Best practice guideline on scientific surveys and holistic methods in the Black Sea

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CONTENTS

SUMMARY OF METHODS USED FOR ASSESSING FISHERIES STOCKS IN THE BLACK SEA BY SCIENTIFIC SURVEYS IN BULGARIA

Figures content

Tables contents

SUMMARY OF METHODS USED FOR ASSESSING FISHERIES STOCKS IN THE BLACK SEA BY SCIENTIFIC SURVEYS IN BULGARIA

I. TRAWL SURVEYS FOR MID-WATER SPECIES EXPLOITATION BIOMASS ASSESSMENT

1. *Material and methods*

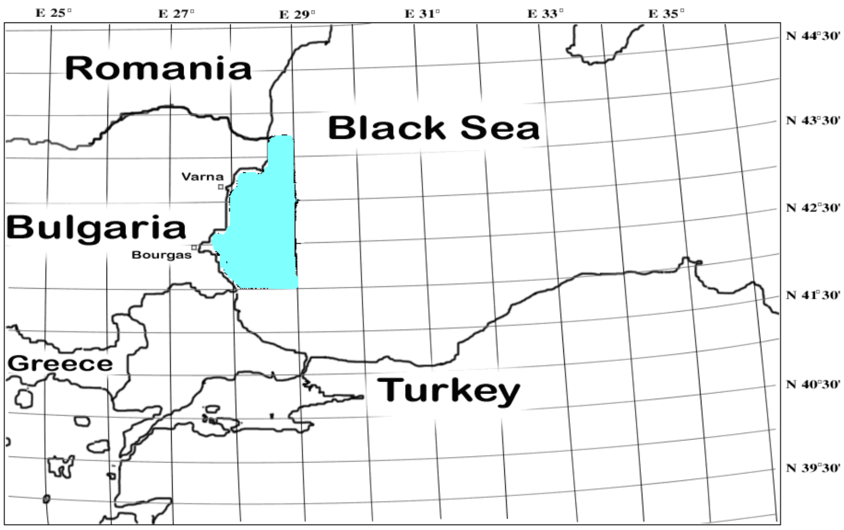


Figure 1 Study area (common EU waters).

The present investigations has been carried out with F/V “FV 3”
The trawl has the following characteristics:

Vertical opening - 4 m;
Mesh size of the cod end: 6.5mm;
“Effective” part of the trawl mouth – 16m;

The vessel was equipped with “Waveon” type GPS with GSM modem GPRS (Vessel Monitoring System). The trawling were carried out in the northern and southern part of the Bulgarian Black Sea coast, during the day with average vessel velocity 5.19 km/h. Information, send by the equipment on board consist the following parameters: Date, hour of signal, velocity, present coordinates. The positions were generated by the equipment in 1 minute interval. In further removed stations from the coast (above 15 miles) some parts remained unrecorded. Nevertheless, the information collected is good enough (reliable) and could serve for analysis of the data from the trawl survey and stock assessment of sprat in front the Bulgarian Black Sea coast. Also, on board of vessel was put electronic log-book for experimental use.

For the purposes of analysis, the standardization of the sampling gears is necessary and in northern and southern part the research was done with one and the same equipment and gears.

2. Method

Stratification sampling methodology (Sparre et al, 1989; Gulland, 1966, Sparre &Venema, 1998, Foote, 1996) in the corresponding marine area was applied (Fig). Taking into account exact depths (isobaths), the whole area was divided to sub areas, i.e. “stratums”, depending on the depth: first stratum – 35- 50 m., second 50-75m, and third 75-100m. Additional IVth stratum has been added in research in 2010 (15-35m). The examined area was divided to equal sized fields - with total number 55; each sector was assessed as 63 км2 (5' Lat. × 5' Long.). The trawling activities were carried out in meridian direction. The duration of each trawling was 60 min; average velocity 2.8 knots (5.19 km/h).

3. Pros and cons of the method

Method Pros:

1. Sampling procedure is under control;
2. The reliability of the data obtained; the data are independent from commercial fishery data;

Cons:

Representative character of the sampling (Foote, 1996); the trawl is selective and does not fully present exploited stock; sampling is possible on the soft bottom only;

4. Gaps of knowledge

1. Depth in the beginning and in the end of each trawling;
2. Geographic coordinates in the beginning and in the end of each trawling;
3. Vessel velocity;
4. Trawling duration;

The first treatment of the biological parameters on board of the F/V “FV 3”

Qualitative and quantitative composition of the catch;

- Taking sample –at least 300 individuals for biological investigations;

Laboratory processing includes age determination of the turbot by binocular microscope with X 10 magnification, in reflected light. The otoliths (statolits) are situated in the middle ear of fish and they are balance organ. By counting the otolith rings it’s easy to establish seasonal and yearly increments of the fish. The turbot otholits are comparably big and compact and have the so-called “opaque” and “hyaline” zones (dark and light circles). Each pair of these zones represents yearly increment (1-1+ year old).

The food spectrum of sprat was identified to the lowest possible level and IRI for different prey species presented in stomach content was also calculated. Stomach Fullness Index was calculated as well.

The samples were collected in accordance with the variation statistics theory:

1. The samples were collected from numerous catches;
2. Each sample contains at least 200 individuals;
3. The samples are representing arbitrary excerpt from the total catch, i.e. the specimen have not been chosen;

The processing of the samples was carried out by following manner:

1. Distribution of the individuals by size classes. Sprat possesses a small linear size, that’s why the corresponding classes were at intervals of 0.5 cm;

2. If the gonad maturation is investigated, the fishes from the corresponding length classes are divided by sex and stage of maturity is recorded;
3. From each size class 10 otholits were taken for age determination. The processing was facilitated by using glycerin;
4. Length, age and sex composition are generalized;
5. Condition factor was determined by so called Fulton coefficient;

5. Statistical analysis

5.1. Swept area method and other tatitical methods

This method is based on bottom trawling across the seafloor (area swept), weighted with chains, rock-hopper and roller gear, or steel beams. Widely used direct method for demersal species stock assessment.

The main point of the method: the trawl doors are designed to drag along the seafloor for defined distance. Trawling area was calculated as follows:

(1)
$$a = D * hr * X2$$
$$D = V * t$$

(Where: a – trawling area, V – trawling velocity, hr* X2 – trawl door distance, t – trawling duration (h), D – dragged distance on the seafloor;

(2)
$$D = 60 * \sqrt{(Lat_1 - Lat_2)^2 + (Lon_2 - Lon_1) * \cos(0.5 * (Lat_1 + Lat_2))}$$

(3)
$$D = \sqrt{VS^2 + CS^2 + 2 * VS * CS * \cos(dirV - dirC)},$$

Where, VS is vessel velocity, CS - present velocity (knots), dir$V$ vessel course (degrees) and *dirC*- present course (degrees).

Stock biomass is calculated using catch per unit area, as fraction of catch per unit effort from dragged area:

(4)
$$(\frac{C_{w/t}}{a/t}) = C_{w/a} kg / sq.km$$

Where: *Cw/t* – catch per unit effort, a/t – trawling area (km2) per unit time;

Stock biomass of the given species per each stratum could be calculated as follows:

(5)
$$B = (\overline{C_{w/a}}) * A$$

Where: $\overline{C_{w/a}}$ - mean CPUA for total trawling number in each stratum, A- area of the stratum.

Total area of the investigated region is equal to the sum of areas of each stratum:

(6) *A = A1+A2+A3*

Average weightened catch per whole aquatic territory is calculated as follows:

(7)
$$\overline{Ca}(A) = Ca1 * A1 + Ca2 * A2 + Ca3 * A3 / A$$

Where: Ca1- catch per unit area in stratum 1, A1 – area of stratum 1,etc., A- size of total area.

Accordingly, total stock biomass for the whole aquatory is equal to:

(8) $$B = \overline{Ca}(A) * A$$

Where: $\overline{Ca}(A)$- average weightened catch per whole investigated aquatory, A – total investigated aquatory.

5.2. Maximum sustainable yield, optimum levels of fishing mortality (Fopt) and total allowable catch (TAC)

Maximum sustainable yield (MSY):

The Gulland's formulation for unexploited stocks (Gulland, 1970):

(7) $MSY = 0.5*M*Bv$

Where: M – natural mortality coefficient; Bv – unexploited biomass;

BEVERTON HOLT Steepness formulation:

(9) $$R = \frac{4hR_0S}{S_0(1-h)+S(5h-1)}$$ R- recruitment resulting from SSB S

(10) $$\alpha = \frac{0.8hR_0}{h-0.2}$$

(11) $$\beta = \frac{0.2(1-h)S_0}{h-0.2}$$

Length-converted catch curve:

(12) $(\bar{L}-L') = a + bL'$ where

(13) $\bar{L} = (\frac{L\infty + L'}{1+(Z/K)})$ from which

(14) $L\infty = -a/b$ and

(15) $Z/K = -(1+b)/b$

$L\infty$ Z/K Estimates and regression parameters

(16) $$\ln(N_i/\Delta t_i) = a + bt_i$$

N_i is the number of fish in length class i, □ti is the time needed for the fish to grow through length class i, ti is the age (or the relative age, computed with $t_o = 0$) corresponding to the midlength of class i, and where b, with sign changed, is an estimate of Z.

Following estimation of Z, the routine can be used to estimate M using Pauly's M equation and *F*, from *Z = M+F*, as well as the exploitation ratio, *E = F/Z*.

Catch curve analysis can then be extended to an estimation of probabilities of capture by backward projection of the number that would be expected if no selectivity had taken place (N'), using

(17) $$N_{i-1'} = N'_i Exp(z\Delta t_i)$$

Δt_i as defined above

(18)

$$Z = (Z_i + Z_{i+1})/2,$$
$$Z_i = M + F_i$$
$$F_{i-1} = F_{i-x}, X = F$$

Probability of capture

$$\ln[(1/P_L) - 1] = S_1 - S_2 L$$

(19)

P_L - Probability of capture for length L and

$$L_{25} = (\ln(3) - S_1)/S_2$$
$$L_{50} = S_1 / S_2$$
$$L_{75} = (\ln(3) + S_1)/S_2$$

$L_{25\%}$ - length at which 25% of the fish will be vulnerable to the gear (left-hand selection)

$L_{50\%}$ - length at which 50% of the fish will be vulnerable to the gear (left-hand selection)

$L_{75\%}$ - length at which 75% of the fish will be vulnerable to the gear (left-hand selection)

RELATIVE Yield per recruit and Biomass per recruit – knife edge selection:

(20) $$Y'/R = EU^{M/K}\left\{1 - \frac{3U}{(1+m)}\right\} + \frac{3U^2}{(1+2m)} - \frac{U^3}{(1+3m)}$$

$$m = (1-E)/(M/K) = (K/Z)$$
$$U = 1 - (L_c / L\infty)$$

where

(21) $$(B'/R)_i = (1-E)A/B$$

Where

(22) $$A = \left\{1 - \frac{3U}{(1+m)} + \frac{3U^2}{(1+2m)} - \frac{U^3}{(1+3m)}\right\}$$

(23) $$B = \left\{1 - \frac{3U}{1+m'} + \frac{3U^2}{(1+2m')} - \frac{U^3}{1+3m')}\right\}$$ and where

$$m' = 1/(M/K) = m/(1-E)$$

$E_{max,}\ E_{0.1,}\ E_{0.5}$

$E_{0.1}$ - level of exploitation at which the marginal increase in yield per recruit reaches 1/10 of the marginal increase computed at a very low value of E

$E_{0.5}$ - exploitation level which will result in a reduction of the unexploited biomass by 50%

E_{max} - exploitation level which maximizes Y/R or Y'/R

Optimum level of the fishing mortality (F_{opt}), Total Allowable Catch (TAC):

(24) $$YPR = \int_{tc}^{\infty} F * e^{-(F+M)t} W(t)dt$$

Where:

(25) $$w_t = \alpha L_{\infty}^{\beta}(1-e^{-k(t-t0)})^{\beta}$$

t_0, k - Von Bertalanffy equation parameters

α, β - Length-weight equation parameters

Beverton&Holt (1957) model assumes that n=3 ; the fate of individual recruit from the moment it first became potentially vulnerable to the fishery (at age tc or at length lc) until it reaches at age t_{max}. Yield per recruit is a function of two parameters over which the fishery manager in principle has control: Fishing mortality (F) and optimum exploitation age tc (or optimum exploitation length - l_c).

We accept that *R = R0*, or the recruitment is constantly equal to 100 billion individuals during the year. Several management strategies could be applied in order to determinate the rational exploitation levels of the given stock, aiming stable recruitment, sustainable growth and stable age structure:

(26) Y/R = Y′W∞.exp M (tr – t0) = $$Y' \frac{W_{\infty}}{(1-\frac{L_t}{L_{\infty}})^{\frac{M}{K}}}$$

(27) $F_{0.1}$ -where, the slope of the curve is 10% from the slope in F = 0

$$F_{0.1} < F_{0.x} < F_{max} YPR$$

Calculation of TAC is:

(28) TAC= Y (%) when $F_{0.1}$/ B Prodanov and Kolarov (1983)

For estimation of the optimum levels of exploitation of the given species the influence of F on the Yield-per-recruit was tested. Ricker's equation was used:

(29) $Y=F^*\sum Bt\ [exp\ (Gt-Z)]-1/Gt-Z$

Ricker's equation modification (Prodanov, 1989):

When, C max = YE

(30) $G>Z \quad B'0/B0 < 1/2 \quad P>2$

(31) $G=Z \quad B'0/B0 + ½ \quad P=2$

(32) $G<Z \quad B'0/B0 +1/2 \quad 1<P<2$

Where: Y- catch; F-fishing mortality from tr to to; tr – age at maturity; tλ – maximum age; B_t – biomass at age t (Bt=Nt*Wt); N_t – number at age t; W_t – weight at age t; Z – Total mortality ($Z = F+M$); G_t – instantaneous weight growth at age t:

(33) $Gt=ln\ (Wt+1/Wt)$

The level of $F=F_{opt}$ was established with the ratio Bf/Bo=0.5., i.e. for optimum we took that rate of F at which the biomass of the given species (in condition that $R=R_0$) represents 0.5 biomass of the species in virgin state (B_o) i.e. at F = 0, the optimum ratio is 0.75.

5.3. Lenght, weight growth and age composition:

Von Bertalanffy (1938) equations have been wide used for determination of the length and weight growth (Spare et al., 1989; Hilborn &Waters, 1992):

(34) $$L_t = L_\infty \left\{1 - \exp\left[-k\left(t - t_0\right)\right]\right\}$$

(35) $$W_t = W_\infty \left\{1 - \exp\left[-k\left(t - t_0\right)\right]\right\}^n$$

Where: L_t, Wt is the length and weight of the fish at age t years; L∞, W∞ - asymptotic length, weight respectively, k – growth rate parameter, t_o – pre-natal parameter.
The dependence between length and weight by age is calculated as follows:

(36) $$W_t = qL_t^{\ n}$$

Where: q – parameter: "condition factor"; n – parameter.

Condition factor (c.f.) of Fulton (Ricker, 1975):

(37) $$K = \frac{W}{L^3} * 100000$$

Where: W – weight in kg; L – length in cm.

Natural mortality coefficient:

Pauly's method (1980):

(38) $$\log M = -0.2107 - 0.0824 * \log L_\infty + 0.6757 * \log k + 0.4687 * \log T^\circ C$$

Where: L∞, W∞ and κ – parameters in von Bertalanffy equation; T C^o – mean annual temperature of the habitat (feeding and spawning area).

