment, as well as the pelagic hauls data. In particular, the data processing included:

- clarification of alfonsino distribution on the banks;
- calculation of the real horizontal and vertical parameters of schools with the standard methods (Yudanov, 1967) adapted to the certain conditions on the seamounts;
- calculation of the concentration area and volume;
- calculation of fished part concentration volume (according to the trawl eye echograms);
- calculation of pelagic schools density by comparing catch values and the volume of fished part concentration.

The analytical stock assessment and possible total allowable catch (TAC) of alfonsino have not been carried out due to the lack of initial data.

Results

Historical Review of Fishery

By the present time, on the Corner Rise (34-37°N, 47-53°W), the commercial aggregations of alfonsino have been found on three seamounts. Two of them named "Perspektivnaya" (known also as "Kükenthal") and "Vybornaya" ("C-3") are located in NAFO RA. One more bank named "Rezervnaya" ("Milne Edwards") is located in the Central Western Atlantic.

The development of the Corner Rise fishery was initiated in 1976, when, according to the unofficial data, Russian vessels caught over 10,000 t, mainly splendid alfonsino (Vinnichenko, 1997b; Anon, 2009). In the following year, there were no stable fish concentrations in the area, and the catch reduced to 800 t. During the subsequent fifteen years, the seamounts were periodically controlled by EVs and RVs, which caught more than 2,000 t in total. Commercial trawlers operated there only in 1987, when their total catch together with one EV was more than 2,800 t. The fishery was resumed after a seven-year break, in the mid of the 1990s, and it was carried out with varying intensity till the end of the last century (Clark *et al*, 2007) with the annual catch of 600-4,700 t. In 2003, one trawler tried to operate for a short period there, but, there were no commercial concentrations found. During the last decade Russian vessels have not been there.

Russian data on fishing efforts is not given in this paper owing to their fragmentariness and insufficient reliability.

There is no statistics on Russian fishery on separate seamounts, but, in accordance with the approximate estimation, the "Perspektivnaya" bank was considered to be the most important ground where 50-70% of the total catch was taken. Also, the fishery was carried out on the "Vybornaya" and "Rezervnaya" banks, where the catches were 15-25% of the total yield each.

Pelagic trawls were used by Russian vessels as the basic gear with catches reaching 40-60 t per short hauling and taking mainly splendid alfonsino (95-100%). In some cases, black scabbard fish *Aphanopus carbo* made up the bulk of the catches. The bottom trawl was only applied on the "Perspektivnaya" bank in 1977 (Vinnichenko, 2010), at that area, besides alfonsino, wreckfish *Polyprium americanus*, black scabbardfish, cardinalfish *Epigonus telescopus* and other species amounted the significant part of catches.

Since 2004, Spain has been carrying out the fishery on the Corner Rise. The first cruise was experimental (Duran Muñoz *et al*, 2005), later the commercial trawlers primarily operated in the area. The fishery by Spanish fleet was the most active in 2005, when their catch amounted to 1,200 t (González-Costas, Lorenzo, 2007; NAFO, 2013b). Later, the catch dropped and was within the limits of 52-479 t.

In different years, the fishing efforts of the Spanish fleet varied from 6 to 50 fishing days, the average catch per fishing day – from 8.3 to 40.9 t. The data on discards is only available for 2004-2005, when they accounted for about 1% of the catch (Thompson, Campanis, 2007).

In 2005-2007, practically all the Spanish catch was obtained with the pelagic trawl on the "Perspektivnaya" seamount (González-Costas, Lorenzo, 2007). During the experimental cruises in 2004 and 2012, the main catches were also taken on that bank, however, at that bank, bottom trawls were primarily used. The catches taken in 2004-2007 and 2012, consisted mainly (92-95%) of alfonsino

(Duran Muñoz *et al*, 2005; Anon, 2012). There are no data on fishing location, species composition of catches and fishing gear for other years.

Canada made the attempts to arrange the fishery in the Corner Rise too (Kulka *et al*, 2007). According to the unconfirmed data, the same was done by France and Japan, but all the efforts were unsuccessful.

Biological characteristics

According to the Russian data, alfonsino was represented in trawl catches by specimens ranging from 17 to 60 cm with mainly 34-43 cm fork length and the weight ranging from 1.2 to 1.7 kg. The Spanish catches comprised fish of similar size composition (González-Costas, Lorenzo, 2007; Anon, 2012).

