THE STOCK AND FISHERY VARIABILITY OF THE ARGENTINE SQUID ILLEX ARGENTINUS IN 1982-2004 RELATED TO ENVIRONMENTAL CONDITIONS

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ABSTRACT

The Argentine shortfin squid Illex argentinus is the most important commercial squid species in South West Atlantic and in the world cephalopod fishery since beginning 1980-s. In 1991-2001 its yearly catch had varied from 505 to 1145 thousand t (15-32% of total world catch of cephalopods). Its total instantaneous biomass according to expert evaluation is 2-5 million t, but real interannual variability ranged probably more widely. Unfortunately we haven’t actual ecological data for estimations of stock size long-term variability. So there is one possibility only: to use fishery statistics, especially data on CPUE. The mean monthly CPUE of Soviet/Russian trawler of BMRT type were recognized as indices of squid abundance. We use the Soviet/Russian fishery statistics on Illex argentinus for fishery seasons of 1983-1997 and 1999-2004. In addition to these data for description of stock condition, the Falkland and Argentine EEZ annual squid catches were used. By qualitative analysis of data 1982-2004 on abundance of slope-oceanic group was testified the presence of quasi-seven years periodicity. There were observed two such cycles. During this period the years of good condition of stock prevailed. But in 1986, 1994-1995 and 2003-2004 there were observed the slump of stock size. Most pronounced and system collapse of the Argentine squid stock was observed in 2004. Both the shelf autumn spawning group and the winter spawning slope-oceanic group suffered sharp numbers decreases. The combination of two factors provoked this
stock collapse: environmental change (mainly due to water dynamics of the Falkland-Brazil currents system and increase of paralarval stage mortality) and the high level of fishing effort that is distributed on nearly whole species range on the shelf and slope zones.

Key words: Argentine squid, environmental controlling factors, fishery, Illex argentinus, South-West Atlantic, stock dynamics

INTRODUCTION

The Argentine shortfin squid Illex argentinus (Castellanos, 1960) is the most important commercial squid species in South West Atlantic and in the world cephalopod fishery since beginning 1980-s. In 1991-2001 its yearly catch had varied from 505 to 1145 thousand t i.e. 15-32% of total world catch of cephalopods (FAO, 2003).

Its total instantaneous biomass according to expert evaluation is 2-5 million t (Nigmatullin, 2004), but real interannual variability ranged probably significantly more widely. During its large-scaled fishery history there were some periods of high and low abundance. These number fluctuations were more strongly pronounced in slope-oceanic winter spawning group of Illex argentinus (Csirke, 1987; Nigmatullin, Laptikhovsky, 1996; Brunetti et al., 1998).

Unfortunately we have not actual ecological data for estimations of stock size long-term variability. In this situation there is the one possibility only: to use fishery statistics and especially data on CPUE as quasi-real reflections of stock state. We have at our disposal the set of data on CPUE of the Soviet/Russian fleet in 1982-2004 and will be used for this estimation as basic material. At the same time there are need to analysis data for two separate stocks due following reason.

In Illex argentinus is distinguished two main ecological groups – shelf and slope-oceanic. First one is probably complex of stocks with most abundant group that spawned in autumn (April-July) and all its life cycle carry out in the shelf and upper slope waters. It serve as a basis for fishery in first part of fishing season from December-January to March-April with common maximum of CPUE in February. The slope-oceanic winter spawning group has very complicated life cycles with slope, oceanic, shelf and again slope periods. It's most abundant and migratory; and it provides the second part of total
fishing season from March-April to May-June and sometimes July also. The spawning grounds of both groups are situated in north part of species range mainly between 28-38°S. The autumn-spawning shelf group spawned in the waters of outer shelf, and winter-spawning slope-oceanic group – in the waters of slope. Larvae and fry carried southward by the Brazil Current and their destiny in many respects depends from peculiarities of water masses dynamics in the Brazil-Falkland Confluence area (BFC i.e. in zone of the Subtropical front). They must migrate with warm eddies and meanders via this front to open waters of the Argentine depression, and then after attaining 12-15 cm of ML juveniles migrate to the Patagonian shelf for active feeding, somatic growth and maturation (Nigmatullin, 1989, 2002; Parfeniuk et al., 1993; Arkhipkin, 1993, 2000; Nigmatullin, Laptikhovsky, 1996; Vidal, Haimovici, 1997; Bakun, Csirke, 1998; Brunetti et al., 1998, 1999; Carvalho, Nigmatullin, 1998; Haimovici et al., 1998; Waluda, 2000; Waluda et al., 1999, 2001a,b; Laptikhovsky et al., 2001).