5.4. Length cohort analysis

The average size of fish stocks in a given period of time is calculated with the help of cohort analysis of the average composition of the catch (Jones, 1981).

Jones (1984) provides a method of modifying of cohort analysis of Pope (1972), using the size distributions, instead of the age structure.This method assumes that the population is in steady state, such that the amount of catches within one years is equivalent to the amount of cohort size composition during life-span of the species.

Due to this fact, the size composition of catches during one years or the average composition of catches in a number of years, is perceived as "pseudocohort" and not as a real cohort.

The method has many advantages: no need to be determined age of fish, provides estimates of fishing mortality for each size range, reflecting effects of selectivity and recruitment and allows assessment of the impact of the fishing effort change and the selectivity of fishing gear.

The method of linear kohort analysis based on the basic equation of cohort analysis of the Pope (1972):

(39) $$N_t = N_{t+1} * \exp(\frac{M}{2}) + C_t * \exp(\frac{M}{2})$$

On the basis of this equation Jones made the following transformation:

(40) $$N_t = N_{t+1} + \Delta t * \exp(M_t) + C_t^{M\Delta t/2},$$

where: Δt is the time required for the growth of fish in a measured interval. There are different ways to express the growth of fish, but most often used is that of Bertalanffy (1938). The transformation of this equation gives an age expression as depending on the length of the fish, i.e:

(41) $$t = t_0 - 1/k * \ln(1 - L_t / L\infty)$$

Therefore, if t_1 is age corresponding to the L_1:

(42) $$t_1 = t_0 - 1/k * \ln(1 - L_1 / L_\infty)$$

Similarly, if t_2 is the age corresponding to the L_2:

(43) $$t_2 = t_0 - 1/k * \ln(1 - L_2 / L_\infty)$$

From those equations follows that the time required to increase from L_1 to L_2 will be the difference between them:

(44) $$\Delta t = t_2 - t_1 = 1/k * \ln(\frac{L_\infty - L_1}{L\infty - L_2})$$

Δt substituting in equation (20), we get:

(45) $$N_1 = (N_2 . X_L + C_1) . X_L,$$

where: C_1 are numbers of fish caught during the year, with a length between L_1 and L_2; N_1 and N_2 are the numbers of fish in the sea with a length L_1 and L_2:

(46) $X_L = (\frac{L\infty - L_1}{L\infty - L_2})^{M/2k}$

Using equation (25) may proceed with the implementation of cohort data analysis to the length data in the same way as equation (19) applies to the age composition of catches.

The values of the coefficients Z, F ratio and F/Z for each size class is determined as follows: - The F / Z ratio is calculated according to the expression:

(39) $F / Z = C_L / N_L - N_{L+1}$

-value of the coefficient F is calculated by the equation:

(47) $F = Z\text{-}M$

where: Z - coefficient of total mortality.

Size of the largest group size is calculated by the expression:

(48) $N_{L\lambda} = \frac{C_{L\lambda}}{F_{st} / Z}$

Abundance of other size groups is calculated in striet succession toward the smallest classes according to equations (25) and (26). The average number of fish in the sea of a size class is calculated by the equation:

(49) $\bar{N}_L = N_L - N_{L+1/Z}$

The average biomass of the appropriate size classes is equal to:

(50) $\bar{B}_L = N_L . \bar{W}_L$

Unlike cohort and virtual population analysis, which require data on age structure of catches in different years, in cohort size composition analysis is take into consideration that incoming size composition of catches concerns for the stability of the stock. Stationary size composition of catches, however, occurs very rarely in fish populations.

5.5. Gear/mesh size, selectivity

The selectivity of the mid-water trawl was investigated:

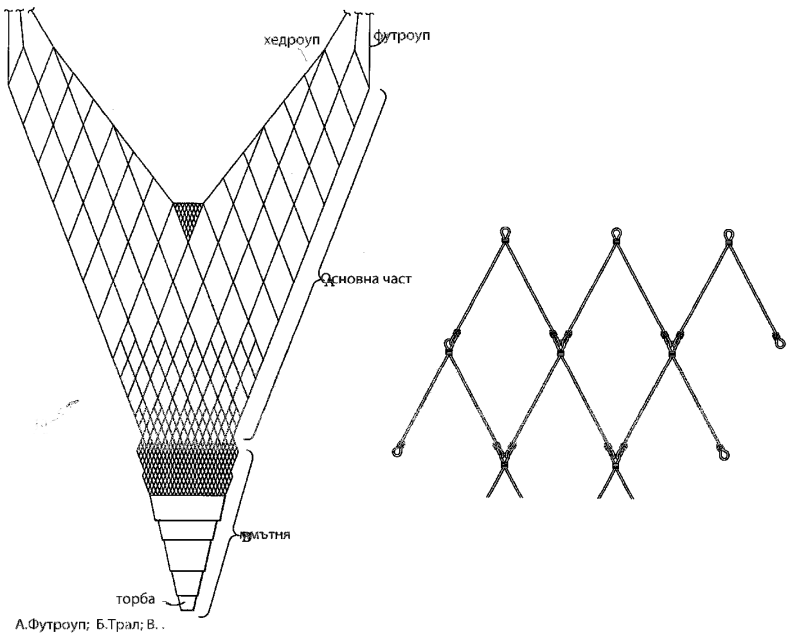


Figure 2 Trawl scheme and mesh size of mid-water trawl

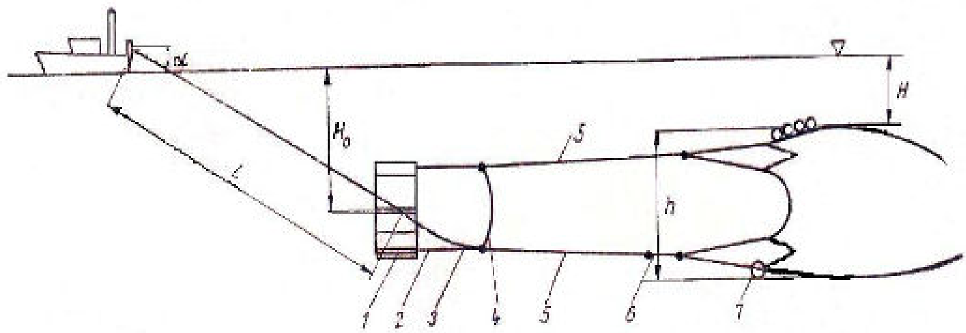


Figure 3 Scheme of the trawl, used in the "swept area" research (after Grudev et al., 1981): 1- trawl board; 2 – board bars; 3- transitional wire; 4- jack; 5- cables; 6- extensor; 7 – profounder.

Table 1 The selectivity of the mid-water trawl at different mesh sizes of the codend.

Mesh size	Selectivity	**8.00 mm**	**7.5 mm**	**6.5 mm**	
	L25%	6.2 cm	5.4 cm	5.2 cm	
Probability of	*L50%*	7.0 cm	6.2 cm	5.7 cm	
retention					
	L75%	7.8 cm	7.00 cm	6.2 cm	
	SF	4.4	4.13	4.77	
	SR	1.6	1.6	1	

5.5.1. Parameters of the selectivity of the trawl (whiting)

For determination of the catchability coefficients we choose length-converted catch curve method for the whiting (by catch in sprat fishery). On Fig. is presented the curve for total mortality estimation Z = 0.81, M = 0.7, F = 0.11 and exploitation rate E = 0.14 – low, because the fishing mortality of whiting is 1/5 from those of sprat, due to the fact that there is no independent whiting fishery. On Fig.20 graphic representation of the catch probability with trawl is presented. The resulted values are as follows:

$L_{25\%}$ = 15.83 cm; $L_{50\%}$ = 17.27 cm; $L_{75\%}$ = 18.71cm.

The analysis show that the individuals with lower sizes (analyzed) would escape from the trawl freely. Trawl will hold individuals with mean lengths 15.83 cm with probability 25%, 17.27 cm with probability 50% and with the highest probability in the codend of the trawl will be caught and detain specimen with length of 18.71 cm (Fig.).

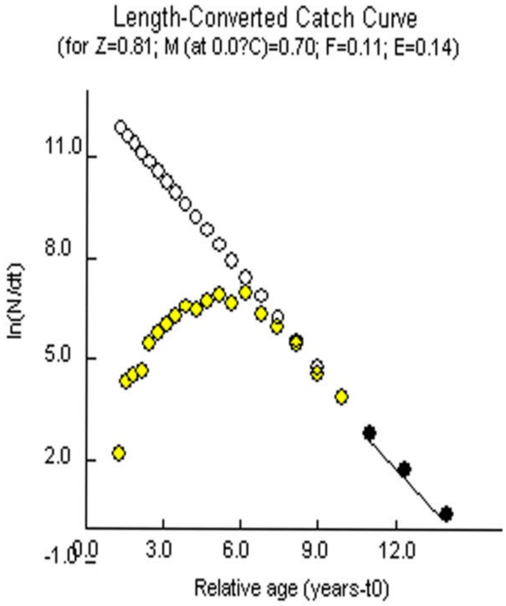


Figure 4 Length-converted catch curve for the whiting.

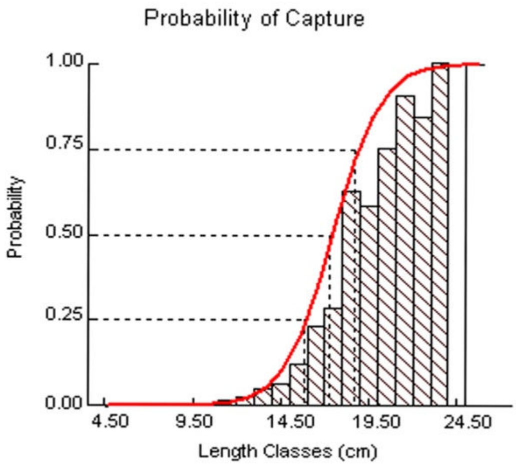


Figure 5 Logarithmic curve of the selectivity of the trawl – bycatch.

II. ICHTHYOLOGIC RESEARCH OF TRANSITIONAL AND COASTAL AREAS (VARNA LAKE AND VARNA BAY, FP 7 WISER)

1. Method

Figure 6 Satellite image of Varna Lake and Varna Bay

2. Description

Varna Lake (43°11′25″N-27°49′30″E – 43°12′28″N-27°53E) is the biggest inner basin along the Bulgarian Black Sea coast. It is situated in south-western direction from Varna, with surface 17.4 km^2 and volume 165.5 $mil.m^3$) and maximum depth of 19m. The catchments of the Lake are 2680 km^2.

The organisms sustain simultaneously impact of the various environmental pollutants – water eutrophication from domestic and industrial discharges, heavy metals and oil pollutants. The disturbance of the equilibrium makes the system extremely vulnerable to the external influences, and due to non-linear character of the relations, even small change in the environment could lead to considerable consequences.

Varna Bay is located in the northern part of the Bulgarian Black Sea coast. It is locked between Cape Galata and Cape St. George. The biggest width between them is 3.5 sea miles. After the Burgas bay, it is the largest in the Bulgarian Black Sea coast. The beach is covered with sand, the central part with slimy sludge. The bay has flat bottom, which is obliquely to the east. Its maximum depth is 18.5 meters. In the western part it is artificially linked with Lake Varna, which has a major impact on biodiversity of both pools.

The sampling area covers Varna Lake and Varna Bay in the period of 31st August to 4th September 2009. Two main types of gear were used: beam trawls and fyke nets (passive gear). For each fishing event were recorded: biological data, parameters of the sampling protocol and some environmental data. Biological data are the number of fish caught from each species (or family or gender when it was not possible to identify catches at the species level) and their size. Data from the sampling protocol include type of gear, date and time of sampling, geographic coordinates of the fishing event, duration of soaking for fyke nets and trawled distance for beam trawls. Some irregularities in the environmental data provided for the fishing events were encountered. For example, while salinity class; temperature and depth were recorded in most of the fishing events (94%, 91% and 85% respectively), oxygen saturation and pH were only recorded in 53% and 10% of the fishing events respectively.

A fishing event is described as a beam trawl haul, a seine haul or a fyke net collection.

The respective trawling (using beam trawl) were carried out in the corresponding area, covered Varna Lake and Varna Bay areas (Fig.2). When was necessary, because the trawl net was upside-down, or some artifacts were caught in the meshes, the respective hauls were repeated. The salinity and temperature were measured at the surface and the bottom of the sampling stations. Water from the bottom was taken by bathometer. Then, on board the salinity and temperature were measured.

All species caught, were sorted in the plastic boxes filled with water. Then, all were separated by species and the TL (cm) was measured. Weight was measured using electronic balance, all on board.

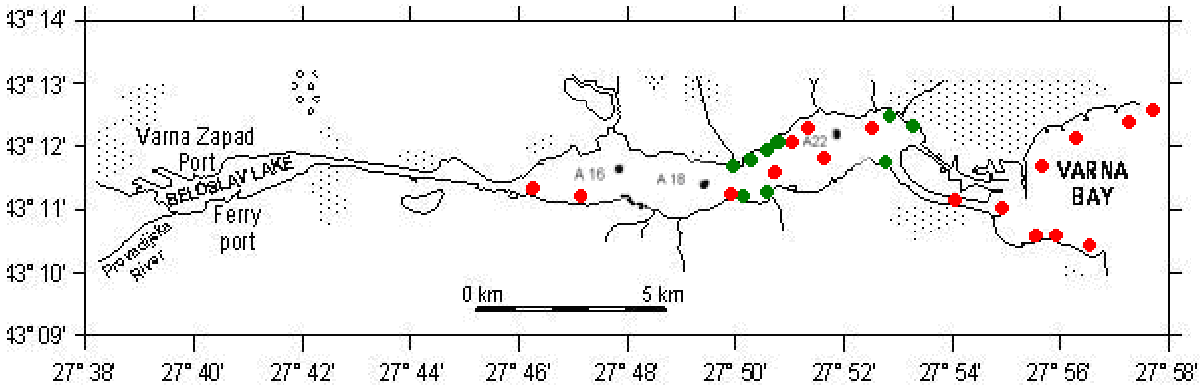


Figure 7 Sampling stations of fyke nets and bottom trawl. A) Bottom trawl (red dots); Fyke nets (green dots).

The fyke nets were set only in the Varna Lake, at the northern coast, mostly (Fig.2).

3. Species

Various marine species

4. Ecosystem considerations

1. Sampling times and duration;
2. GPS position (start - stop);
3. Depth;
4. Temperature;
5. Salinity/Conductivity;

Sampling for the water from bottom layers for temperature and salinity measures.

5. Gear used

Open fishing boat, LOA = 6.5m; width = 2.5m, Engine power 60hp – onboard, draft = 0.7m.

Facilities: Hard cleats for towing and towing line (60m), on a light winch to aid recovery of beam trawl. Depth finder and DGPS.

