ICES CM 2004/Session K: 11

The dense male aggregation over submarine mounts as an integral part of species range in the Blue shark *Prionace glauca*.

Feodor Litvinov

Abstract
In addition to permanent species populations of seamounts, there are dense aggregations of oceanic and semioceanic sharks over some of them: Prionace glauca, Isurus oxyrinchus, Alopias superciliosus, Sphyrna zygaena. Sharks are up to 20 times more abundant there than in oceanic waters. Such aggregations exist in East Atlantic, over Meteor, Yer, Erving and Atlantis in Northern Hemisphere, and over Whale Ridge to the South. In Eastern Pacific such aggregations were observed over Nazka Ridge, and westward and eastward of Galapagos Islands, not related to any pronounced mounts. Blue shark Prionace glauca absolutely dominates these aggregations. Aggregations mainly consist of Blue shark adult males of 170-280 cm; in East Atlantic these are associated with young sharks of 50-140 cm in Moroccan and Namibian neritic waters. So, one may see the pairs (adult male aggregations)-("kindergartens") corresponded to northern and southern groups of populations. Most probable such "male clubs" are intended for first copulation with young females, leaving neritic "kindergartens" for oceanic waters. Similar picture may be seen in East Pacific: there are Blue shark "kindergartens" in Santa Barbara and Ensenada waters; such places may be supposed in South America neritic waters. No doubts, the dense male aggregations are extremely vulnerable to overfishing and certain protection measures to be undertaken immediately. It is still unknown, are such aggregations all-the-year-round or seasonal, but it is clear that aggregations of top predators significantly influence oceanic ecosystems, including seamounts, and interactions between large pelagic sharks aggregations and populations of fish and invertebrates inhabiting seamounts are still unknown. Thus, from one side sharks aggregations themselves need protection, and from other side their influence to be taken into account when planning exploitation of species inhabiting submarine mounts.

Keywords: Blue shark, copulation, infra-species units, submarine mounts.

Feodor Litvinov: Atlantic Scientific Research Institute of Marine Fisheries and Oceanography (AtlantNIRO), 5, Dmitry Donskoy Str., Kaliningrad, 236000, Russia [tel: +7 0112 225887, fax: +7 0112 219997, e-mail: flit@atlant.baltnet.ru].

Introduction

The blue shark *Prionace glauca* is probably the widest ranging and abundant chondrichthyian. It is circumglobal in temperate and tropical waters (Compagno, 1984). It absolutely predominates elasmobranch taxocenes of the most of oceanic biotops, excluding shelf and waters adjacent to some islands (Litvinov, 1989). The same time its range structure and life history is poor known: e.g. the last reviews (Froese, Pauly, 2004) indicates that the species may be found close inshore where the continental shelf is narrow; however it will be shown below that the blue hark lives for the first years of life in the coastal waters.
While blue sharks are among the most abundant, widespread, fecund and faster growing of the elasmobranchs, and a pelagic species that is widely distributed throughout the world's oceans, they are also the most heavily fished sharks in the world. The impact of annual fisheries mortality (mainly of bycatch), estimated at 10 to 20 million individuals, is likely to be having an

effect on the world population, but monitoring data are inadequate to assess the scale of any population decline. There is concern over the removal of such large numbers of this likely keystone predator from the oceanic ecosystem (Stevens, 2000). Last years the demand for shark fins is highly increased. The price for one kilo of fins is 10-50 times higher than for the shark meat (FIS data), so the danger for the blue shark became imminent. In such circumstances it is very important to know in detail the species range structure and life history in order to determine the crucial points for the species survival and introduce protection measures when and where it is necessary.

Materials and methods

The data were collected in 1978-1987 long line surveys, 290 drifts and 76 931 hooks in total (Table 1). In addition one young blue shark was caught by purse seine in Ensenada waters in 1992 September. The most part of the data were collected by the author or in accordance with the instructions he had prepared.

Table 1. Areas and periods of the data collecting.