Earlier there were carried out some studies (Waluda et al., 1999, 2001a,b, 2002; Waluda, 2000; Devitsyn et al., 2001; Laptikhovsky et al., 2001, 2002) for understanding relation between squid abundance and hydrological situation in spawning/hatching grounds. However this problem remains not decided and demand of future investigations. Moreover, in literature is not description of time series on *Illex argentinus* abundance variations.

The aim of this communication is to describe in first approximation of *Illex argentinus* stocks fluctuations in 1983-2004 and the hydrological situations in spawning and “nursery” grounds by using of satellite data on anomaly sea-surface temperature (ASST), and their relationships.

**MATERIAL AND METHODS**

This study based on the comparison of the hydrological condition in the areas and periods of the passing early “critical” stages of squid life cycle (Fig. 1) on the one hand and the situation on the fishery grounds during the exploitation of given squid generation on the other hand.

*Oceanographic data*
The areas where take place the formation of stock recruitment that we used for oceanographic data collecting are following. 1. The spawning ground is situated on the waters of the shelf and slope between 34°30’-39°30’S and 52°30’-56°30’W. 2. The area the Brazil and Falkland Currents Confluence (BFC) is between 41°30’-42°30’S and 52°30’-53°30’W (Fig. 1). The first area is very important for the paralarvae transport and in its conditions are determining the paralarvae mortality rate. The oceanographic condition in BFC area plays the decisive role for migration of fry and early juveniles of slope-oceanic group to southern direction in the nursery zone (Parfeniuk et al., 1993; Bakun, Csirke, 1998).

For description of hydrological condition in these two areas were used the average monthly satellite data on anomaly of sea-surface temperature (ASST) from December 1981 to June 2004 with spatial resolution of 1° latitude by 1° longitude. These data were available from the National Center for Atmospheric Research (NCEP/NCAR, 2004) and this database was described (Reynolds et al., 2002). From these initial data were formed the matrices by size in 271 lines (months) on 19 and 4 columns (regular grid nodes).

The principal component analysis (Vainovsky, Malinin, 1992) was used for ASST data analysis for two studied areas. The data were standardized according to columns, and, according to standardized matrix, the variation - covariation matrix was calculated and on the base of it the eigenvectors were computed. Using of the component analysis allows tracing the main trends in process and disposes of "small noise".

The analysis of ASST principal component decomposition has revealed that the first component contains 79% of the data variance for the spawning area. It high correlates (r≥0.8) with variability of initial data in the whole spawning ground area. The maximal loadings of the first principal component are found in the slope zone (r≥0.9). That is why the first component variation may be interpreted as general ASST variability in this studied area.

The second principal component accounts for 10% of the total variance in the spawning area and has the high correlation coefficients (|r|>0.5) with the ASST gradients in the SW – NE direction. It may be an evidence of the relations between ASST and dynamic processes.

The first principal component of ASST in BFC front region accounts for 96% of the total variance and reflects the mean large-scale variability of the SST. One might be
suggested to use only this mode for the SST variability in that region. In the presence of
the positive anomaly it might be connected with the Brazil Current strengthening, and
vice versa – in the case of negative anomaly - with the Falkland Current strengthening.

The typification of hydrological situations for each three months by
eigenvector of matrix was made. For classification were used data for April-June and
August-October in first spawning area, and for October-December - in second BFC
area. As a criterion to set a significance level value = |0.65|. Because the principal
components are normalized and standardized, this value is the reference point for
classification. In this classification is not reflected all spectrum of possible
hydrological situations, however it enable to give an idea of main realized situations.

The principal component was classified by using three grades scale: grade 1 -
below the norm (< 0.65), 2 – the norm (± 0.65) and 3 – above the norm (> 0.65).
Grade 1 connects with steady negative anomaly and the last formed due to influence
the Subantarctic waters of the Falkland Current. Grade 2 corresponds to climatic
norm. Grade 3 reflects steady positive anomaly that connected with predominant
impact on the situation by waters of the Brazil Current.