Beam trawl 2m (4 spare nets, 5mm mesh codend and drop flap to prevent fish escaping)

The characteristics of WISER-built nets:

• 1.5 m width; 25-30 kg total weight
• 1 tickle chain (820g/m type)
• Warp length depthx3, towing speed 1.5 - 2 knots (ca. 400m per tow)

Fyke nets:

- Double fyke (Belgium type;) 8m central panel 6mm (knot-to-knot) mesh;
- 24h deployment, from boat or wading form shore (fixed with anchors/canes);
- Single not tandem arrangements;
- Unattended recording of abiotic parameters;

Figure 8 A. Beam trawl B. Fyke net

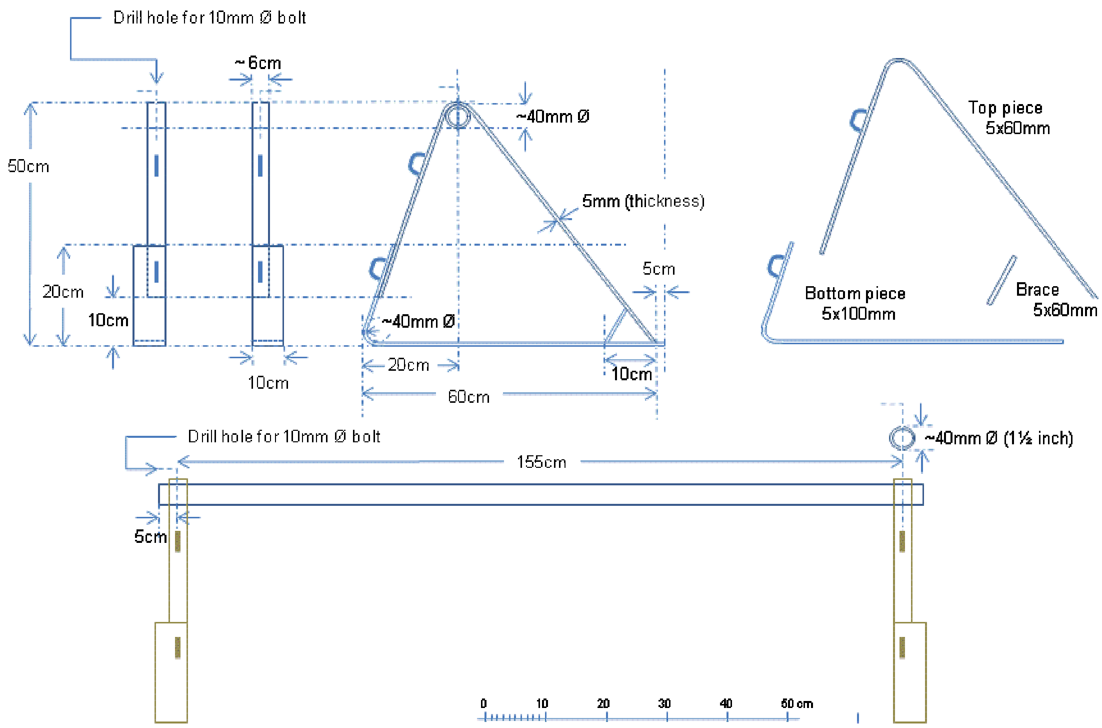


Figure 9 Dimensions of the beam trawl. The design is based on the CEMAGREF 1.5m beam trawl.

The species caught (26) belong to 13 families were caught in the sampling stations for the period of 31st August to 4th September.

The majority of species caught by fyke nets in the Varna Lake were from Fam.Gobiidae, Syngnatidae and Mullidae. The species caught in the Varna Bay only, were: *Arnoglossus kessleri*, *Pomatoshistus microps, Scorpaena porcus, Callionymus risso, Gobius paganellus, Proterorhinus marmoratus*, and *Neogobius platyrostris* (7 species).

The species detected in the catch in Varna Lake only, were: *Platichthys flesus, Zosterisessor ophiocephalus, Neogobius cepahlargoides, Liza aurata, Trachurus mediterraneus* (5 species).

The species caught in both investigated water bodies were: *Parablenius tentacularis, Salaria pavo, Symphodus roisali, Symphodus cinereus, Mullus barbatus, Neogobius gymnotrachelus, Neogobius melanostomus, Gobius niger, Atherina boyeri, Syngnatus typhle, S.tenuirostris, S.abaster (nigrolineatus), Hippocampus ramulosus* (13 species). The most abundant species from Lake and Varna Bay were Round goby (*Neogobius melanosotomus*) and Black goby (*Gobius niger*).

Table 2 List of species, divided by categories and trophic level

	1	**2**	**3**	**4**	**5**
Arnoglossus kessleri	ER	IB	PISC	4.05	B
Atherina boyeri	ER/MJ	Z	PISC	2.77	P
Callionymus risso	ER	IB	INV	3.03	B
Gobius niger	ER	IB	INV	3.28	B
Gobius paganellus	ER	IB	INV	3.3	B
Hippocampus guttolatus	ER	Z	INV	3.5	B
Liza aurata	MJ	O	INV	2.65	D
Liza saliens	MJ	O	AUT	2.99	D
Mullus barbatus	ER/MJ	O	INV	3.195	D
Neogobius cephalargoides	ER	IB	INV	*	D
Neogobius melanostomus	ER	IB	INV	3.245	B

Neogobius gymnotrachelus	ER	IB	INV	3.385	B
Neogobius platyrostris	ER	IB	INV	*	B
Parablennius tentacularis	ER	O	INV	3.12	B
Platichthys flesus	MJ	IB	PISC	3.245	B
Pomatoshistus microps	ER	IB	INV	3.225	B
Proterorhinus marmoratus	MJ	IB	INV	3.48	B
Salaria pavo	ER	O	INV	2.975	B
Scorpaena porcus	ER	O	PISC/INV	3.855	B
Syngnathus tenuirostris	ER	Z	INV	*	D
Syngnathus thyple	ER	F	INV	4.3	D
Syngnathus abaster	ER	Z	INV	3.2	D
Symphodus roissali	ER/MJ	IS	INV	3.46	B
Symphodus cinereus	ER/MJ	IS	INV	3.285	D
Trachurus mediterraneus	MJ/MS	F	PISC	3.48	P
Zosterisessor ophiocephalus	ER	F	INV	3.39	B

1. Guide ecologique dce 2007 (Ecological guide defined for French WFD purpose in 2007.
2. Guide trophique dce 2007 (Trophic guide defined for French WFD in 2007)
3. Guide trophique_lp (Trophic guide_lp)
4. Trophic level of the species (www.fishbase.org)
5. Repartition_dce 2007.

Legend:

FW	Freshwater species
CA	Diadromous species
MA	Marine adventious species
ER	Estuarine resident species
MS	Marine seasonal species
MJ	Marine juvenile species
IB	Bentic invertabrate feeder
IS	Supra benthic invertebrate feeder
Z	zooplankton feeder
O	Omnivorous
F	Piscivorous
V	Herbivorous
INV	Invertabrate feeder
PISC	Piscivorous
AUT	other
D	demersal
B	benthic
P	pelagic

As it is described in table 1, the majority of species are estuarine resident species (ecological status), benthic invertebrate feeders, with trophic level from 2.975 (*Salaria pavo*) to 4.3 (*Syngnathus thyple*).

III. BLACK MUSSEL BEDS INVESTIGATION IN FRONT THE BULGARIAN BLACK SEA COAST

The state of the mussel banks , existed before 1975, in front the Bulgarian Black Sea coast, reduced later by th invasion of the predatory sea snail-*Rapana venosa* and by the process of eutrophication **;**

To calculate the stock biomass in 6 mussel beds in front of the Bulgarian Black Sea coast ;

To calculate the mean density and biomass ;

To establish the by-catch composition ;

To make the qualitative assessment of the sea snail populations in the mussel beds areas.

1. Method

The research has been carried out by using the dredge in the corresponding area (Fig.)

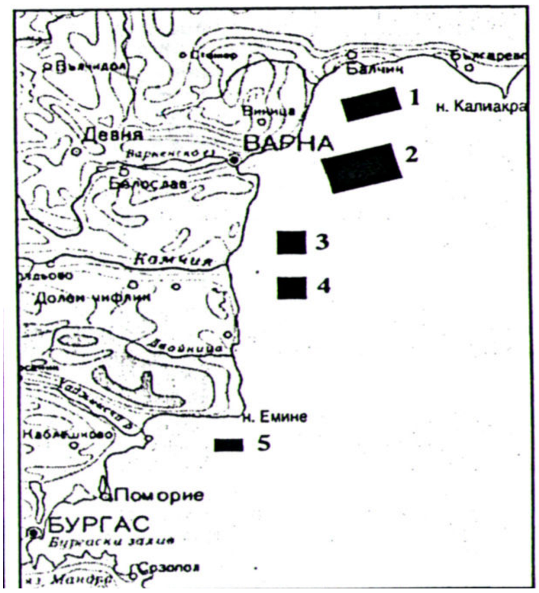


Figure 10 The polygons (mussel beds) researched in front of Bulgarian coast.

Description

Six mussel beds have been researched:

Balchik

43.22 N 28.08.5 E

43.24.5N 28.22.2 E

43.18N 28.06E

43.21N 28.26.5E

On depth of 16-20m. Total number of the trawlings 15.

Galata

43.17N 28.03.7E

43.15.1N 28.33.7E
43.16.5N 27.59.2E
43.10N 28.10.5E
17-24m depth trawling direction North-east-southwest.
14 trawlings

Biala
43.05.2N 27.56.5E
43.04.9N 28.09.8E
42.55.5N 27.55E
42.55.5N 28.07E
Depth : 21-35m
16trawlings

Emine
42.51.8N 27.54.5E
42.51.8N 28.13E
42.42.5N 27.54.2E
42.42.5N28.02.8E
18-40m
6 trawlings

Saint Vlas
42.42.5N 27.04.8E
42.01.8N 27.53.5E
42.35.5N 27.42.8E
42.34N27.50.8E
17-27m
Between Cape Emine and Sunny beach resort :
11 trawlings

Maslen Nos
42.26.8N 27.44.2E
42.19N 27.55.2E
42.14.5N 27.51.1E
42.17.8N 28.10.3E
23-55m
11 trawlings

From each tow 100 mussels have been separeted for analusis of the lenght composition. By catch of Rapana venosa and other species have been estimated as well.

The stock biomass has been calculated by swept area method :
The area of one trawling has been calculated ;
The area of the mussel bed is calculated ;
On the basis if the average catch obtained from one trawling and covered area the toatal stock has been calculated;
The size structure of the mussels has been useed to calculate the the exploitation stock of the mussels.

IV. EXTRACTION OF THE BABY CLAM (*CHAMELEA GALLINA*) TROUGH DREDGING

A. **B.**

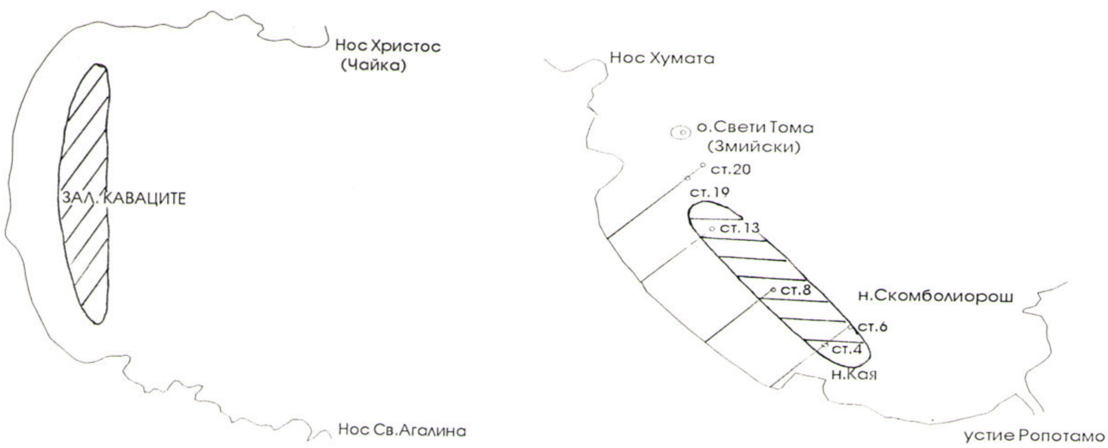
Figure 11 Metallic dredge for baby clam extraction from soft ground (A, B).

1. Method

2. Description

The dredging for baby clam has been carried out by metallic dredge with the following dimensions:

The distance between separate teethes, situated in the front part and between the ribs, forming the main corpus is 12-15mm.The “teethes” of the dredge are constructed in such a way in order the dredge to operate at maximum depth of 10cm I the sandy substrate. To the back side of the metallic dredge is attached the codend compound by 3 layers net, as the inner is with smaller mesh size -15mm. The dredge is connected with the vessel arrow by the rope, attached to the upper frame of the front opening of dredge. Additionally, one more rope exists, lashed together to the two side of the “sledge” like construction.



A. **B.**

Figure 12 The area of interest (**A, B** polygons) researched by dreging for *Chamelea gallina* off Bulgarian coast.

The area between the Island "Saint Toma" and the mouth of the Ropotamo River is the most suitable for the dredging activities, due to the possibility the dredge to be towed along of 1200-1500m distance, parallel to the shore. The dredge has been dropped down in the one side of the area and operates about 15-20 min, up to the end of the researched zone and step by step is pulled out into the surface, washed on board. Simultaneously, the vessel turned around (180°). Immediately after that, the codend is tied up and is dropped down into the working regime, in the opposite direction, as the vessel sail the same distance, for the same time at average vessel speed of 3780m/h. During the next 15 minutes, when the dredge operates on the deck the production extracted has been packed and sorted.

The scheme of the metallic dredge is presented on fig.

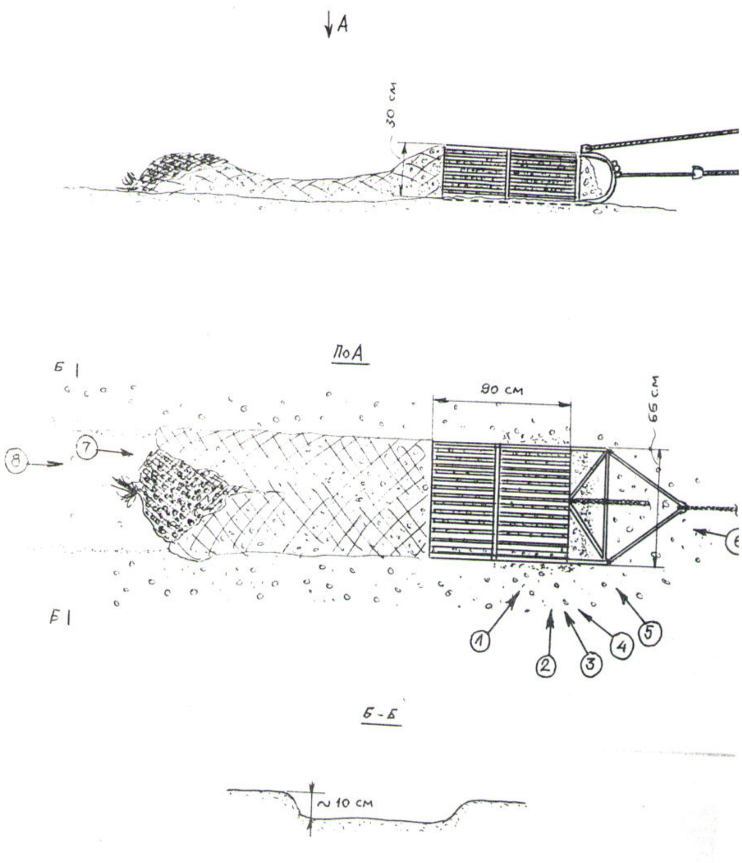


Figure 13 Scheme of the dredge used for baby clam with codend.