As compared with the other deep-water fishes, alfonsino has a relatively short life cycle (up to 14 years) and higher growth and maturation rates (Anon, 1993; Kotlyar, 1996; Kulka *et al*, 2007; Vinnichenko, 2010). The sexual maturation begins in the second year of life under 18 cm mean length, and, by age 5-6, all specimens become mature under 25-30 cm length (Pshenichny *et al*, 1986; Anon, 1993). The most active spawning is observed in the near-bottom layers in July-August. Alfonsino spawns by portions, amounting about 10-12. The individual fecundity is very high, from 810,000 to 2,350,000 eggs. The duration of individual spawning period was estimated to be up to 2 months (Alekseeva, 1983).

Alfonsino feeds on various mesopelagic fish (Myctophidae, Sternoptychidae, Chauliodontidae etc.), squids, shrimp and euphausiids (Pshenichny *et al*, 1986; Anon, 1993; Vinnichenko, 1997a).

Behavior, distribution, migrations and habitat

Behavior and distribution of alfonsino are highly variable. Echo records of its schools can be registered in the pelagial and near-bottom layers; and they can appear and disappear for short or long-time periods. However, the absence of schools echo records does not mean the absence of fish on the seamount, as a smaller or larger portion of alfonsino aggregations is permanently distributed near bottom in the microrelief folds where fish cannot be registered by echo instruments (Pshenichny *et al*, 1986; Anon, 1993; Vinnichenko, 1996).

The aggregations of large mature alfonsino were registered by echo sounder at 300-950 m depths (mainly, at 420-750 m depths) with water temperature of 7.5-17 °C. However, its fishery was performed at the depths greater than 400 m, primarily, at 600-1000 m (Pshenichny *et al*, 1986; Anon, 1993; Vinnichenko, 1997b, 2010).

The available information on distribution of immature alfonsino is quite limited. Small numbers of fish as long as 17-30 cm were found occasionally in the catches taken above the seamounts, however, the exact layers where they were caught are not known. Most likely, small alfonsino are primarily distributed in the 200-450 m layer where the echo sounders register numerous small schools with height 10-20 m, which are practically not fished by trawl. There is some information on the occurrence of few specimen as long as 10-18 cm in the catches taken by pelagic trawl in Divs. 6EF and 4Vs (Duran Muñoz *et al*, 2005). According to the personal communication of P. Duran Muñoz, the alfonsino with such length were mainly caught in 200-400 m layers, both above seamounts and outside them.

Young alfonsino with 25-98 mm length were caught above the Corner Rise seamounts by the fry-sampling trawl in the 0-600 m water layers during fall, where water temperatures were 14-26° C (Sherstyukov, Noskov, 1986).

The horizontal migrations of large alfonsino are limited by the area of seamounts within the 3,000 m isobath, where their extent is not more than a few miles (Galaktionov, 1984; Vinnichenko, 1996). In the open sea, despite the study to be thorough enough, there was no any migrating mature alfonsino found (Kotlyar, 1996; Duran Muñoz, personal communication). The indirect evidence indicating the absence of large alfonsino migrations from the banks is the data on all year round fishery on the Corner Rise (Table 1). The single alfonsino juveniles only occurred outside the seamounts (Kotlyar, 1996; Duran Muñoz *et al*, 2005) and they might be brought by currents for a great distance.

The main factor, which appeared to determine a pattern of alfonsino daily vertical migrations is the vertical shifting of its food organisms. The latters, in their turn, are closely related to variations in illumination of the sea (by the Sun and the Moon) and hydro-meteorological conditions in the area of seamounts. The research results have revealed several types of alfonsino vertical migrations (Vinnichenko, 1986; Vinnichenko, 1997b).

Population structure

There are two points of view among Russian scientists concerning the stock structure of alfonsino in the North Atlantic.

In the opinion of most researchers this species is believed to form a population on each separate seamount or a group of closely located banks, does not migrate for long distances and all the stages of its life cycle are developed within the limited area (Klimenko, 1983; Melnikov *et al*, 1993; Vinnichenko, 1995; Vinnichenko, 2006; Kulka *et al*, 2007).

Some scientists assume the alfonsino long-distance migrations and existence of single population in hundreds miles remote areas (Alekseev *et al*, 1987; Anon, 2009). Regarding the open part of the North Atlantic, this hypothesis assumes the existence of a reproductive part of the areal on the Corner Rise and the feeding part of the areal on the Azores banks.