In addition to this background characteristic, the ASST gradient in SW-NE
direction was estimated in the spawning area. Scale for gradient values is following.
Grade 1 – cold advection is predominant, it is slackening in the course of observation
time. Grade 2 – water advection processes within the norm; they are either not
pronounced or in the course of observation time changes from weak pronounced
warm advection to weak pronounced cold advection and vice versa. Grade 3 - warm
advection is predominant.

Then by combination of two estimates for April-June data (shelf group) and
three ones for August-December (slope-oceanic group) were re-united to one estimate
by 5 grades scale of categories of hydrological (CH) situations (Table 1) as the set of
scenario. For first group it elaborated using data from the spawning ground only. For
last squid group in this estimate are integrated the hydrological conditions in the
spawning ground and in BFC area in compliance with early stages of ontogenesis are
developed.

The background ASST characteristics (the horizontal ASST distribution) give
an idea on the hydrological conditions in the spawning ground, and ASST gradient
data – on the ratio between warm and cold advection. The background ASST
characteristics in BFC area revealed on variability of intensity and position the Brazil Current and the Falkland Current. The peculiarities of their interaction determines the condition for warm meanders and eddies formation, and then the probability of young squid migrations to southward.

Table 1. The categories of hydrological CH) situations (in grades) by years, studied areas and months. SG – spawning ground area, BFC – the Brazil-Falkland Confluence area, BG - background characteristic, * - local estimate in 1-3 grades scale, ** - integral estimate in 1-5 grades scale.

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<th>SW-NW gradient*</th>
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<th>SG August-October</th>
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For shelf group 5 grades scale for April-June data from the spawning ground are is following. In key combinations of grades the first numeral is the grade estimation for the background characteristic, and second – for ASST gradient (values in initial 3 grades scale).

Grade 1. On the warm background the water advection was insignificant or absent. Key combination (KC): 3-2.
Grade 2. On the norm background there were observed the steady cold advection or norm situation. KC: 2-1 or 2-2.

Grade 3. There were observed the situations of intensive warming or cooling that intensify with time. KC: 1-1, 3-3 or 2-3.

Grade 4. The background ASST characteristic was on the level of norm (the average long-term value) with cold advection. KC: 2-1.

Grade 5. On the warm background occurred the cold advection, and vice versa, on the cold background occurred the warm advection. KC: 3-1 or 1-3.

For slope-oceanic group this scale is following. In key combination of grades the first numeral is the grade estimation for the background ASST characteristic, second is for ASST gradient for spawning ground, and third numeral is the background ASST characteristic for BFC area.

Grade 1. In the spawning ground was observed the norm situation, and the steady negative anomaly was in BFC area. KC: 2-1-1.

Grade 2. The warm advection was observed in the spawning ground and the situation in BFC area was within norm. KC: 2-3-2 or 1-2-2.

Grade 3. All characteristics were within norm or there were the positive anomaly. KC: 2-2-2, 3-3-3, 2-2-3 or 3-3-2.

Grade 4. There are two variants of situations. a) In the spawning area on the norm or warm SST background was observed cold advection; or on the cold SST background took place warm advection. In BFC area was developed the well-pronounced warm or cold anomaly. b) In the spawning area was observed any combinations of hydrological conditions, but in BFC area was observed well-pronounced positive SST anomaly. KC: 1-3-1, 1-3-3, 1-1-1, 2-3-3, 1-2-3 or 2-2-1.

Each taken separately these diverse combinations of hydrological situations is favourable for survival of paralarvae or fry and juvenile stages.

Grade 5. In the spawning ground was observed any temperature background but took place slacken cold advection; in BFC area was well-pronounced warm anomaly (it supposedly connected with the Brazil Current strengthening). KC: 1-1-3, 3-1-3 or 2-1-3.

Similar hydrodynamic conditions (grade 5) with cold high productive waters advection in the spawning grounds (that probably is optimal for paralarvae survival)
and intensification of the Brazil waters containing fry and juveniles in BFC area (that contribute to their southward migration) are probably optimal for successful slope-oceanic squid recruitment.

It is supposed that these 5 grades scales are constructed in following order: from 1 to 5 grades to improve the conditions for early squid stages survival.