V. STOCK ASSESSMENTS OF DEMERSAL FISH SPECIES BY SCIENTIFIC SURVEYS

1. *Method*

Demersal fishes are important commercial fisheries target in the Black Sea since most of them are “local” species and make only limited migrations to and off the coast related to the reproduction and the feeding. Being accessible for fishing almost throughout the year, they represent a valuable resource. Demersal fishes of commercial importance in Bulgaria comprise turbot, flounder, thornback ray, picked dogfish, gobies, etc. Those species were intensively fished since the 1950s when the first studies on their stocks were initiated with special focus on the turbot and its sustainable exploitation. The first studies on turbot stocks off Bulgarian coast were initiated in 1955 with special focus on the turbot sustainable exploitation and application of swept area method. The studies continued till 1992 when ceased and started again in 2006. Since 2006 all demersal surveys in Bulgarian area apply swept area method.

2. *Description*

During the period 1955 – 1992 non-stratified sampling by swept area methods was applied. Since 2006 a standard methodology for stratified random sampling was employed. The method is based on bottom trawling across the seafloor (area swept) and is widely used as a direct method for demersal fish stock assessment when only an index of abundance is required. The seabed area covered during a single haul represents a basic measurement unit. The fields are grouped in larger sectors – so called strata, with geographic and depth boundaries. The studied area is divided into four strata according to depth – Stratum 1 (15 - 35 m), Stratum 2 (35 – 50 m), Stratum 3 (50 – 75 m) and Stratum 4 (75 – 100 m).

According to this method, the trawl sweeps a well defined path, the area of which is the length of the path multiplied by the width of the trawl, called the "swept area" or the "effective path swept". The swept area, a, can be estimated from – equation 1:

(51) $$a = D*hr*X2$$
$$D = V*t$$

where: a - swept area, V - velocity of the trawl over the ground when trawling, X2 is that fraction of the head-rope length hr, which is equal to the width of the path swept by the trawl, the "wing spread", t - is the time spent trawling , D- distance covered.

For the estimation of turbot biomass, the catch per unit of area (CPUA) is used– equation 2:

(52) $$\frac{C_{w/t}}{a/t} = \frac{Cw}{a} kg/km^2$$

where: Cw/t – catch in weight per unit of area, a/t – the area swept per hour.

The biomass of the investigated species for each stratum is obtained from– equation 3:

(53) $$B = \left(\overline{C_{w/a}}\right) * A$$

where: - the mean catch per unit area of all hauls, A – the total size of the area under investigation in stratum.

The total area of survey region, equal to the sum of all strata areas, becomes:

A = A1+A2+A3+A4

The mean catch for the entire survey area is obtained from – equation 4:

(54) $$\overline{Ca}(A) = \frac{Ca1 * A1 + Ca2 * A2 + Ca3 * A3 + Ca * A4}{A}$$

where: Ca1- catch per unit area of stratum 1 and etc., A1 – area of stratum 1 and etc., A – total area of survey region.

The total biomass in the survey area is estimated by - equation (5):

(55) $$B = \overline{Ca}(A) * A$$

where: $\overline{Ca}(A)$ - mean catch for the entire survey area, A – total area of survey region.

3. *Species*

Turbot (*Psetta maxima*)

4. *Ecosystem considerations (type of data collected)*

Physical parameters (temperature, salinity) are observed.

Biological samples from the catch (mainly fish) for the estimation of population parameters by species.

5. *Area (maps, coordinates)*

Study area covers Bulgarian territorial waters and EEZ up to 100 m depth – Fig.1.1.

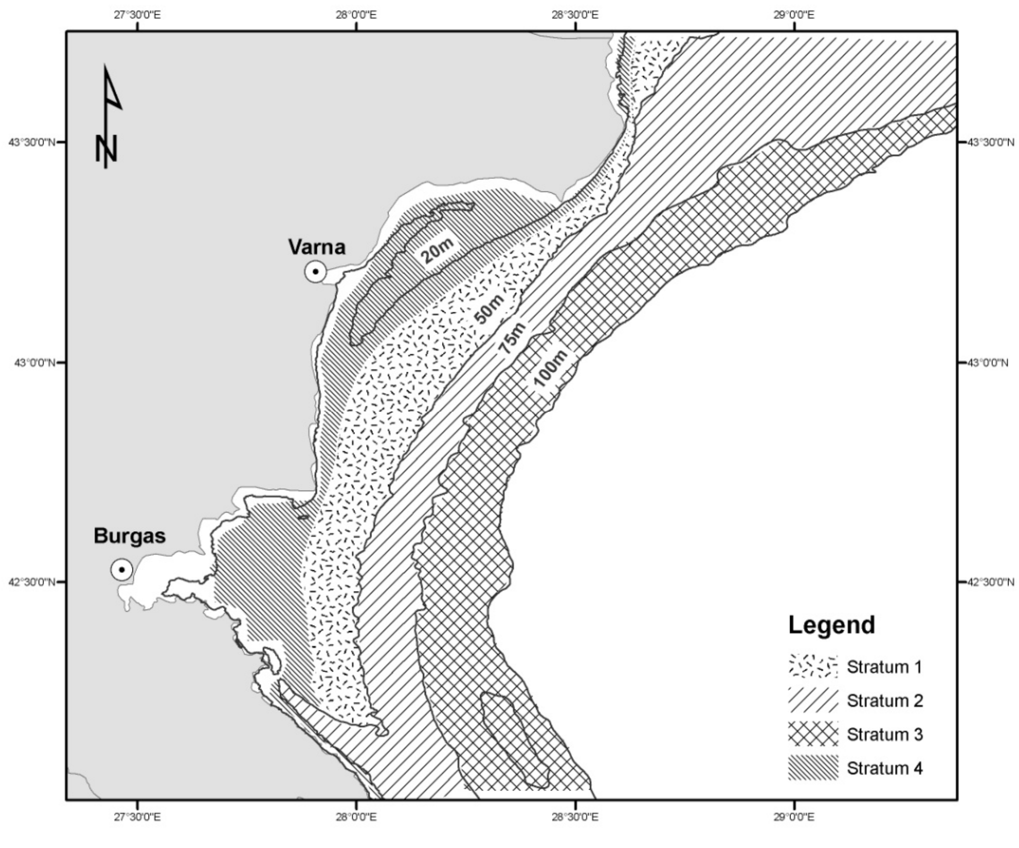


Figure 14 Stratification of sampling area in front of Bulgarian coast. (After Panayotova et.al, 2012).

6. Gear characteristics (including schemes, TTTs)

Different fishing gears were used during the surveys. In the period till 90s – bottom trawl Vineron – Dahl type was used (headrope – 25 m, effective opening – 15 m).

Later, for the surveys during the period 2006 – 2009, bottom trawl had the following dimensions: head rope length – 26 m and effective part of wing spread – 10-12 m.

In the period, 2010 – 2011 bottom trawl type 22/27 – 34 m was used. Length of the head rope – 45 m, vertical spread of trawl – 3 m and effective part of wing spread – 13 m.

7. Mesh size, mm

Mesh size of codend - 10x10cm
Mesh size of codend - 8x8 mm.

8. Justification (for using gears)

It is recommended the same or similar type of bottom trawls and mesh sizes to be used in the surveys for standardization of methodology and compatibility of results at national and regional level.

9. Models/assessment

For the assessment of relative biomass and abundance indices, swept area method was applied and historical results for the period 1955 - 2010 are given on Tabl.1.

Table 3 Estimated relative biomass of turbot in front of the Bulgarian Black Sea coast during the period 2006 – 2010 (Panayotova et al, 2011, 2012).

Period	**Biomass (t)**						
	1955	**1993**	**2006**	**2007**	**2008**	**2009**	**2010**
Spring	850	100	447.38	1778.76	1966.18	1502.04	633.12
Autumn - winter			1441.10	1896.57		1609.84	329.42

10. Gaps in data collection (recommendations to fill)

The surveys are very limited and different vessels and gears are applied.

11. Knowledge gaps

Lack of estimation of catchability coefficients of used fishing gears.

12. Recommendations

Standardization of applied methodology and gears at regional level and elaboration of sampling protocol.

Tagging of fish for clarification of degree of stocks migrations and sharing.

VI. STOCK ASSESSMENTS OF PELAGIC FISH SPECIES BY HYDROACOUSTIC SURVEYS

1. Method

One of the widely acknowledged and efficient methods for assessing of pelagic fish stocks is acoustic method, which cover large areas for relatively short time.

2. Description

Acoustic surveys cover partially territorial waters and EEZ of Bulgaria with area of about 3 150 nm^2. Acoustic data were collected by using of EK 60 system (SIMRAD), operating at 38, 120 and 200 kHz simultaneously with hull-mounted split-beam transducers on the R/V "Akademik", Institute of Oceanology, Varna - Bulgarian Academy of Sciences. The main frequency for the assessment of fish biomass was 38 kHz. GPS data were collected for pairing acoustic density readings with geographic location. Study area was covered by parallel transects perpendicular to bathymetry. Inter-transect distance - 5 nm. Sampling takes place during the day and night with vessel speed of 7.5 – 8.5 knots. Calibrations before and after each survey were carried out. The MEDIAS protocol for acoustic sampling is followed.

The available software packages for data collection and processing are BI 60, ER 60 (Simrad, Norway) and LSSS (MAREC, Norway).

Pelagic trawl, equipped with monitoring system based on SIMRAD ITI sensor is used for direct fishing and estimation of species composition and size frequency distribution. The ITI measures the trawl depth, vertical opening of the trawl mouth and temperature at the trawl depth.

3. Species

The targeted fish species are sprat (*S. sprattus*), whiting (*M. merlangus*), horse mackerel (*T.trachurus*), anchovy (*E.encrasicolus*).

4. Ecosystem considerations (type of data collected)

During the surveys, the following environmental parameters and biological data are collected:

Sea water temperature at different depths

Salinity at different depths.

Dissolved oxygen at different depths

Zooplankton - species composition, abundance and biomass

Food diet by species

Biological samples from the catch (mainly fish) for the estimation of population parameters by species.

5. Area (maps, coordinates)

Survey area covers territorial waters and EEZ of Bulgaria – Fig.2.1.

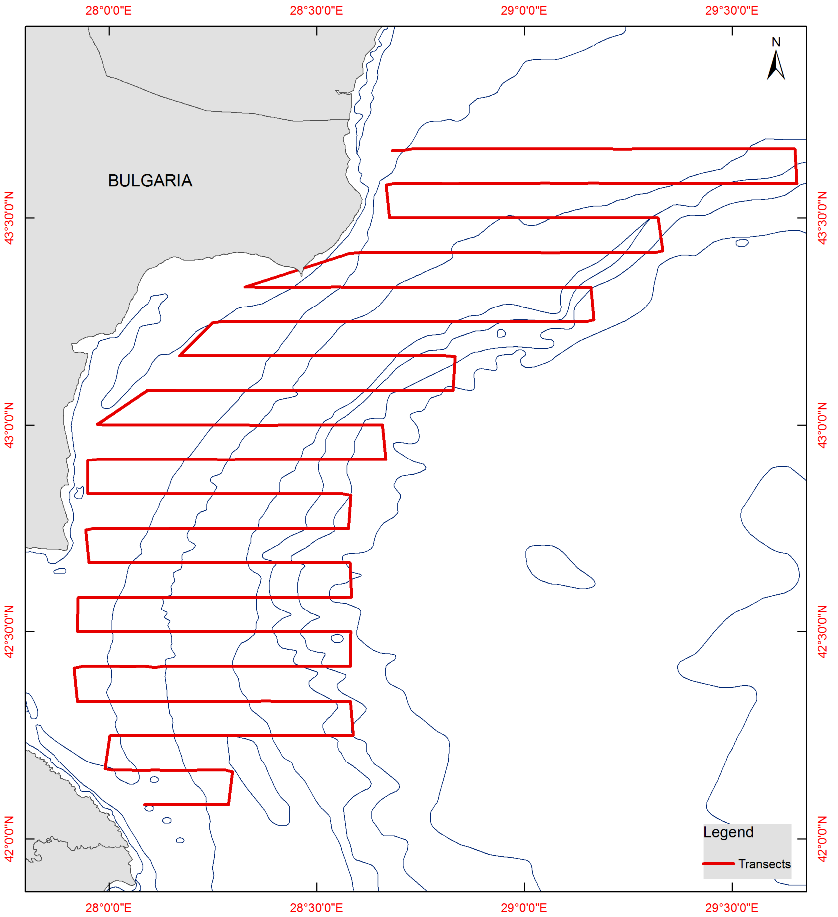


Figure 15 Survey design for acoustic surveys in Bulgarian area.

6. *Gear characteristics (including schemes, TTTs)*

Pelagic trawl with horizontal opening – 25 - 40 m and vertical opening – 10 - 15 m.

7. *Mesh size, mm*

Mesh size of codend - 5x5 mm.

8. *Justification (for using gears)*

Pelagic trawl is required.

9. *Models/assessment*

The acoustic investigations were performed by multi-frequency echosounder (38, 120, and 200 kHz) SIMRAD EK60 configured with split-beam transducers (Simrad ES38B, ES120-7C and ES200-7C, respectively). The transducers are mounted in the vessel keel, at 5 m below the sea surface. The settings of the EK60 are presented in Table.2.1. Operational parameters for the 38 kHz echosounder were a 1ms pulse duration and ping interval – maximum depending on depth. The acoustic data are indexed by time and geographic position using navigational data from a GPS receiver input to the echosounder software (Simrad ER60). The threshold set to - 80 dB for data acquisition and - 70 dB for data processing. Acoustic data were collected with Simrad ER60 software and subsequently analyzed on LSSS software.

Table 4 Simrad EK60 settings used during the pilot hydroacoustic survey in Black Sea, December 2010, R/V "Akademik".

Transceiver menu	38 kHz Hull mounted
Absorption coefficient	4.9 dB/km
Pulse duration	1.024 ms
Bandwidth	2.43 kHz
Max Power	2000 W
Two-way beam angle	-20.6 dB
3 dB Beam width	7.10 □
Log/Navigation Menu	
Speed, position, vessel log	Serial from ship's GPS
Operation Menu	
Ping interval (s)	Máximum depending on depth
Display/Printer Menu	
TVG	20 log R
Integration line	N/A
TS colour min.	-50 dB
Sv colour min.	-80 dB

Post-processing included elimination of data deeper than 0.5 m above the seabed echo and shallower than 10 m below the surface, removal of acoustical and electrical noise, and visual identification of fish aggregations. Volume backscatter (*Sv*) data were integrated and averaged throughout the water column and over 1 nautical mile (nmi) (Elementary Distance Sampling Unit (EDSU) to give Nautical Area Scattering Coefficients (NASC, symbol s_A) values ($m^2.nmi^{-2}$, Simmonds & Maclennan, 2005). NASC values for the entire water column and NASC values attributed to target species are exported.

Species composition and length distribution are determined as weighted mean of all trawl data. From these distributions the mean acoustic cross section is calculated according to the following target strength-length (TS) relationships:

Clupeoids TS = 20 log L (cm) – 71.2 (ICES, 1983)

Gadoids TS = 20 log L (cm) – 67.4 (Foote, 1987)

The total number of fish (total N) is estimated as a product of the mean nautical area scattering coefficient NASC (sA) and the polygon area, divided by the corresponding mean cross section (σ). The total numbers are separated into species according to the mean catch composition.