Biomass of aggregations

By Russian data, on the Corner Rise, the greatest biomass of mature alfonsino (distribution depths of 400-950 m) was registered on the "Perspektivnaya" seamount (Table 1). On the "Vybornaya" and "Rezervnaya" seamounts, on the whole, the aggregation biomasses were much lower.

The parameters and biomass of the fish concentrations were maximal on all the seamounts in the first part of the 1980s. In June 1995, and, especially, in May 1987, the biomass of schools was noticeably less (Table 1).

In some cases, on the seamounts, the alfonsino echo-records were practically not registered or they were weak. In particular, in January 2001 the alfonsino concentrations were absent on all banks (Shnar *et al*, 2005), in May 1987 the small concentrations were only registered, in December 2009 there were no aggregations on the “Perspektivnaya” and “Rezervnaya” seamounts (Table 1). In accordance with the cruise reports by EVs and the reports from masters of FVs, the similar situations took place in January and April 1982, in July 1986, in spring 1999 and 2003.

Discussion

The seamounts of the Corner Rise are among the areas with unstable fishery resources and higher commercial risk. The fish behavior and distribution, as well as the forms and density of aggregations, are quite variable (see above), which together with hard ground conditions and dissected bottom topography of the banks highly complicates the trawling. The fishery is also hampered by small size of alfonsino schools and unsteady water circulation above the seamounts, which causes abrupt catch fluctuations (Anon, 1993; Vinnichenko, 1996, 2006; González-Costas, Lorenzo, 2007). In these conditions, the proficiency of fishery on the seamounts, depending on which the catches per effort by trawlers of the same type might vary by several times, has become especially important.

To avoid the accidents in operating on the seamounts, fishermen try not to conduct pelagic trawling near bottom. Due to this, using the pelagic trawls does not mean a significant adverse impact on VMEs as well as it excludes the necessity to ban the trawl fishery in July-August which was recommended by NAFO SC in order to protect alfonsino spawning (NAFO, 2013b).

The aggregations of alfonsino were revealed on the Corner Rise about 40 years ago. Nevertheless, during the past period, the fishing vessels operated there only for 17 years including 1976-1977, 1987, 1994-1997, 1999, 2003 and 2005-2012, which is not enough to form the appropriate database. In some other years, EVs and RVs went to work on the Corner Rise, but the results of their fishing activities often did not correspond to fishing possibilities since the vessels worked for a short time (from 1 to 15 days), sometimes they left the area where the dense aggregations were present.

Thus, on the Corner Rise, the fishery statistics did not always show a real state of fishery resources, and, therefore, using it to estimate the alfonsino stock status is somewhat complicated. In future, some efforts should be made to improve the fishery reports from this area.

It is currently impossible to use the information on fishing efforts and catch per unit effort (CPUE) for the alfonsino stock assessment since available raw data is patchy and insufficiently valid. Particularly, data on fishing efforts of the Russian fishery is available only for some years, and validity of information on the Spanish fishery in 2004 and 2005 is in doubt. Solution to this issue involves obtaining the missing data and revision of the existing statistics, as well as standardization of CPUE.

Knowledge of fish stock structure is quite important for development of the fishery management. As for the splendid alfonsino of the North Atlantic, this issue has remained to be open. However, currently there are already some reasons to consider the hypothesis of some scientists, according to which the alfonsino migrates between the Corner Rise and the Azores seamounts and there is a single population in these areas (Alekseev *et al*, 1987), not to be justified enough. In particular, the mentioned hypothesis cannot explain:

- occurrence of several alfonsino populations in the North Atlantic by the data from genetic and biometric research (Titova, 1981; Schönhuth *et al*, 2005);
- permanent presence of young and older alfonsino groups on the Corner Rise and in the Azores area (Vinnichenko *et al*, 1979; Sherstyukov, Noskov, 1986; Vinnichenko *et al*, 1994; Vinnichenko, 1995; Vinnichenko, 1996);
- absence of migrating mature alfonsino in the oceanic areas outside the seamounts;
- longtime (for several years) absence of alfonsino concentrations on the seamounts after extremely intensive fishery.

At the same time, the above-mentioned information proves the occurrence of isolated alfonsino populations on each separate seamount.

The necessity to develop justified measures of fishery regulation causes the research of alfonsino stock structure to continue. Until more complete data to manage its fishery have been obtained it is reasonable to be based on the principle of population existence on each separate seamount. Such regulation most closely corresponds to precautionary approach, since the risk of stock overfishing as consequence of hard fishery on separate seamounts decreases. The ICES already advices to use the same principle for the assessment and management of orange roughy stocks (ICES, 2014c). The approach should be applied in practice in relation to alfonsino on the Corner Rise by establishing individual TACs for each of the three known seamounts.