**Fishery / Abundance data**

There are three main fishery grounds in the Argentine squid fishery (Csirke, 1987; Brunetti, 1990; Nigmatullin et al., 1995; Nigmatullin, Laptikhovsky, 1996; Haimovici et al., 1998; Brunetti et al., 1999). The first one is limited region in the edge of shelf and slope of 45-47° S and 41-42° S outside of Argentine EEZ (i.e. zone of “free” fishery). The large-scale fishery to target on this squid had started in 1978-1982. Last 15 years here had worked about 100-250 jiggers and 20-60 trawlers (Csirke, 1987; Nigmatullin, Laptikhovsky, 1996; FIS, 2004).

The second fishery ground is the Falkland shelf, where in 1978-1986 squid fished mainly by trawlers in “free” regime. Since 1997 fishery carried out on licence base mainly by jiggers and the total fishing effort was quasi-stable: there fished yearly 79-170 vessels, mainly more than 100 (FID, 1997, 2004a).

Third fishing ground is the Argentine EEZ. The large-scale squid fishery started here from 1993 when Argentine Government had introduced the licence system for foreign jiggers. Last decade in this region fished about 100-150 jiggers and tens trawlers (Brunetti, 1990; Haimovici et al., 1998; Brunetti et al., 1999; FIS, 2004).

Most correct and informative fishery data that may be used for abundance estimations of both *Illex argentinus* main groups are received in the Argentine EEZ. But in total catches here predominant winter spawning squids that fished mainly in southern part of fishing ground with the Argentine EEZ (Brunetti et al., 1999; FIS, 2004) In Falkland EEZ fished only the representatives of winter spawning group and in some years the total catch level is determined not squid abundance but the peculiarities of their distribution due oceanographic conditions in the southern part of the Patagonian shelf (for example the situation of 2002) (FID, 1997, 2004a; FIS, 2004). In first fishing ground outside the Argentine EEZ the fishing fleet used squid of both group but influence of distribution factor on CPUE value also significant. Optimal variant for abundance estimation of given year generation is using data from all three fishing grounds. But it is
possible only since 1993 when fishing fleet densely had been “controlled” whole area of three fishing grounds.

Correspondingly three sets of data were used for characterize the long-term squid abundance variability. The base of this time series is the data on the mean monthly CPUE of Soviet/Russian trawler of BMRT type (2000-3500 GRT). These data were recognized as indices of squid abundance. We use the Soviet/Russian fishery statistics on *Illex argentinus* for fishery seasons of 1983-1997 and 1999-2004 in the first fishing ground of 45-47°S and 41-42°S. The large-scale Soviet fishery on *Illex argentinus* had started in 1982. Then Soviet/Russian total yearly catch varied from 17-105 thousand t to 9.0-0.5 thousand t (Fig. 2), and number of trawlers also varied from 12-90 to 7-1 (Nigmatullin et al., 1995; Nigmatullin, Laptikhovsky, 1996; Nigmatullin, 2002).

For analysis were used data for two typical months with maximal catches – February and May (Fig. 3). Second maximum of CPUE is in June, but the fishing season in 60% years was finished here in end of May. These two months were selected also for the following reasons. In February *Illex* fishery is mostly based on the autumn spawning shelf group, and in May - fully on winter spawning slope-oceanic group (Nigmatullin, Laptikhovsky, 1996; Laptikhovsky et al., 2001, 2002; Nigmatullin, 2002). Thus these months are the most representative for showing an abundance of the particular groups.

The CPUE data was used since 1983 because the SST data for 1981 is not available. The Russian fishery was not carried out in February and May 1998-1999 and May 2000. For estimations of fishery situations in first fishing ground in May 1998 and 2000, February and May 1999 were made on the base of information that was received from the Russian seamen from transport and fishing non-Russian vessels.

In addition to these data for description of stock condition, the data on annual squid catches in the Falkland EEZ for 1987-2004 (FID, 1989, 1997, 2004a,b) and in the Argentine EEZ for 1993-2004 (Brunetti et al., 1999; FIS, 2004) were used.

There are some difficulties in using absolute values of CPUE and total catch as indices of abundance: their concrete value depends from many factors *in pari causa* of abundance of fished stock. They are total fishing effort, the level of competition between vessels, the characteristics of fishing concentrations distribution, etc. Moreover, combined using the data of CPUE and total catch also involves additional difficulties. In this case more optimal using the rank characteristics: the category of abundance (CA) that based on the category of fishing situations. The rank classification of the different
Fishery data from 1 to 5 grades (from very bad to best-case value) is following.