10. Gaps in data collection (recommendations to fill)

Acoustic surveys in the Bulgarian Black Sea area with split-beam echosounder started in 2010 and there is lack of such kind of surveys for previous years.

11. Knowledge gaps

Lack of regular acoustic surveys in the Black Sea.

12. Recommendations

At regional level, MEDIAS protocol should be followed.

VII. ICHTHYOPLANKTON BASED SURVEYS CARRIED OUT IN BULGARIA

1. Introduction and Background

Due to enhanced demands for fishery independent information which is not related to any commercial catch data the Institute of Fish Resources in Varna, Bulgaria started implementing hydroacoustic (1984) and ichthyoplankton based surveys (1989) for fish stock assessment.

The stock biomass assessment of small pelagics such as anchovy and horse mackerel is undoubtedly embarrassed in the western and northwestern part of the Black Sea as these species migrate there in spring for feeding and spawning and in autumn on their way back to their wintering grounds, being this way highly movable; in summer during the spawning season they are strongly dispersed occupying rather broad area as demonstrated by fish surveillance and hydroacoustic surveys. For these reasons and also because the catches in this area are negligible compared to the southeastern part where the populations of these fish species form in November-March dense wintering concentrations suitable for intensive commercial fishing, fishery independent method based on ichthyoplankton surveys were considered as most appropriate for carrying out spawning stock biomass estimates (Mikhailov et al., unpubl. data). Joint surveys were organised during the period 1989-1991 in the Bulgarian Black Sea area.

These first daily egg production based investigations in the Black Sea attained the magnitude of large-scale ones covering practically its entire northwestern part that is the preferred spawning ground of the major summer-spawning fishes and were initiated by Russian (VNIRO, Moscow) and Ukrainian (YugNIRO, Kerch) scientists in 1987 in the northwestern part of the basin involving later (1989) Bulgarian and then (1991) Romanian scientists.

2. Method

Various methods for assessing the spawning stock biomass stock (SSB) of fish by ichtyoplankton surveys have been developed and are currently available. The basic idea is that the biomass of a fish stock can be estimated from the abundance of its spawn and is first proposed by Hensen and Apstein (1897).

Choice of the appropriate ichthyoplankton-based method for biomass estimation is dependent upon many factors including the spawning habits of the spawners, whether annual fecundity is determinate or indeterminate, and the level of precision desired, costs, and availability of other information. Estimates of egg or larva production are imprecise in some cases because the number of samples required for a precise estimate is too expensive to collect.

The Daily Egg Production Method (DEPM), also called the Egg Production Method, is an ichthyoplankton-based method for estimating the SSB of pelagic schooling fish. It is applicable to batch-spawning species with indeterminate annual fecundity, and was developed in the late 1970s at the Coastal Division of the Southwest Fisheries Science Center, La Jolla, California under the guidance of Reuben Lasker (Parker, 1980; Lasker, 1985). This method has been applied to anchovy, sardine, sprat, mackerel, and horse mackerel in 16 locations around the world since 1980 (Stratoudakis et al. 2006). The application was extended to demersal species, like snapper in New Zealand (Zeldis and Francis, 1998) and hake off Spain (Murua et al. 2009).

Besides biomass estimation, application of the DEPM provides regional time-series on important biological parameters of fish stocks, which may lead to better understanding of their reproductive biology, particularly when such parameters can be compared among species and stocks, or habitats and seasons (Alheit, 1993; Somarakis, 2004).

3. *Description*

The DEPM combines an estimate of the daily population fecundity with an estimate of the daily egg production to estimate stock size. The model for the DEPM was developed by Parker (1980, 1985):

$$(56) \quad Bs = K \cdot A(Po \cdot We)/(R \cdot FS)$$

where Bs = spawning biomass in metric tons, Po = daily egg production estimated as number of eggs per sampling unit, *We* = average weight of mature females in population (g), R = sex ratio, proportion of females in population, by weight, F = batch fecundity, average number of eggs per female released per spawning event, S = spawning fraction, fraction of females spawning per day, A = survey area (in sampling units), and k = conversion factor from grams to metric tons.

The DEPM is based on the studies of Hunter and Goldberg (1980) who introduced new methods for determining batch fecundity and spawning fraction. These two parameters have to be determined when estimating the stock size of multiple spawning fish with indeterminate fecundity, i.e., fish that continuously mature unyolked oocytes and spawn them within a single spawning season. In these species, annual fecundity is not determined before the onset of the spawning season (Hunter and Macewicz, 1985; Hunter et al., 1985).

Not long ago, batch (multiple, serial) spawning was considered by many as exceptional behaviour, but now it appears to be the prevalent way of spawning, at least in tropical and temperate fishes.

Traditional methods for estimating the annual (absolute individual fecundity) of fish was to define the number of oocytes in the ovary in stage trophoplasmic growth (synthesis and accumulation of yolky substance) before the onset of the spawning season (Chugunova, Petrova, 1953; Macer, 1974; Alekseeva, Alexeev, 1983; Mikhailov, 1993). The number of batches released during the spawning was determined by the number of stages of development seen on histological slides (Naumov, 1968; MacGregor, 1976; Le Clus, 1979).

Such approach would be correct if all the eggs to be released in a season develop synchronously prior to spawning and could be identified if a distinct hiatus in oocyte maturity classes exists between the small, immature unyolked oocytes and the synchronously maturing annual batch (Hickling and Rutenberg 1936; Yamamoto 1956). In this case differentiation of oocytes by size and state has taken place before the season from the reserve (protoplasmic) oocytes, that are imminent to be spawned in the next years. i.e. in fish with determinate fecundity.

In particular, all total (isochronal) and some multiple spawners are characterized by such fecundity. Under the classification of Gotting (1961) and Oven (1976) they belong to fish with intermittent oocyte maturation.

In many temperate and tropical fishes (called multiple, serial, heterochronal), annual fecundity is seasonally indeterminate and batch fecundity is the only useful measurement (Hunter, et. al. 1985). This means that in their active ovaries the oocytes usually occur in almost all maturity stages - from small unyolked oocytes, d<0.1 mm to yolked oocytes, d=0.4-07 mm, and no distinct hiatus exists between maturity classes except for one between hydrated oocytes and advanced yolked oocytes. Such fishes spawn many times during a season and the new batches are recruited by the small unyolked oocytes permanently maturing during the same season. As a result there could be released not only the trophoplasmic but also those developed from the protoplasmic oocytes. According to the above classification fish with such characteristics of gonad maturation belong to fish with continuous oocyte maturation.

In sum, the annul fecundity or egg production rate can be determined by the estimates of batch fecundity and spawning frequency carried out in a definite period during the ichthyoplankton survey.

Batch Fecundity. Batch fecundity, the number of eggs released by a female during a single spawning event, is best and most precisely determined by counting all those oocytes that are hydrated shortly before spawning (Hunter et al., 1985). The Hydrated Oocyte Method yields much better results than traditional methods and saves time because oocyte diameter does not need to be determined. A disadvantage is the restricted times of the day when they could be found (Lissovenko et.al, 1988; Andrianov et al., 1996; Mikhailov et al., 2000) or the large number of fish sometimes needed to find females in the hydrated state, since they are patchily distributed over the spawning area (Alheit et al., 1984). For the Black Sea anchovy, Engraulis encrasicolus, L. this period is between 2000 and 23000 hours. In addition, only those females with hydrated oocytes can be used for fecundity estimates where hydration has proceeded sufficiently and where ovulation has not begun. When comparing batch fecundity of females of different sizes or species, relative batch fecundity (batch fecundity standardized for ovary-free female weight) is a more meaningful parameter**.** The trends emerging from these comparisons are that species with larger body sizes produce fewer eggs per gram of body weight than species of smaller size. Relative batch fecundity of clupeoid fish studied so far varies considerably within seasons and between years (Alheit, 1989). The conclusion to be drawn from accumulated information on batch fecundity is that, when applying the DEPM, batch fecundity has to be determined separately for each DEPM survey. Using values of batch fecundity from other years or different phases of the spawning season could give rise to considerable errors in the biomass estimate.

Spawning Frequency. The spawning frequency represents reciprocal quantity of the fraction of mature females spawning per day**.** The higher its relative magnitude is the more often i.e. in less time intervals each average female spawns. Thus, if 16% (spawning fraction) of the female population spawn daily, as it is the case with the northern anchovy, Engraulis mordax, then the average female spawns every 6-7 (6.23) (spawning frequency) days. If 100% of the females spawn (i.e. the whole mature female population) each female would lay eggs every day. It is evident that knowing the daily spawning fraction we could define the length of the mean period between two successive spawnings. Using this interval, and also the duration of the whole season, we are able to define the number of batches spawned by an average female per year. Ultimately, proceeding from them as well as the batch fecundity the total annual fecundity could be easily estimated.

In their pioneering studies Hunter and Goldberg (1980) and Hunter and Masewicz (1980) developed an elegant histological approach to determine spawning frequency by recording the percentage of females with post-ovulatory follicles of age (stage) 1 day (up to

24 h after spawning). Post-ovulatory follicles are the empty follicles known for a long time ago to remain after ovulation (Cuningham, 1898 by Hunter and Goldberg, 1980). It's interesting to note that Japanese scientists as far back as the 1970s have come to the idea to use this remnant structures for defining the spawning frequency. However the needed methodology could not be developed as it was done in the late 1970. Later on Alheit (1984) upgraded further the method extending the period of sampling during both day and night (not only night) and used also the post-ovulatory follicles at age 2 days (from 24 h to 48 prior to spawning. The advantage of these methods is that the changes in the empty follicles could be recorded in any time of the day.

Investigations in the Black Sea (Adrianov et. al, 1996; Mikhailov et al., 2000) demonstrated that the approach to determine the spawning fraction from the percentage of females with post-ovulatory follicles can be applied to the Black Sea anchovy, although under the environmental conditions in the Black Sea the resorption of postovulatory follicles is faster than in Californian Bight. Therefore, it have to be noted that the rate of metabolic processes and respectively the degeneration of post-ovulatory follicles and resorption of yolky oocytes are temperature dependent and differ for different climate zones. The second factor that may affect the rate of oocyte resorption is the physiological state of the fish itself. Fish species such as Black Sea anchovy, that spawn almost every day, must have higher rate of resorption compared to fish not so active and not spawning on a daily basis. This is the reason why it is considered reasonable to determine the spawning fraction only by the number of the females with hydrated oocytes.

In particular the recorded synchrony in the transition of the processes of maturation and hydration, ovulation and spawning of eggs in all females allows us to estimate the spawning fraction by the relative number of fish with hydrated oocytes caught in the time 1400-2000 h. Put in another way, as the above processes in most fishes last few hours it gives surety that fish with hydrated eggs will spawn within the current day.

The research done made possible to identify specific spawning characteristics of the Black Sea anchovy. It is evident that anchovy spawns in the dark time of the day between 2000-2300 h. In all females expected to spawn in the night synchronous cyclic changes in the ovaries occur during the previous day: from 2300 to 0500 h - period of rest when no changes are recorded in the ovaries; since 0500 h maturation of the new egg batch commences that is destined to be shed in the forthcoming night. At 1000-1100 h the hydration of oocytes starts, at 1400 h the formation of the successive egg batch ends and at 2000 h the spawning begins.

The batch of hydrated oocytes in the ovaries can be easily distinguished on fresh/fixed material between 1400-2000 h. During this period the fraction of daily spawning females and the batch fecundity, as well can be determined. From 2300 to 0500 h the spawning fraction could be defined also by the occurrence of distinct 1 day post-ovulatory follicles. The last have remained after the spawning in the last night and have undergone considerable degradation.

The "method of hydrated oocytes" is applied successfully by many authors (De Martini, Fountain, 1981; Lissovenko, Prutko, 1986, 1987; Clarke, 1987; Shaefer, 1987; Arkhipov et al, 1991; Mikhailov et all, unpubl. data) for different fish species. However, caution should be taken as number of studies clearly demonstrated that females with hydrated oocytes are usually oversampled by purse seine and trawls (Alheit et aI., 1984).

When determining spawning fraction of multiple spawning fish for estimating the biomass using the DEPM, as for batch fecundity, samples must be collected during the egg survey to avoid a bias introduced by applying data from other years or other phases of the spawning season.

4. Species

Anchovy, horse mackerel and red mullet (SSB only for the first two species).

5. Ecosystem considerations (type of data collected)

Data collected throughout the ichthyoplankton surveys: oceanographic, hydrobiological; ichthyoplankton samplings: ichthyoplankton developmental stages and abundance, egg production; young fish samplings: total length, total body weight, body gutted weight, gonad weight, stomach fullness, fattiness of internal organs, adult fish samplings - the same parameters as for young fish along with ageing, sex, maturity stages, batch fecundity estimates.

6. Area (maps, coordinates)

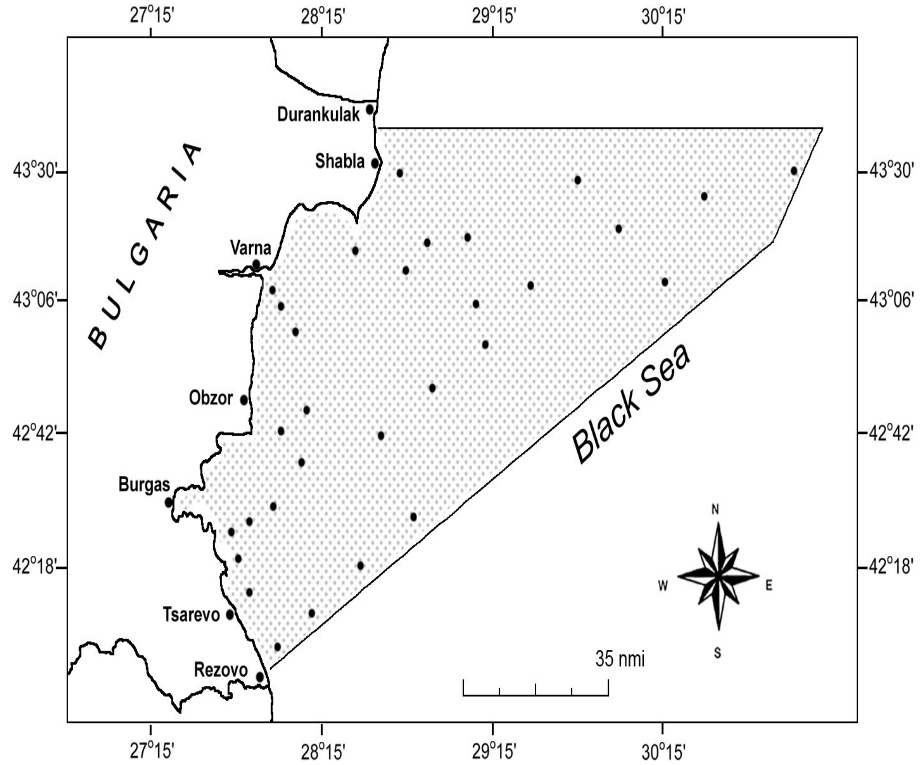
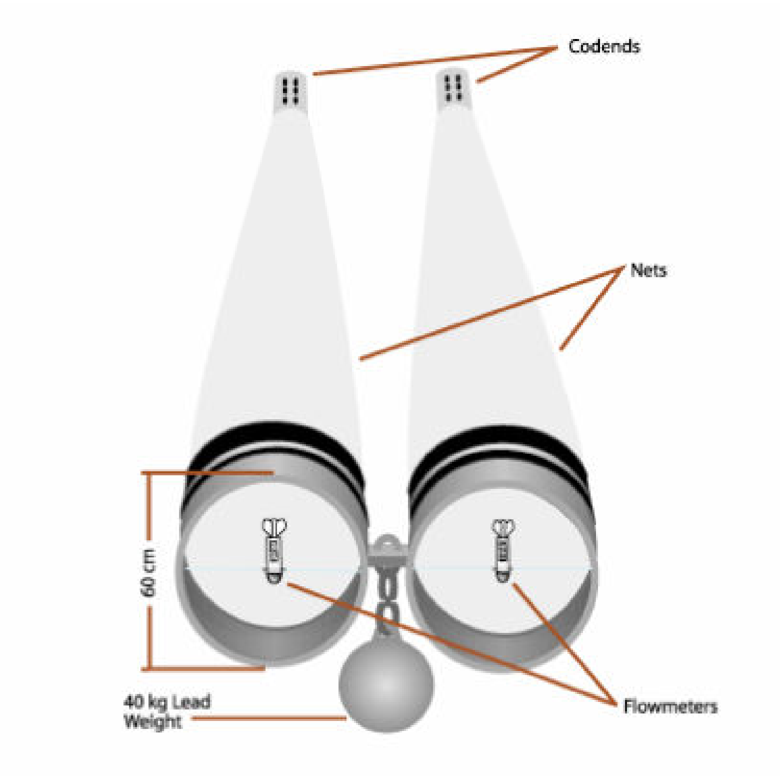


Figure 16 Schematic of ichthyoplankton surveys in the Bulgarian Black Sea area showing the location of stations sampled in 1989-1991 using Bongo net.