#	Period	Number of drifts (tolls)	Area
1	1978 September-October	24	Western Central Atlantic open waters
2	1978 November	4	North Atlantic open waters
3	1978 November	7	Marine mounts southward of Azores: Great Meteor, Hyeres, Irving, Plato, Flamingo, Atlantis
4	1980 December	4	-"-
5	1980 July-September	43	Open Atlantic
6	1980 September	9	Whale Ridge, oceanic waters
7	-"-	5	Whale Ridge, neritic waters
8	November 1979-January 1980	14	Moroccan waters
9	1980 January-February	12	Sierra-Leone waters
10	June-September 1982	27	Guinea Bay
11	June-September 1982	23	San-Tome and Principe waters
12	May-July 1982	24	Nicaraguan waters, Atlantic coast
13	November 1985-March 1986	21	Nicaraguan waters, Atlantic coast
14	May-July 1986	26	Cuban waters
15	May-June 1981	10	Waters of Grenada Isl.
16	1984 April-June	7	East Pacific, eastward and westward of Galapagos Isl.
17	June 1984	37	East Pacific, off Peru
18	1987 April	2	Nazca and Sala y Gomez Submarine mounts
19	1992 September (purse seine)	1	Ensenada, Mexico

The most part of the areas investigated is mapped in Litvinov (1989).
All the drifts were carried out by the standard tuna pelagic long-lines, distance between hooks 50 meters, there were fished water layers from 65 to 228, additionally from surface to 65 m from the shipboard. The small pelagics (sardine mackerel, hors mackerel) and squids were used for bait. The main quantitative parameter for the species abundance was number of sharks of the certain species caught per 100 hooks. Not all of sharks were taken on the shipboard, it significantly

depends on the crew skill, but in the most case the species, sex and approximate length of the sharks and skates was determined. The number of sharks per 100 hooks calculated for the single drifts and whole certain areas was considered as the Index of the Relative Abundance (IRA). Roughly speaking, IRA value of 10 sharks per 100 hooks corresponds to the density (derived from the average blue shark speed (Carey and Scharold, 1990) and drifting period) of two sharks per 1000 square kilometers (Litvinov, 1997).

Results

As it was shown (Litvinov, 1989), the blue shark is not uniformly distributed in oceanic waters: the average IRA value is about 1.0 in Atlantic and East Pacific; the same time there are zones of the sharply increased abundance (ZIA) and IRA may be 10-20 times higher there. For the first time ZIA were revealed in 1978 November on submarine mounts southward of Azores, the results were confirmed in 1980 December. The average IRA derived from the all drifts was 9.81, it was much higher in the single drifts above Meteor and Atlantis: 14.0-22.3. Such abundance was restricted directly to the points just over submarine mounts peaks and was not observed in the nearest waters: in 1978 November in one drift which was carried out 60 nautical miles southward of Great Meteor Bank IRA was as low as 0.33; in 1980 between peaks of Hyeres and Irving it was 0.67, i.e. lower that the average oceanic value. It is to be noted, that these aggregations were formed by adult males of 200-300 cm LT mainly or even exclusively. There was reported the considerable sexual segregation in the blue shark, with females more abundant at higher latitudes than males (Compagno, 1984), like in some other elasmobranch species in order to avoid competition for food (Litvinov, 2003, Patokina, Litvinov, present edition). The existence of the dense aggregations of males restricted to peaks of submarine mounts are hardly to be explained in this way. As a rule, the dense aggregations of males of different taxa: mammals, birds, etc., are intended for copulation with females arriving to such places. It is most probable, that the phenomenon takes place in this case as well: there are the blue shark spawning grounds and “kindergartens” eastward of these mounts on the Moroccan shelf (Fig.1), the newborn and young blue sharks of 50-140 cm occurs in shelf and upper slope waters (Litvinov, 1989, Patokina, Litvinov, present edition). The most probable 4-5 years old subadult females leaving “kindergartens” are directed to these “men clubs” where the first copulation takes place. Then sperm may be stored in the shell glands for a prolonged period while ovaries and oviducts enlarge and become differentiated and fertilization takes place (Compagno, 1984). In such a case the submarine peaks serve as indicators designed to facilitate meeting. The similar picture is seen in Atlantic Southern Hemisphere: in 1980 September it was revealed blue shark aggregations over the Whale Ridge submarine mouts, in oceanic (IRA=2.62) and neritic (IRA=6.03) waters. There were caught 258 blue sharks in total, from 40 to 280 LT. Sex ratio of newborns and youngs (LT=30-150) were exactly 1:1 (73:72), it was 2.0 for the longer sharks (53:26), males predominated in the largest sharks.