For the mean month CPUE of the Soviet/Russian BMRT trawlers it is:

1 grade - 0.1-5.0 t per day
2 grade – 5.1-10.0 t
3 grade – 10.1-15.0 t
4 grade – 15.1-20.0 t
5 grade - > 21.0 t.

For the total catch in the Falkland EEZ:

1 grade - < 50 thousand t per fishing season
2 grade - 51-100 thousand t
3 grade - 101-150 thousand t
4 grade - 151-200 thousand t
5 grade - 201-266 thousand t.

For the total catch in the Argentine EEZ:

1 grade - < 75 thousand t per fishing season
2 grade - 75.1-150 thousand t
3 grade - 151-225 thousand t
4 grade - 226-300 thousand t
5 grade – 301-435 thousand t.

For comparative analysis of CH and CA values for the squid shelf group used the data of February CPUE only (Table 2). For squid slope-oceanic group were used data of May CPUE for period 198-2004 and this data combined with data on total catch in Falkland EEZ for 1987-2004 and Argentine EEZ for 1993-2004. In later case the predominant estimations were the ranks based on CPUE data (for keeping of succession). Then they were corrected by the rank estimations of the Falkland and Argentine catches. In result for each year we had received two rank estimations of squid abundance – for shelf and slope-oceanic groups (Table 2). Hereinafter we will be often designating the abundance of these groups correspondingly as February and “May” (the latter – conditionally) abundance (catches).
Table 2. The categories of squid abundance (in grades) by years, fishing grounds and months obtained from different source (see text). For future analysis used the data from second (February) and last (“May”) columns. Grades of “May” column are integral estimations from 3, 4 and 5 columns for categories of abundance of winter spawning slope-oceanic group.

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* - By data of Soviet trawlers (Nigmatullin, Laptikhovsky, 1996); ** - By personal communications of Russian seamen.

The non-parametric correlation coefficient by Spearman (Ajvazyan, Mhitarjan, 1998) was used for estimation of correlation level between the categories of hydrological situations and squid abundance (both in grades). The estimations were carried out by level p= 0.05.
RESULTS

The analysis of obtained sequence of data on CH and CA (Fig. 4, 5) not revealed the statistically significant systematic trends and periodicity. All periodicity correspond to “white noise”.

But by visual evaluation of data for CA of slope-oceanic squid group (Table 2; Fig. 5) testify for the presence of quasi-seven years periodicity. Two such cycles were observed. In 1982-1985 CA value was high and international fleet exploited the stock near virgin condition.

First distinctly CA decline was occurred in 1986. This CA fall was shown not only in the 45-47°S fishing ground (Table 2), but it was noticeable in the Falkland shelf also (Nigmatullin, Laptikhovsky, 1996). In this year the Argentine squid catch of the Argentine fleet had decreased to 2-3 times in comparison with 1982-1985 (Brunetti, 1990). Thus probably it was the crisis of whole stock.

Then the level of CA during 7 years (1987-1993) was in top condition with insignificantly variation. And then again more pronounced and prolonged CA decline was in 1994-1995 (review: Nigmatullin, Laptikhovsky, 1996). This stock fallen was shown in the Falkland and Argentine EEZ also (FID, 1997; Brunetti et al., 1999 and see Table 2). In 1996-2002 CA value rose up to normal level with maximum in 1999.

New decline of CA level was observed in 2003-2004: it was the unexampled collapse. It very negatively affected to shelf group also (Fig. 4). In 2004 the common commercial CPUE level was not obtained and fishing season was finished early than usually on 1-3 months in all fishing grounds (FIS, 2004; our data).

The values of AC in February 1983-1997 and 1999-20044 were positively correlated with CH values in April-June of the preceding year (r = 0.71). Same positive correlation (r = 0.61) was calculated for AS values in “May” 1983-2004 and CH for August-December of the preceding year.

There was calculated correlation coefficient by Spearman for two fishing periods with different total fishing effort - 1983-1993 (relatively low and spatially non-uniformly) and 1994-2004 (relatively high and nearly uniformly include all fishing grounds). For the shelf group this positive correlations for 1983-1994 and 1994-2003
were nearly similar – \( r = 0.63 \) and 0.67 correspondingly. But same values for slope-oceanic groups were differed. For data of 1983-1994 it was 0.5 but for data of 1994-2003 – 0.82. Probably this difference is caused by more complete and correct used data for last period (Table 2).