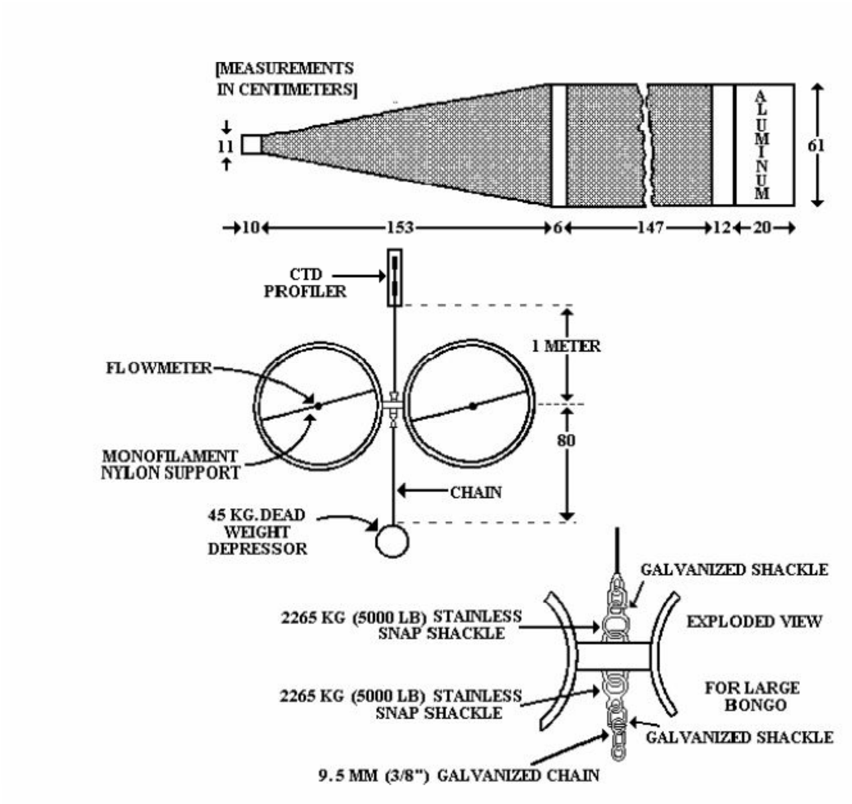
The area of the ichthyoplankton surveys comprised the territorial waters and economic zone of the Bulgarian Black Sea between the northern and southern borders. It was defined approximately by the coordinates: Lat N/Long E: 43°40'N/28°36'E; 43°40'N /30°55'E; 43°16'N/30°52'E; 42°4'N/28°4'E. They were carried out in the period 1989-1991 (July-August) during the peak of fish summer spawning.

7. Gear characteristics (including schemes, TTTs)

Bongo net tows for ichthyoplankton sampling. The Bongo sampler consists of an aluminum frame with two cylinders each with a suspended flowmeter in the opening (Fig. 17 A, B). The towing wire passes between the cylinders so that it is not in the sampling path. The attached nets are of a cylinder-cone configuration, 3.5 m long, with a 61 cm diameter mouth opening. A 40-45-kg dead weight provides a consistent depressing force for tow standardization.



A.



B.

Figure 17 Bongo Net (after NOAA Fisheries Protocols for Ichthyoplankton Surveys, 2003). The flowmeter is mounted in the center of the mouth openings; a detachable lead 40-45 kg weight is shackled to the center pivot on the frame (A). Diagram of the Bongo sampler with corresponding sizes (B).

Ichthyoplankton hauls are taken obliquely from the depth of 25 m to the surface and at a constant ship speed (2.5 kts), wire angle and retrieval rate. The plankton samples are fixed immediately in 5 % buffered Formalin. In the laboratory they are further processed, fish eggs and larvae sorted and identified to species level as well as their stage of development. The ichthyoplankton data are then summarized to standardize the number of eggs and larvae in each plankton haul to the number under 1 m^2 of sea surface. The egg production is estimated by the swept area method.

Based on data for catches per unit area data, the entire survey area is divided into sections (strata) with close values of catches. Then the average catch under m^2 for each stratum is defined and basing on its area the total egg abundance in it is estimated. Finally, the abundance in all strata is summarized.

Young fish trawl hauls for sampling post-larvae and juveniles of summer-spawning fish. During each tow of 23-meter midwater trawl with mesh size of the codend 6.5 mm sampling is done in the surface 0-10 m layer and ship speed of 5 kts. Out of the total catch of young fishes a random sample is taken and immediately fixed in 10% neutralized formalin. The sample handling is worked in the laboratory. Considering that the quantities of larger juveniles in the length range 7.5 - 10 cm (TL) is not significant, from the rest catch the largest fish are selected which are processed while fresh still on board.

Midwater trawl hauls for adults. Usually 8-10 half-hour or one-hour trawl hauls by 27-meter midwater trawl are conducted in the upper 25-meter layer (above thermocline) with intervals of 3 hours. At each station from each positive haul 100 specimens are randomly taken and fixed in 10% neutralized formalin. The fish are processed further in the laboratory. The measurements include the total and standard length, total and gutted weight, the fish are sexed and maturity staged defined macroscopically, the gonad weight is measured, degree stomach fullness and fattiness of the internal organs are determined as well. Batch fecundity of selected females is defined and histological slides of ovaries prepared. In cases of larger catches samples of anchovy and horse mackerel are processed while fresh on board of the vessel.

8. Mesh size

The mesh aperture of the nets of the Bongo sampler is 0.333 mm. The mesh size of the young fish trawl and midwater trawl codends is 6.5 mm.

9. Justification (for using gears)

Bongo net tows for ichthyoplankton sampling are carried out to obtain estimates of egg and larvae abundance in the surface layer (0-25 m). Trawl hauls provide data for adult fish biology and reproductive parameters needed for SSB estimate.

10. Models/assessment

The SSB of anchovy and horse mackerel in the Bulgarian Black Sea area was estimated for the period 1989-1991.

Table 5 The stock assessment of SSB of anchovy and horse mackerel by DEPM method.

Year, season	Species	SSB in tons, method
1989, early July-mid August	1) anchovy, 2) horse mackerel, 3) red mullet	1) 3 180 (DEPM); 9 110 (Sette and Ahlstrom method) 2) 6 850 (Sette and Ahlstrom method)
1990, mid July-mid/late August	1) anchovy, 2) horse mackerel, 3) red mullet	1) 6 000 (DEPM); 10 000 (Sette and Ahlstrom method) 2) 840 (Sette and Ahlstrom method)
1991, early July-late August	1) anchovy, 2) horse mackerel, 3) red mullet	1) 7 100 (DEPM); 13 100 (Sette and Ahlstrom method) 2) 430 (Sette and Ahlstrom method)

11. Gaps in data collection

When the quantity of eggs at different stages of development in the area of survey is defined we can further calculate the number of eggs spawned in this area on a daily basis. It is therefore necessary to know the share of eggs that survive to each stage of embryogenesis as well as the total duration of embryonic development (from egg spawning to larvae hatching). Due to lack of data for egg mortality rates literature data were used. That is a significant gap in input data when assessing the daily egg production all the more that its coefficient of variation is usually much higher than those for the other DEPM parameters. Besides, egg mortality rates are known to display considerable interannual variations that is documented for a number of fish species such as anchovies, sardines, etc. This means that this parameter has definite effect on the final biomass estimate and its unreliable evaluation could give rise to considerable errors in the SSB assessment.

After this short period of ichthyoplankton surveys off the Bulgarian coast (1989-1991) the application of DEPM terminated due to lack of every financial support. In this way the approach that we consider as most appropriate for biomass estimate of small pelagics and yielding time series on many biological variables of fish stocks is not available for a long time and at present.

12. Knowledge gaps

Although recent refinements are used aiming to increase the precision of biomass estimates from the daily egg production method it is unlikely that it will become a very precise method. Nevertheless, methodological developments are bringing about substantial decrease of the coefficients of variation of egg abundance.

Knowledge of survey design adapted to local population dynamics is required to optimize DEPM performance in terms of precision and cost. However, in some cases adequate delimitation of the spawning area cannot be entirely based on prior knowledge, requiring some adaptive decisions during the ichthyoplankton survey.

13. Recommendations

Based on past experience gained it is recommended that ichthyoplankton based surveys are resumed, conducted regularly and cover the entire northwestern part of the Black Sea (waters of Russia, Ukraine, Romania and Bulgaria) as to encompass practically the whole spawning area of summer-spawning fishes.

It is recommended to carry out DEPM surveys at peak of spawning season in July-August for summer-spawning fishes.

Determination of egg mortality rates should be done simultaneously with ichtyoplankton and adult fish sampling as egg mortality rates are quite variable among years and between life stage. Concomitant oceanographic and hydrobiological research should be done to define the environmental impact on the biological parameters inherent for particular ichthyoplankton survey.

The DEPM can be applied successfully along with hydro-acoustic biomass estimates, whereby the two methods provide largely independent estimates of stock size (Armstrong et aI., 1988; Shelton et aI., 1993). Using the hydro-acoustic and daily egg production estimates of population size together would allow greater accuracy, i.e. the resulting coefficients of variation are substantially more precise, than would be possible using only one of the estimates. Besides, it would allow to test the consistency of both approaches.

VIII. SUMMARY OF METHODS USED FOR ASSESSING FISHERIES STOCKS IN THE ROMANIAN BLACK SEA AREA BY SCIENTIFIC SURVEYS

Exchange of good practices in the fields of methods and tools to assess the present state of fish stocks by scientific surveys, holistic models

Aim and purpose of this group of activities is:

- collate information on methods currently used for assessing fisheries stocks in the Black Sea by scientific surveys, comparing them with holistic methods used in other regions and for different aquatic systems, where possible filling gaps, providing improvements and developing a set of best-practice guidelines for stock assessment using adequate tools for assessing the condition of stocks in the Black Sea.
- to prepare a comprehensive summary of methods used for assessing fisheries stocks in the Black Sea: description of the contemporary and historical techniques/methods used to assess and model stocks in this region; description of the types of data and information collected and used in the analysis for all these methods; description of the knowledge gaps in the current method of Black Sea stock assessment and the barriers to obtaining data; recommendations for the most practical and appropriate method for regular multi-species, stocks assessment in the Black Sea with suggestions on how to fill knowledge / data / information gaps in the future.
- establish the most reliable methods for stock assessment;
- data and necessary equipments;
- methods for data collection;
- establish of research surveys and the periodicity of meetings for common assessment of stocks;

1. Introduction

Fisheries Resources Management is integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and accomplishment of other fisheries objectives (FAO,1997).

The collection of data and information is not an end in itself but is essential for informed decision-making. It is therefore important for the management authority to ensure that the data collected are analysed correctly, disseminated to where they can best be used, and used appropriately in decision-making. Information is also needed to assure the public at large that resources are managed responsibly and that the objectives are being reached. Approaches to collecting data for fisheries management vary substantially, depending on, for example, the nature of the fishery, the staff and facilities available, and the social and economic importance of the fishery. Whatever methods are used, the quantity and quality of the data collected will have a direct influence on the quality of the management which can be exercised, and so the most effective use must be made of personnel and facilities available for data collection.

It must be recognized that data and information are required at the three levels, policy formulation, formulation of management plans, and the determination of management actions to implement the policy and plans. These will overlap considerably and each of the three steps will be influenced by what has happened or is happening at the other two levels. Nevertheless, the three processes are distinct, occur on different time scales and require different information to different levels of detail. Where necessary, differences in methods and approaches between, e.g., artisanal and commercial fisheries and at different time scales need to be emphasised.

In general, as the locality and scope of decisions moves from management implementation to management planning to policy formulation, the degree of synthesis and aggregation of information required will increase. At the level of management implementation, details on the current biomass and the age structure and distribution of a stock may be extremely important. However, at the other end of the spectrum, the policy-makers may need to focus mainly on the options for potential annual yield, provided by technical experts, the fisheries' national socio-economic role and their interactions with other macro-economic or macro-policy considerations. Many stocks, and possibly most marine stocks, are not found exclusively within the areas of national jurisdiction of a single State but are distributed across international boundaries. These stocks must be managed as units or the management actions will almost certainly fail to achieve the desired objectives. Where this requires cooperation between management authorities of different countries, provinces or local agencies, the task of cooperative management is made much easier and more effective if the different partners in the cooperative management all collect data according to common definitions, classifications and methodologies and in a pre-agreed, standardized format, enabling all data to be combined and compared as required. Collection of data in a standardized manner will require that the cooperating partners meet periodically to agree on the data requirements, the methods to collect the data, the amount of data to be collected and to review the sample design within each independent jurisdiction. In addition, joint training of staff involved in data collection will almost certainly be advantageous.

The collection, collation and dissemination of data should be carried out in the most cost-effective manner possible so as to minimize costs while acquiring the required information. Collection and analysis systems should be based on appropriate statistical designs to ensure that sufficient but only necessary data are collected.

Duplication in data collection and analysis should be avoided unless deliberately intended for validation purposes or for other reasons related to maintaining quality.

Unnecessary duplication is most likely to occur where there are straddling or shared stocks with multiple authorities having common.

In some cases, the value of the fishery to the users or society may not be sufficient to justify the costs of a proposed monitoring, control and surveillance system and cheaper alternatives may need to be developed. Only approaches which are feasible with the personnel and facilities available to an agency should be considered. Implementing a management plan which cannot be enforced will damage the credibility of an authority, with repercussions possibly spreading to other fisheries.