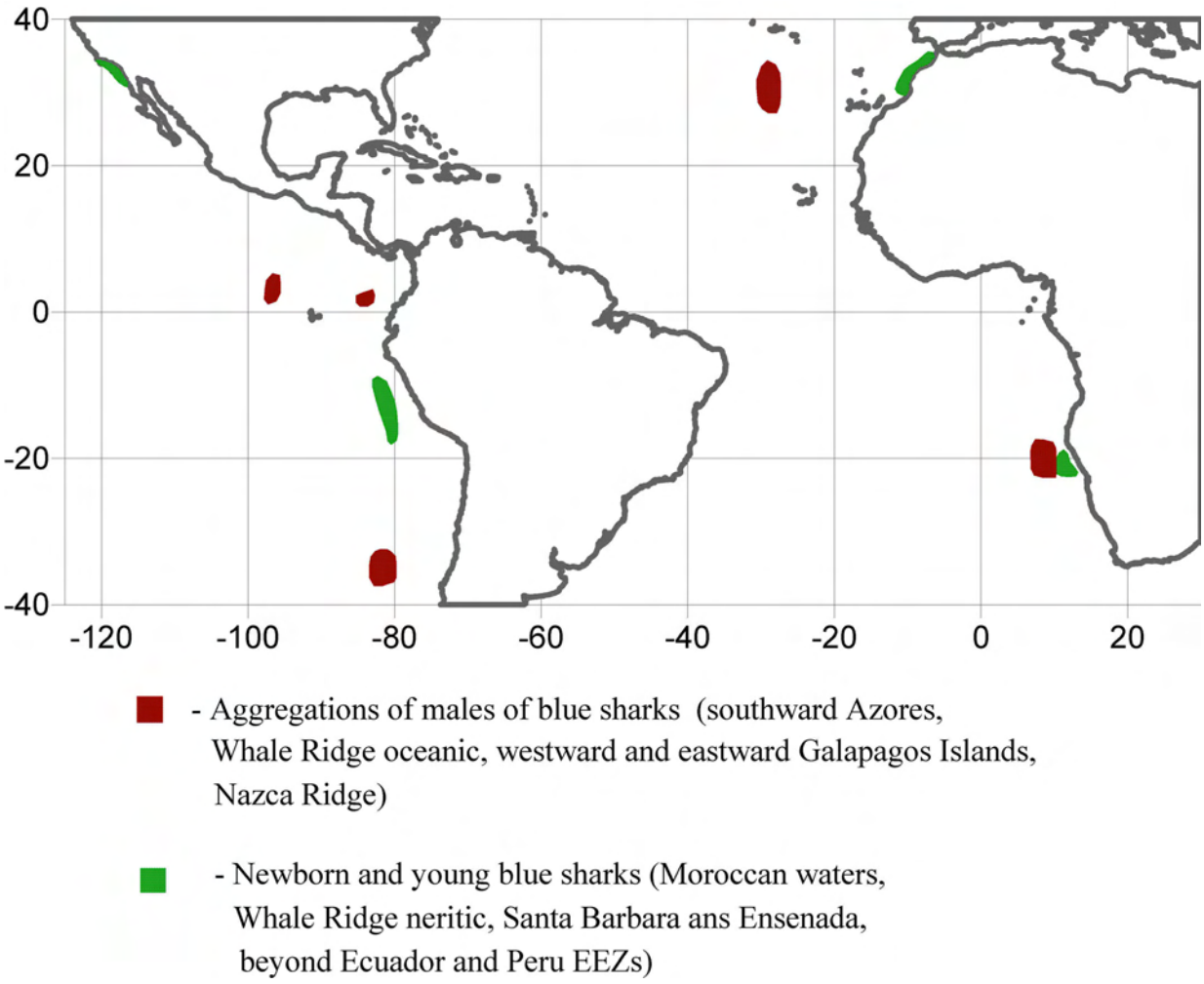

Fig. 1. Aggregations of male aggregations ("male clubs") and newborn and young blue sharks in Eastern Atlantic and Eastern Pacific