The stock size of alfonsino is comparatively small. By the analysis of the data collected in 1980-1995, in the open North Atlantic, the alfonsino biomass was about 50,000-80,000 t (Vinnichenko, 1995), including the one on the Corner Rise being 36,000-40,000 t. The values were probably overestimated because the biomasses were calculated applying the catchability coefficient of 0.3 for a pelagic trawl. Applying the catchability coefficient of 1.0 would be obviously more reasonable, since it is more corresponding to peculiarities of the fish behavior and the precautionary approach. In this case, the calculated alfonsino biomass values obtained on the Corner Rise in 1980-1995 decrease to 11,000-12,000 t.

It should be taken into consideration that the data with a time limitation of mainly 20-30 years were used for the calculations mentioned above. Therefore, most of them have obsoleted, need correcting, and at present they can only serve as a landmark to determine a possible catch. In the latest five years TAS has not been conducted on the Corner Rise and, therefore, the status of alfonsino stocks is currently unknown.

A reliability of TAS for alfonsino requires separate consideration. In our opinion, the terms “estimation of concentration biomass” and “stock estimation” of this species should be distinctly differentiated. Due to the patterns of alfonsino distribution and behavior, the pelagic concentrations available for assessment may only represent the part of the stock on the bank (see above). At present, apparently, it is not possible to estimate the meaning of this factor for the results of the TAS conducted before, but its influence is evident. In future, when conducting these works it is necessary to consider variability of vertical migrations and distribution of the alfonsino. In particular, the TAS should be carried out under the occurrence of dense pelagic schools above the seamounts. At that, it is reasonable to carry out TAS several times in different daytime and after a certain time interval. Following these conditions increases the probability of the main stock part assessment, and the data from survey during which the maximal biomass was registered should be considered the most impartial. However, compliance with these requirements onboard RVs is complicated by limited research periods. Therefore, conducting TAS onboard FVs equipped with special instruments seems to be more reasonable.

The lack of regular research and the low precision of estimates do not allow learning the year-to-year dynamics of the alfonsino stocks on the Corner Rise in details. Nevertheless, significant biomass variations were recorded on all the fishable banks (Table 1). A small alfonsino biomass was registered in May 1987 and the lack of the fish aggregations in January 2001 were probably the result of active fishery in 1987 and 1994-1999. On the other hand, the survey results might be influenced by the underestimation of biomass because of the patterns of alfonsino distribution, as well as the reduction of its stocks, caused by natural factors. A negative result of the research obtained in

December 2009 is explained by a short period of works (several hours) and poor weather conditions.

According to the ICES advice, due to the spatial distribution associated with seamounts, the life history, and the aggregation behavior, the alfonsino stocks are easily overexploited; they can only sustain low rates of exploitation. To prevent depleting localized aggregations that have not yet been mapped and assessed the exploitation of new seamounts should not be allowed (ICES, 2014). Under a limited stock this species form dense local concentrations and, therefore, may be easily overfished. The gained experience in fishery shows that even comparatively small catch of the alfonsino (within 3,000-10,000 t) leads to decrease in size, density and stability of aggregations and, as a consequence, to reduction in catch and fishing efficiency. On the other hand, the alfonsino abundance is relatively quickly recovered after intensive fishery that is caused by peculiarities of the fish biology (see above). The previous experience shows that it takes about 5 years to recover the alfonsino stock (on conditions that no fishing carried out) to the level, which will permit to have profitable fishery (Vinnichenko, 1996, 2006; Clark *et al*, 2007).

In the 2000s, the fishery on the Corner Rise was limited with the annual catch of 52-1,187 t (González-Costas, Lorenzo, 2007; NAFO, 2013b), on the average, 346 t. It allows considering, that after the intensive fishery in the 1970s-1990s in this area, the alfonsino abundance has recovered and now the stocks are at the level of the 1980s-90s, which is about 11,000-12,000 t.

Until now, biological reference points for the splendid alfonsino on the Corner Rise have not been determined. From other areas information on this issue is available in respect for the North-West Pacific, where Fmsy for alfonsino was specified in the range from 0.54 to 0.77 (Anon, 2008). In view of the uncertainties for the alfonsino of the Corner Rise should be applied precautionary approach, which should provide a relatively low level of fishing mortality (F=0,1), that corresponds to the annual catch of 9% of mature fish biomass on each separate bank. In this case, the stock size, perhaps, will not reduce significantly. In future, after the basic biological reference points have been determined, the allowable catch should be revised.