**DISCUSSION**

In the slope-oceanic group was revealed the presence of quasi-seven years periodicity. Similar 7-9 years pattern of periodicity was found in relative numbers of cold days in Argentina for spring season (Rusticucci et al., 2003). In this season exactly the spawning events of squid slope-oceanic group take place. Probably this coincidence is not casual: may be it is chain of one consecution of events – from the atmospheric circulation to surface water dynamics and its influence on squid recruitment success.

If our CPUE data reflects the natural state of the shelf stock, its level more stable in time. But in 2004 it also was in collapse (FIS, 2004).

There are found the positive correlations between both group squid abundance and types of hydrological situations. On the basis obtained data we may briefly describe the scenario of the condition for formation high or low squid abundance.

The high abundance of shelf group squid in February was observed in following hydrological situation in the spawning grounds in April-June of the preceding year. There must be the steady positive SST anomaly that connected with solar warming and the Brazil Current strengthening. At the same time there must be strongly pronounced TTS gradient along shelf axis that connected with cold advection of the Falkland Current waters and formation of the local frontal zones.

Low abundance of shelf group in February formed in case in the spawning ground in April-June of the preceding year was observed steady positive anomaly but there were no water advection and no the local frontal zones.

The high abundance of the slope-oceanic group in “May” (within the Falkland and Argentine EEZ mainly during March-June) appear when in August-October of the preceding year in the spawning ground was observed same situation that above described for April-June (for high abundance). Moreover, in October-December in BFC area was
predominant the positive SST anomaly that mainly caused by the Brazil Current strengthening.

In opposite, low abundance of this group formed in following conditions. In the slope zone of the spawning ground in August-October was observed the steady negative SST anomaly and water advection was within the norm. In BFC area in October-December was predominant the negative SST anomaly. In this situation the Falkland Current is strengthening and the core of the Brazil Current deviate to the east (most of squid fry move to the east and the rate of mortality must be increased).

In particular in October-December 2003 the Falkland Current was intensify and negative SST anomaly during three months culminate up to more than –1°C. This situation may be one of the factors that caused very low squid abundance in 2004.

These obtained relations possibility to use for fishery forecasting with advance time of 4-6 months. Our result confirms the possibility using the relations between the hydrological conditions (in particular SST and ASST data) in the spawning and “nursery” grounds and catches of given squid generation in the fishing grounds that were discovered earlier (Waluda et al., 1999, 2001a,b; Waluda, 2000; Devitsyn et al., 2001; Laptikhovsky et al., 2001, 2002).

From the beginning of the Argentine squid large-scale fishery, the total fishery effort was increased and from 1993-1994 it became stabilize on high level and it was distributed on all potential range of fishing concentrations ((Nigmatullin, Laptikhovsky, 1996; FID, 1997, 2004; Haimovici et al., 1998; Brunetti et al., 1999; FIS, 2004). This very high fishery “press” on squid stock probably is not significantly influenced on the level of recruitment and stock size in the years of medium and high squid abundance due very high reproductive potential and “elastic” ecological traits of its population.

But in the situations of stock decreasing the fishery “pressure” “played” the role of the additional strong negative factor for normal reproduction due high fishery mortality rate. In this case the combination of two factors provoked stock collapse: environmental change (mainly due to water dynamics of the Falkland-Brazil currents system and increase of paralarval stage mortality) and the high level of fishing effort that is distributed on nearly whole species range on the shelf and slope zones. Probably in consequence of these two factors superposition, each stock crisis during 1982-2004 is more and more pronounced and prolonged. Hence the adaptive fishery management and
developing of fishery ecology investigations for this species on the international basis are urgent questions today.

ACKNOWLEDGEMENTS

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REFERENCES


Fig. 1. Isolines of SST in November (climatology 1971-2000 from IGOSS nmc Reyn_SmithOiv2) and areas of SST data collection. 1 – spawning area, 2 – the Brazil-Falkland Confluence area.
Fig. 2. Annual catches of Soviet (1) and Russian (2) fleets in 1982-2004. Data for 1992-1997 are total catches of former Soviet countries fleets.

Fig. 4. The grade values of the hydrological (1) situations in the spawning ground in April - June and fishery (2) situations in February of next year.

Fig. 5. The grade values of the hydrological (1) situations in the spawning ground and BFC frontal zone in August-December and fishery (2) situations in “May” of next year.