Summarizing all the written above, it may be concluded, that in the East Atlantic there are well pronounced two pairs (adult males aggregation on oceanic waters)/(newborns and youngs in neritic and shelf waters) of the blue shark. Moreover, while abundant in Moroccan waters and off Namibia, blue sharks were rather scarce in Sierra-Leone neritic and coastal waters in 1980 Janyuary-February, the silky shark Carcharhinus falciformis prevailed where (the same picture was observed in waters of Nicaragua, Cuba and Grenada), most probable due to high water temperature. So, existence of two spawning grounds in Northern and Southern Hemisphere coupled with adult male aggregations and pronounced disruption between them may be considered as indicator for infraspecies (subspecies?) taxa (Litvinov, 1989). It is to be noted, that just 3% of the total catch of blue sharks caught near San Tome and Principe Isl. in 1982 June-September were youngs of 135-175 cm LT, the bulk of catch consisted of adult males and females of 175-275 cm TL; adult females had pronounced fresh bite wounds resulted from mating behavior (Compagno, 1984) and a number of males demonstrated sperm exuding from claspers. So, it may be concluded that second of third copulation (for females) was observed.

The dense male aggregations of the blue shark similar to Atlantic ones, were revealed in the East Pacific, to the East (IRA=12.93) and West (IRA=5.88)of Galapagos Islands (Litvinov, 1989). The sharks were of 140-330 cm TL, mainly 200-270 cm. Males prevailed (sex ratio was 5.2:1 to west and 5.75:1 to east), the most part of females were gravid, containing from 21 to 54 embryos of 6-38 cm TL. There are no submarine mounts below these aggregations, so some other concentrator was used, probably water temperature or some other gradient. The same time in

waters beyond Ecuador and Peru EEZs the share of small blue sharks of 140-190 cm LT was very high, about 50% of the total, and nearly all of them were males. This phenomenon may be explained in the following way: there is a spawning ground in neritic and coastal waters of Peru and Ecuador and closer to the coast younger and newborn blue sharks occur in sex ratio about 1:1; most probable subadult females of the blue sharks leave "kindergartens" earlier than males, going to "male clubs" for the first copulation. Southeastward this "kindergarten" another "male clubs" were revealed, over submarine mounts Ekliptika (Ecliptic) and "Professor Mesyatsev" of Nazca Ridge in 1987 April. There were caught exclusively adult males of *Prionace glauca*. Thus, one can see the picture very similar to Whale Ridge in Atlantic: males aggregations above submarine mounts in oceanic waters and "kindergarten" opposite closer to the continent.

R.M. Love in his popular book (1991) mentions 90-120 cm (3-4 ft) blue sharks just outside a kelp bed north of Santa Barbara. Southward of these waters author of the present paper in 1992 September obtained the blue shark female of 86 cm TL from purse seine in waters off Ensenada, during control of the gear dolphin safety carried out by IATTC staff member.

Conclusion

Thus, it may be concluded, that the blue shark has a very complicated and differentiated range structure and life history: despite of the fact this is an oceanic species, it spawns in shelf and neritic waters and spends there 3-4 years. Subadult females leave kindergartens" and go for the first copulation to "male clubs" which are situated opposite in oceanic waters. As usual, such male aggregations are situated above the peaks of submarine mounts, but it is not obligatory, some other indicators may be used, e.g. features of water structure (gradients). The second and further copulations of the adult females may occur in other areas. Most probable, in East Atlantic the species is divided into two infraspecies (subspecies) units, northern and southern ones, and in East Pacific as well.