The spatial distribution of living aquatic resources is dynamic, changing seasonally and sometimes markedly from year to year. Changes in distribution can cause changes in catchability by the fishery or by survey gear. These could be interpreted as changes in abundance, leading to incorrect decisions on management action being taken. Therefore, CPUE data should not be used alone without some additional information on geographic distribution and trends in stock distribution. The best approaches to this are not well defined, but a relatively simple approach that can be taken to incorporating geographic trends is to stratify the area or areas in which a stock is fished into sub-areas, and to analyse each sub-area separately. This will enable evaluation of the CPUE, or survey index, in a variety of localities and thus increase the probability of picking up changes in CPUE in parts of the range brought about by changes in distribution.

As with data for the development of a management plan, if the value of the fishery can justify it, a valid fisheries-independent estimate of stock abundance provides extremely useful supplementary information. For fisheries which are highly dependent on recruiting age-classes (such as most short-lived species), a survey directed on pre-recruits may be most useful. Surveys should use standard fishing techniques which must remain constant, or be calibrated to each other, for valid estimates of trends or changes in stock abundance to be made from one survey to the next. Experience has shown that it is frequently difficult to avoid changes in fishing technique, and care must be taken in interpreting data where this is suspected to have occurred.

The characteristics and behaviour of the fleet should be monitored to facilitate correct interpretation of CPUE trends. Any changes in fishing grounds, seasonal distribution of effort, gear type or other factors which could influence efficiency of the fishery need to be considered in interpretation of the catch and effort data.

2. Holistic models

In situations where data are limited, for example, when starting up the exploitation of an hitherto unexploited resource, or in cases of limited capability of sampling, one may not have input data of the quality and in the quantity required for an analytical model. One solution would be to start up the collection of the data types required for the analytical approach and then wait until a sufficient amount is available. This approach is, of course, recommendable, because it solves the problem in the long run, but that may take years, while often advice on an exploitation or development strategy may be needed now. The approach taken in this manual is that no matter which type of data you have, there is always some information to be extracted from it, and that advice based on an analysis of a limited data set is usually better than complete guesswork.

In order to cover such data-limited situations, some simple holistic, less data demanding methods have been included in the manual. These methods disregard many of the details of the analytical models. They do not use age or length structures in the description of the stocks, but consider a stock as a homogeneous biomass.

Two types of simple methods are presented, namely the "swept area method" and the "surplus production model" (FAO,1992 -FTP 306/1).

3. *Swept area method*

The stock assessment by scientific surveys is required at all stages of the development of a fishery, but the need for accuracy and precision is different. A practical advantage of survey-based assessments is that advice can be provided quickly after the completion of surveys, thus solving the timeliness issue which frustrates managers. More generally, they can be used alongside existing methods of fish stock assessment, to cross-check the results and/or to bring in more biological knowledge and make conclusions more robust.

The swept area method is based on research trawl survey catches per unit of area. From the densities of fish observed (the weight of the fish caught in the area swept by the trawl) we obtain an estimate of the biomass in the sea from which an estimate of the MSY is obtained. This method is rather imprecise and it predicts only the order of magnitude of MSY.

4. *Demersal trawl surveys*

Bottom trawl surveys are widely used for monitoring demersal stocks when only an index of abundance is required. From unfished stocks (or stocks for which no or few data on the fishery are available) biomass and annual yield estimates may also be derived by bottom trawl surveys. The estimation of total biomass from the catch per unit of effort (or unit area), however, involves several crucial assumptions, leaving such estimates rather imprecise.

The mean catch (either in weight or in numbers) per unit of effort or per unit of area is an index of the stock abundance (i.e. assumed to be proportional to the abundance). This index may be converted into an absolute measure of biomass using the so-called *"swept area method"*. This method falls under the so-called holistic methods.

Reviews of the theory are given in, for example, Gulland (1975), Saville (1977), Troadec (1980), Doubleday (1980) and Grosslein and Laurec (1982). These reviews also give guidelines for conduct of surveys (planning, design, data collection, data recording, analysis and reporting), see also Butler *et al.* (1986), ICOD (1991) and Stromme (1992).

This Chapter gives first a short description of demersal trawl survey planning and a few guidelines for data recording and for field work. For more detailed descriptions of these subjects the reader is referred to, among others, Alverson and Pereyra (1969), Alverson (1971), Mackett (1973), FAO/UNDP (1975), Gulland (1975), Saville (1977), Flowers (1978), Doubleday (1981), Grosslein and Laurec (1982) and Fogarty (1985). The last part of the Chapter is a short account of the theory necessary to perform a stock assessment based on trawl survey data.

5. *Planning a demersal trawl survey*

Below is a list of some important items to consider before conducting a survey.

6. *Definition of objectives*

The objective(s) should be specified. Examples of objectives are:

- Estimation of the total biomass and catch rates;
- Estimation of the biomass of selected species;
- Collection of biological data (e.g. length-frequencies) for estimation of growth and mortality parameters;
- Collection of environmental data.

7. Information about the survey area

Information about depth and bottom conditions to point out trawlable areas and decisions on strata may be obtained from a preliminary survey with echo- sounding. Information from local fishermen may be valuable. Information on seasonal winds, currents and migration patterns of fish stocks are important as well.

8. Choice of gear

The design of the trawl should fit with the expected bottom conditions and the vessel used. If rough bottom is prevalent the gear should be fitted with bobbins in order to avoid damage to the gear. If semi-pelagic species are common a high-opening trawl should be used. The mesh size in the codend should be chosen so that the entire size range of the fishable part of the stock is retained by the trawl. Often 10-20 mm stretched mesh is appropriate. The mesh size used for assessment surveys is usually much smaller than the size used by the commercial fisheries, because samples of small fish are important for assessment methods based on length-frequencies.

If different trawls are used parallel or alternate hauls should be carried out in order to estimate correction factors for pooling of data.

9. Survey design

A procedure for the selection of stations should be decided on. A fixed grid of stations ensures maximum information on the distribution throughout the area, but not necessarily the most precise estimate of biomass. For estimation of stock sizes a completely randomized design or a stratified random sampling design should be preferred. In most cases a stratified sampling design should be chosen because fish are seldom uniformly distributed and in most cases abundance is related to depth. Stratified sampling often gives a much more precise estimate for the same (or even lower) cost than simple random sampling.

The optimum allocation of a given number of hauls between strata will be to sample each stratum in proportion to its standard deviation multiplied by the stratum size. The distribution of hauls within strata should preferably be at random, but often practical matters dictate the sample design. For example, obstacles on the bottom may not allow a proper random distribution of stations.

10. Possible number of hauls

To estimate how many hauls it is possible to make in a given period the following information should be available:

Total number of days available .... N
Time spent going to and from the fishing ground (hrs) t1
Duration of one haul (hrs) t2
Time used for shooting and hauling the trawl (hrs) t3
Time to cover distance between stations (average, hrs) t4
Number of hours available per day (depending on crew,
behaviour of investigated species, navigation, etc.) .... T
Time used for preparations: loading of ice, food, water,
repair of gear and equipment (days) t5

Except for the first and the last day of a cruise, when T should be reduced by t1, the number of hauls per day can be calculated from:

(number of hauls per day) = T/(t2+t3+t4)

(Total number of hauls) = (N-t1-t5)*(number of hauls per day)
+ (hauls made first and last day)

It is important to standardize the length of a haul throughout the survey, since the catchability of species and sizes often depends on the duration of the haul. For survey purposes hauls of 0.5 hour or 1 hour are usually the most adequate.

11. Data recording

When setting up a plan for a trawl survey a crucial point is to decide on the data items to be recorded, the required precision and how often they should be recorded.

The data items to be recorded are determined by the models by which the objectives of the survey can be achieved, e.g. the swept area method, length-frequency analysis, mortality estimation. Such data items would usually include specifications of the gear used, and for each haul the time and position at start and at end of the haul, wire length, wingspread, bottom type and depth. The catch record should include total weight, species composition by weight and length-frequencies (for selected species).

The required precision depends on the subsequent use of the data. However, often the precision of a trawl survey is controlled by the number of hauls, which limits our ability to decide on the precision.

It must be known how the data are going to be processed before data recording takes place, particularly in cases where data reduction takes place before the recording stage. Consequently, before you can design appropriate log sheets you must have a rather precise idea of how data will subsequently be processed. When designing a log sheet, practical considerations are important, e.g. where the data are entered. It is important that the data are well organized to facilitate processing, e.g. by computer. This is especially the case when data from more than one vessel have to be combined. Properly designed recording documents will make the correct recording much easier and more dependable. Several documents are usually required to record all the information collected during a survey. These are in the following categories:

- A log which summarizes the whole cruise.
- Details of individual stations (or hauls), the *"fishing log",* which will generally provide information on the vessel's position, time of start and end of haul, gear rigging etc. Summary information on the catch such as total weight and weight composition by species should also be recorded on the fishing log.
- Detailed information on the catch. This may be in terms of length, weight, sex, maturity stage etc. for each specimen, or samples of length-frequency distributions.

A detailed description of a data processing system for demersal trawl surveys is given in Flowers (1978) who reproduces forms suitable for the work.

12. Deck sampling and catch recording procedures

It is important, before the survey begins, to make sure that the equipment and working conditions are such that the sampling can be carried out easily and without risk. Also, the crew must be instructed not to remove any part of the catch before the sampling has been completed.

The following steps pertain to methods for sorting the catch of a fishery research vessel such that the catch composition, both by weight and by number of each species (species group) can be established. The procedure outlined here is from Pauly (1980, adapted from Losse and Dwiponggo, 1977).

Step 1: Remove all dangerous species. Also remove sturgeons, turtles, and if alive, return these to sea. Record number and kind of animals removed.

Step 2: Remove inorganic debris and plant material. Record type of material removed.

Step 3: Remove the larger fish that are readily visible and place them in a box.

Step 4: Wash the remainder of the catch (of small fish) if necessary, and mix with shovels.

Step 5:Put the mixed catch in boxes, while continuing to remove larger fish and putting them into the box mentioned in Step 3. The boxes should be filled simultaneously, not one after the other, and it should be made certain that all boxes contain approximately the same weight of fish.

Step 6: Count the number of boxes with small fish and record.

Step 7: A rule of thumb is to take one box out of every five at random for subsampling. Record number of boxes taken for subsampling as B1, B2, B3, ... etc.

Step 8: The box(es) taken for sub-sampling is (are) then treated as follows:

- Weigh the total catch in B1 and record.
- Place fish of B1 on a sorting table and sort to species level as far as food fishes and valuable crustaceans (e.g. shrimps) are concerned, and to taxonomic groupings as well-defined as possible (e.g. genus, family, etc.) for other groups (the non-edible fish and miscellaneous crustaceans).
- Repeat procedure, if appropriate, for the other boxes, B2, B3, ... etc.

Step 9: If more than one box was sorted, compute, for each species (or higher taxonomic group) the total weight and number in all sorted boxes.

Step 10: Multiply the numbers and weight of fish and invertebrates by species (or higher taxonomic group) by the ratio of the number of unsorted to sorted boxes.

Step 11: Weigh and count the larger fish mentioned in Steps 3 and 5, by species (very large fish should be weighed individually and measured).

Step 12: Add, when there is an overlap (when the fish of a certain species occurred both in the sorted boxes of small fish and in the large fish box) the weights and numbers obtained in Step 11 to the weights and numbers in Step 10.

Step 13: Step **12** (as well as Step **11,** when there is no overlap) provides estimates of total catch, both in weight and number, by species or higher taxonomic groups. Record the total, both in weight and numbers into an appropriate fishing log and convert to catch per unit if fishing time was less or more than an hour. During surveys, this step must be completed after each haul, or every evening at the latest, to preclude loss of information.

Step 14: In addition to catch sampling, identifying and recording, the work of the fishery scientist generally includes among other things:

- Collecting length-frequency data
- Collecting miscellaneous biological information on the fish caught, e.g., concerning their weight and maturity
- Collecting and preserving specimens for further studies onshore
- Collecting oceanographic data.

13. The swept area

The trawl sweeps a well defined path, the area of which is the length of the path times the width of the trawl, called the *"swept area"* or the "effective path swept". The swept area, a, can be estimated from:

*a = D*hr*X2,*

(57) *D = V*t*

where **V** is the velocity of the trawl over the ground when trawling, **hr** is the length of the head-rope, **t** is the time spent trawling. **X2** is that fraction of the head-rope length, **hr**, which is equal to the width of the path swept by the trawl, the "wing spread", hr*X2. For southeast Asian bottom trawls values of X2 from 0.4 (Shindo, 1973) to 0.66 (SCSP, 1978) are reported. Pauly (1980) suggests X2 = 0.5 as the best compromise. In the Caribbean a value of X2 = 0.6 was used by Klima (1976).

For the estimation of biomass we use the catch per unit area (CPUA), as will appear in the next section. It is estimated by dividing the catch by the swept area (in square nautical miles or square kilometres). This estimate thus depends on how accurately the swept area is estimated. The wing spread is calculated as the fraction **X2** of the head rope length. The wing spread varies with hauling speed, weather conditions, current velocity and direction and warp length and is therefore not well defined. It can be accurately measured by special devices.

When exact positions of the start and the end of the haul are available the distance covered can be estimated in units of nautical miles (nm), by:

$$(58)\ D=60.\sqrt{(\mathrm{Lat1}-\mathrm{Lat2})^2+(\mathrm{Lon1}-\mathrm{Lon2})^2.\cos^2(0{,}5(\mathrm{Lat1}+\mathrm{Lat2}))}$$

where:

D = distance

Lat 1 = latitude at start of haul (degrees)

Lat 2 = latitude at end of haul (degrees)

Lon1 = longitude at start of haul (degrees)

Lon2 = longitude at end of haul (degrees)

14. Biomass estimation by the swept area method

Let **Cw** be the catch in weight of a haul. Then **Cw/t** is the catch in weight per hour, when **t** is the time spent hauling (in hours). Let **a** be the area swept. Then **a/t** is the area swept per hour, and

$$(59)\quad \frac{C_w/t}{a/t}=\frac{C_w}{a}\qquad \mathrm{kg/Nm}^2$$

becomes the catch in weight per unit of area. Let XI be the fraction of the biomass in the effective path swept by the trawl which is actually retained in the gear and let **Cw/a** be the mean catch per unit area of all hauls. Then an estimate of the average biomass per unit area, b, is:

(60) **b = (Cw/a)/X1 kg/Nm²**

$$(60)\quad b=(Cw/a)/X1\ \mathrm{kg/Nm}^2$$

Let **A**, Nm^2 the total size of the area under investigation. Then an estimate of the total biomass, B, in this area, A, is obtained from:

$$(61)\quad B=\frac{\overline{(C_W/a)}.A}{X_1}$$

It is difficult to estimate which proportion of the fish that is present in the area swept by the trawl gear is actually retained by the gear, in other words it is difficult to give a precise estimate of XI. Underwater television recordings show that the reaction of fish to trawls varies markedly between species. The value of XI is usually chosen between 0.5 and 1.0. For trawlers in southeast Asia a value of XI = 0.5 is commonly used in survey work (Isarankura, 1971, Saeger, Martosubroto and Pauly, 1980). Dickson (1974), on the other hand, suggests XI = 1. The difference between these two values of XI is difficult to resolve. Using XI = 0.5 doubles the estimate of biomass compared to that obtained by using XI = 1.0.