In accordance with the results of Russian investigations, the alfonsino stock was the largest on the "Perspektivnaya" bank, and the main catch (around 50%) was taken there. By the preliminary information, almost all the Spanish catch was taken on that seamount in 2004-2013, and there was no harvesting on the other banks due to the lack of fishery. Taking all this into account the fishing efforts should be distributed equally on all the banks and it is recommended to establish the annual catch of 400 t on each of them.

The NEAFC experience showed that, in the conditions of the deficiency in data on the state of deep-sea stocks such a regulation measure as the restriction of fishing efforts was sufficiently efficient. In the similar situation, on the Corner Rise, it would be also reasonable to apply this measure.

Conclusion

This paper is an attempt to estimate a fishery potential and to develop advice on the management of splendid alfonsino on the Corner Rise. Owing to scattered and heterogeneous initial data, using mainly retrospective data, as well as the shortcomings of methods, the results should be considered as preliminary. Nevertheless, the following conclusions can be already drawn:

1. On the Corner Rise, the commercial concentrations of splendid alfonsino are distributed on three seamounts all year round.

2. The stocks of alfonsino are relatively small. By the research data on the Corner Rise for 1976-1995, its spawning biomass was estimated at 11,000-12,000 t. At present, the stocks are probably at the same level.
3. Under comparatively small stocks the alfonsino forms dense local concentrations and may be easily overfished. However, this species is restored relatively quickly after intensive fishery.
4. When determining the allowable catch of alfonsino the existing of separate quite limited stocks on each seamount should be taken into account. The annual catch of the species should not exceed 9% of its spawning biomass (F=0.1).
5. Arranging the sustainable fishery on the Corner Rise is only possible within the framework of NAFO and should provide:
   - obtaining reliable statistical data on fishery;
   - conducting comprehensive researches including the studies on biology, stock structure and habitat;
   - carrying out the stock assessments on the regular basis;
   - development of scientifically justified fishery management measures.
6. The stock estimation should be based on the results of annual TASs, which should be conducted by FVs with appropriate special equipment.
7. In future, with the accumulation of scientific and fishery data the analytical assessment of alfonsino stocks should be developed and used in practice.
8. In the nearest future, it is expedient to arrange the complex of temporary alfonsino management measures which should provide:
   - establishing the TAC of 400 t for each fishable bank that will be equal to the total catch of 1,200 t for the whole area;
   - a ban to use bottom gear for the purpose of the protection of VME and alfonsino spawning;
   - a ban to apply pelagic trawls at the depths less than 600 m in order to protect alfonsino juveniles;
   - assignment of observers to all the FVs in order to provide collecting scientific data and compliance with the fishery management measures.
9. Using the limitation on fishing efforts as an additional measure of alfonsino management is reasonable.
10. For introducing the comparable management measures in the entire area of the Corner Rise, it is necessary to have the negotiations with WECAFC.

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Table 1 Biomass of splendid alfonsino pelagic concentrations on the Corner Rise seamounts by the research data at Russian vessels

Seamount	Period		Vessel	Biomass, 000, t
	Year	Month		
“Perspektivnaya”	1980	September	EV “Pavel Kaikov”	6,6 (22,0)
	1981	March	EV “Kapitan Demidov”	6,5
	1987	May	RV “Kapitan Shaitanov”	0,2
	2001	January	RV “Atlantida”	no concentrations
	2009	July	RV “Atlantida”	1,9
	2009	December	RV “Atlantida”	no concentrations
“Vybornaya”	1978	July	RV “Evrika”	1,0
	1981	March	EV “Kapitan Demidov”	5,7
	1984	September	EV «Nikolay Kuropatkin »	4,1 (13,8)
	1987	May	RV “Kapitan Shaitanov”	0,13
	1995	June	FV “Petr Petrov”	1,7 (5,5)
	2001	January	RV “Atlantida”	no concentrations
“Rezervnaya”	1981	March	EV “Kapitan Demidov”	0,7
	1985	May	EV “Menzelinsk”	4,4 (14,6)
	1987	May	RV “Kapitan Shaitanov”	0,12
	2001	January	RV “Atlantida”	no concentrations
	2009	December	RV “Atlantida”	no concentrations

Note: the biomass values calculated using the catchability coefficient of 0.3 are given in brackets