The abundance of the blue shark in male aggregations may be up to 10-20 higher than in the rest of oceanic waters, so the species is extremely vulnerable there for overfishing. Bearing in mind the extremely high demand for the shark fins one may imagine that the blue shark may be overfished easier and sooner than whales in the past due to such aggregations convenient for fishery. It is to be noted, that the modern structure of elasmobrachs taxon in oceanic waters was established very recently: the blue shark had taken dominant position just some hundreds years ago, some million years it occupied subordinate position, and the shortfin mako shark *Isurus oxyrinchus* was the dominant species (Belyaev, Glickman, 1970; Litvinov, 1989., 1997, 1998). Substitution of the dominant species was sudden and fast and the age of the event may be calculated from the fossil teeth density on the ocean floor and teeth replacement rate (Litvinov, 1983). So, the structure of the oceanic system is very fragile and the balance may be disturbed easily. It is undoubtedly that the dense male aggregations of the blue shark are the crucial points for the species survival and due protection to be put on them on the international level. Another oceanic elasmobranch species participate these aggregations: *Isurus oxyrinchus, Alopias vulpinus, A. superciliosus, Sphyrna zygaena, S. lewini, Carcharhinus falciformis, C. longimanus, Dasyatis violacea*, and their IRA is higher there comparing the rest of oceanic waters. These species deserve further detailed study of their rank structure and life history and protection when necessary.

It is still unknown, are such aggregations all-the-year-round or seasonal, but it is clear that aggregations of top predators significantly influence oceanic ecosystems, including seamounts, and interactions between large pelagic sharks aggregations and populations of fish and invertebrates inhabiting seamounts are still unknown. Thus, from one side sharks aggregations themselves need protection, and from other side their influence to be taken into account when planning exploitation of species inhabiting submarine mounts.

Acknowledgement

Author is very grateful to Oleg Berezhinsky for the good help in map preparation.

References

Belyaev G.M., Glickman L.S. 1970. The sharks teeth on the ocean floor. Transactions of the P.P. Shirshov Institute of oceanology of Academi of Sciences of the USSR. V. 88. P. 252-276.

Carey, F.G. and Scharlold, J.V. 1990. Movements of blue sharks (*Prionace glauca*) in depth and course. *Mar. Biol*. 106, 329-342.

*Compagno L.G.V.*1984a. FAO species catalogue. V. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Pt. 2 Carcharhiniformes //FAO Fish. Synop., (125). V. 4. Pt. 1: 249 p.

FIS. Market Reports. Tuna. 2004 January-August. www.fis.com

Froese, R. and D. Pauly. Editors. 2004. FishBase. World Wide Web electronic publication. www.fishbase.org version (06/2004).

Litvinov F.F.Agapov S.N., Katalimov V.G., Mironov S.G. Rate of tooth Replacement in Blue Shark, *Prionace glauca (Carcharhinidae*), in relation to Feeding. Journal of Ichthyology. Vol. 23, number 1, 1983, p. 143-145.

Litvinov F.F. 1989. Structure of Epipelagic Elasmobranch Communities in the Atlantic and Pacific Oceans and their change in Recent Geological Time. Journal of Ichthyology. Vol. 29, No. 8, 1989, 75-87.

Litvinov F.F. 1997. Fossil shark teeth collected on the ocean floor as a mean to trace and date the global events in the World Ocean history. First Congress of Ichthyologists of Russia. Theses of Reports (Astrakhan, September 1997), p. 20-21.

Litvinov F.F. 1998. The elasmobranch's taxocene structure changes in postpleistocenian time. In: Actual problems of fish taxonomy. Conference dedicated to the 95th anniversary of the birthday of the Corresponding Member of the Russian Academy of Sciences A.N. Svetovidov an to the 90th anniversary of the birthday of Prof. D.N. Taliev. St. Petersburg, 17-19 November 1998. Abstracts. P. 36-37.

Litvinov F. F. 2003. Sexual Dimorphism as an Index of the Isolation of West African Populations of the Cat Shark *Scyliorhinus canicula. Journal of Ichthyology, Vol. 43, No. 1, 2003, pp. 81–85. Translated from Voprosy Ikhtiologii, Vol. 43, No. 1, 2003, pp. 86–90.*

Love R.M. 1991. Probably more than you want to know about the fishes of the Pacific coast. Big Realey Press. Santa Barbara, CA. 215 p.

Patokina F.A. and F.F. Litvinov. 2004. Food composition and distribution of demersal elasmobranches on shelf and upper slope of North-West Africa. ICES CM 2004/Session K: 19

Stevens, J. 2000. *Prionace glauca.* In: IUCN 2003. *2003 IUCN Red List of Threatened Species.* <www.redlist.org>.