The duration of the haul is proportional to the distance covered so the duration should have no direct influence on the catch per unit of area. However, the catchability, XI, of different species may vary according to the duration of the haul because some species, when herded by the trawl get tired soon and get captured while other species are able to swim in front of the trawl for a long period and thus avoid being caught. It is therefore important to standardize the duration of the haul so that results from different hauls can be compared. To investigate the dependence of catchability on haul duration, parallel hauls of different duration (e.g half an hour and one hour) could be made.

At the Romanian marine area, the swept area method is used for determining the index of abundance for sprat and turbot agglomerations as well as to establish the juvenile abundance. The methods use the following parameters: trawling speed, horizontal opening of trawl, time of trawling and value of catch from a trawling.

At the Romanian littoral for turbot demersal trawling was used the bottom trawl 22/27-34 with horizontal opening of 13m. The average speed of the vessel: 2,0 - 2.4 knots, the trawling time is standardized at 60 minutes.

Also, for sprat is used pelagic trawl with the following technical characteristic: 50/35-74, d=22 m. The average speed of the vessel is about 2.5 knots, the trawling time was standardised at 60 minutes.

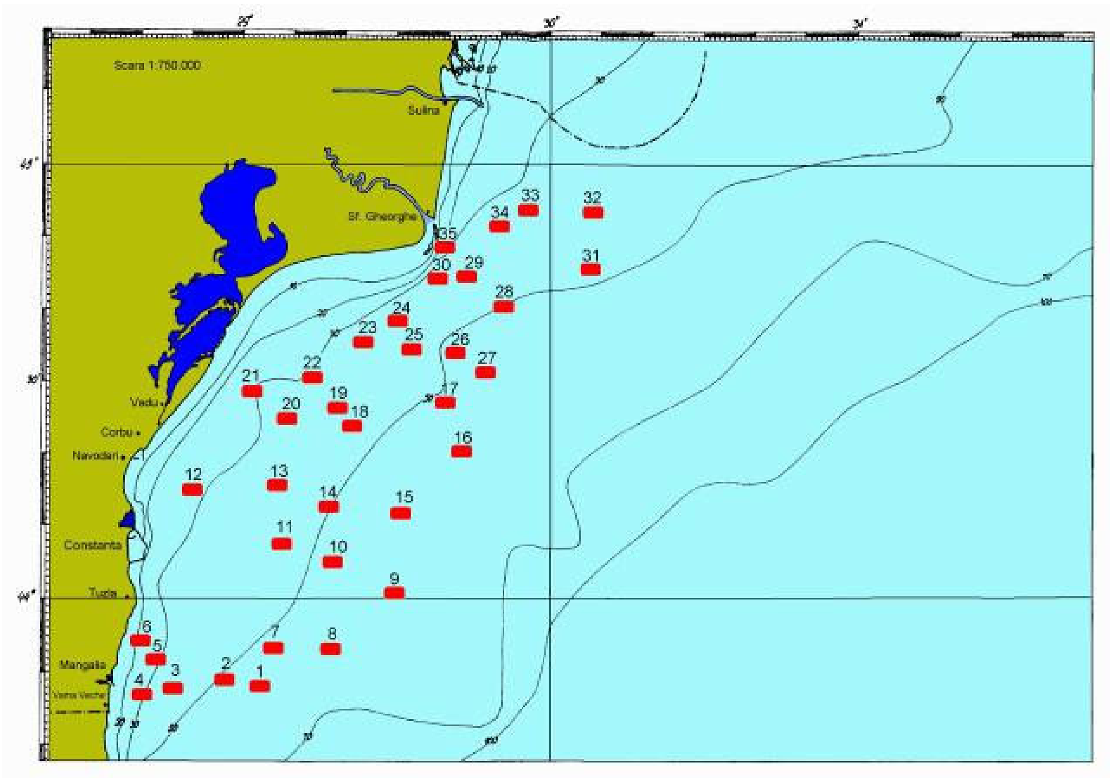


Figure 18 The distribution of the sampling points in the demersal trawl survey, Romanian area

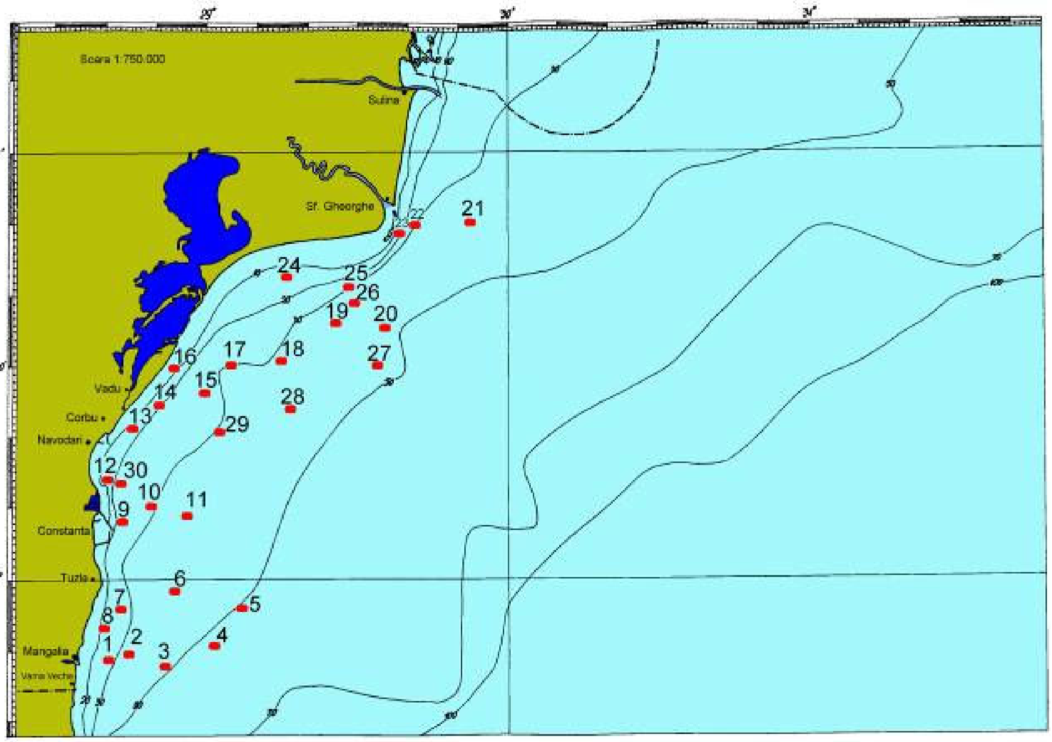


Figure 19 The distribution of the sampling points in the pelagic trawl survey, Romanian area

15. Specialized software for research vessel surveys (SURBA)

It is very important that was investigated thoroughly the potential of assessment methods based on data from research-vessel surveys. While such data are likely to have a greater variance than landings-at-age data, as they are collated from fewer samples, they are also under direct control and are unlikely to be affected by misreporting bias.

Two Working Papers to recent ICES assessment, Working Groups (Casey 2002, Needle 2002a) discussed the need for survey-based assessments, and presented relative-trend assessments for North Sea whiting using two simple methods (RCRV1A and RVS). A third WG paper (Needle 2002b) extended that work and applied a new model (SURBA to the whiting stock in the West of Scotland (sub-area VIa). In this paper, It is extend further both the method and its description, and will be summarised the results of those SURBA applications reported thus far in Working Group reports.

Survey-based assessment methods are unlikely to produce historic population estimates that are directly comparable with those from catch-based methods. There are two main reasons for this: survey data are inherently noisy; and they are generally not collated in such a way as to derive absolute estimates of stock numbers. These factors go some way towards explaining the differences between survey and landings-based assessments highlighted above, although these differences do appear to be quite small. However, it remains the case that landings data will become increasingly biased and unreliable as stocks decline further and fisheries management measures become increasingly punitive.

Throughout this paper, was assumed that that survey indices are unbiased (though variable) representations of stock trends. With good survey design, this will be true to a first approximation.

While development work is still needed, the methodology implemented in SURBA 2.0 is beginning to approach that which would be required for a genuinely unbiased fisheries management scheme. One clear advantage of this model is that it is easy for assessment Working Groups to use – it has a straightforward user interface and produces appropriate plots automatically, although it remains to be seen whether it is doing what we think it is doing. In any case, we should encourage work on a variety of such methods, so that when fisheries management finally acknowledge that commercial fisheries data are unusable in the management context, we will be able to provide valid alternatives.

16. Juvenile fish sampling

For juvenile fish, sampling is done with pelagic trawl Danielevski type, designed by the INCDM specialists. The project of this trawl was developed for trawler ships of 570 Hp (Nikolaev, 1988). Also, gear manufacturing was done in the same institutions with qualified personnel under technical assistance. Starting from the masurements verified experimentally and practically, the retention of fish greater than 15 mm and juveniles of the species group like sprat, anchovy, mackerel and a whiting with swimming reduced capacity compared with adults, the optimal speed of the trawl is in the range of 1 to 1.5 Nd (Anton, 2006). Vertical opening of the trawl is of 4-4.5m; horizontal opening is of 15m.

Juvenile fish samples are analyzed qualitatively and quantitatively after each trawling or preserved in 4-5% formalin and analyzed in the laboratory. Results are expressed as number of individuals/m^2 and are used to determine completion of the stock for each fish species.

Figure 20 Pelagic trawl for juvenile sampling

Station network used for ichtyoplancton sampling by NIMRD “Grigore Antipa”-Constanta is that used in the Cooperative Marine Science Program for the Black Sea (COMSBlack, 1992) for the Romanian seaside, being improved by adding a few stations in the shallow waters and Marine Reservation of the Danube Delta (fig. 2).

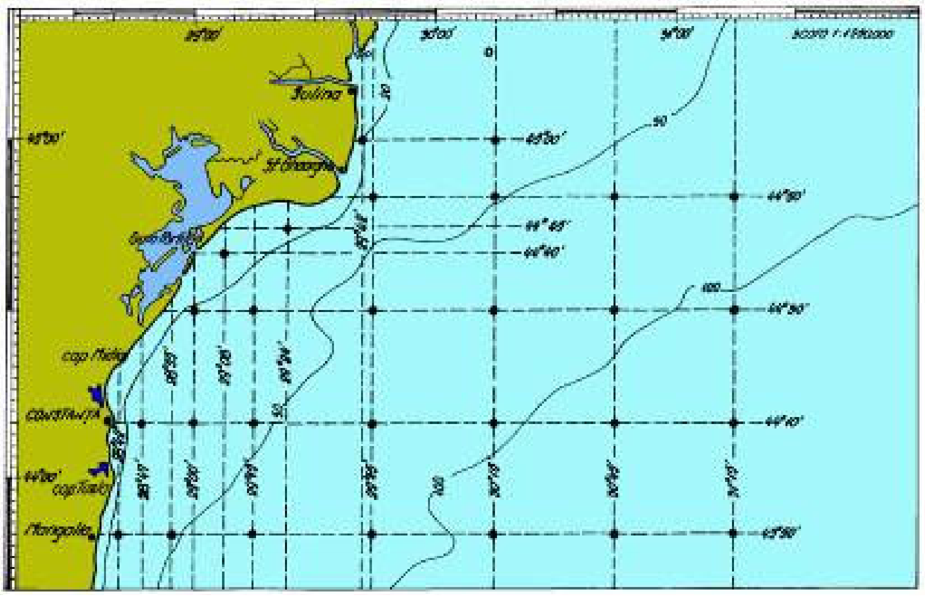


Figure 21 Station network used for ichtyoplancton and juvenile sampling by NIMRD “Grigore Antipa”-Constanta

17. Ichtioplancton sampling

Qualitative and quantitative of the ichtioplancton composition is determined by analyzing the samples taken from fixed stations (Fig.), located on the Romanian shelf (up to 70 m isobath), the method of collection and processing of samples being in generally accepted in the Black Sea area(E. Radu et al., 2002).

The collection is made, usually with Bongo net of 60 cm diameter with 505 μm mesh (Fig. 3,4), equipped with a flowmeter to record distance covered by oblique hauling during 5 minutes at speed of 1.5-2 Nd. For each station are separately recorded the following data: station, time of sampling, the location of the station, water depth (m), the horizon where was released the Bongo net (m), the number of rotations made by flowmeter.

Samples are preserved in formalin 4%, the processing being carried out in the laboratory. Laboratory analysis consists of sorting of each sample taken, under stereomicroscope, establishing quantitative and qualitative structure. Once established these elements, based on the aforementioned parameters, we can determine the density (individuals/m2) for each species. Then proceed to marking the average density on distribution maps (E. Radu et al., 2002).

The data obtained are used to calculate the abundance of eggs, resulting in reproductive intensity, as a first element in the characterization of a fish population status.

Figure 22 Bongo net

Figure 23 Bongo net for ichtyoplancton sampling

18. Determination of spawning intensity and completion level for main pelagic species.

The period for research surveys will be established by each country in accordance with the optimal conditions specific for each geographic zone.

For the species with intense spawning during the cold season (sprat), the surveys will be planned in the period December-February-March, and for the thermophilic ones (anchovy, horse mackerel, blue fish) in the period June-July-August.

For the species spawning during the cold season, the eggs and larvae will be sampled from the whole column of water, and for the warm spawning species the sampling will be made from the water column above the thermocline.

Two surveys/year have to be organized for to establish the completion level of main pelagic species: one in April-May, which will pursue the way of reproduction developing and laying down the eggs in the cold season, the second one in late summer (August-September-October), in order to be qualitative and quantitative inventoried the juveniles occurred following the reproduction of thermophilic species.

Assessment of eggs, larvae and juveniles abundance will be made using the areas methods.

The biomass of spawners will be determined using the method of daily eggs and larvae production (Parker, Sette-Ahlstrom).

IX. ASSESSMENT OF THE SPAWNING STOCK BIOMASS

1. Method Sett and Ahlström

Parameters used:

- Breeding season (presumed by us to be equal to 100 days);
- Duration of egg maturation;
- Total production of eggs in each survey
- Eggs in stages I-IV (or II-VI) of development;
- Knowing the average amount of eggs under one m2 area (in the water column under 1 m2), the surface surveyed and coefficients of mortality recorded for eggs passing from stage I to stage IV of development, we can obtain the egg production for each survey.

The total amount of eggs launchrd in the breeding season (P) was determined as:

(62) $$P = \frac{P_1 t_1 + P_2 t_2 + P_3 t_3}{t'}$$

where: P_1, P_2, P_3 = egg production in the first, 2nd and 3rd survey.

t_1, t_2, t_3 = duration of the survey plus half of time interval between surveys (or number of days until the beginning or end of reproduction).

t '= maximum duration of egg development

Spawning stock biomass is determined by the formula:

(63) Sette Ahlström: $B=\frac{P.m}{F.n}$ where,

P = the amount of eggs launched in the breeding season
F = average individual prolificity
n = sex ratio
m = average weight of fish

2. Method PARKER

(64) $$B = \frac{P}{a.b.c}$$

where: P = daily egg production (24 hours) in the survey (considering that was covered the whole surface (of the best survey)

a = average relative prolificity portion of anchovy (eggs / tonne)

b = the females that are daily spawning
c = the females percentage in the spawning agglomeration

X. ASSESSMENT BASED ON TAGGING DATA (FAO,1992)

The success of tagging experiments depends on the ability and willingness of the fishermen and others dealing with the catch to report on where and when the marked fish was caught. If the data are used also for estimation of growth parameters the size of the recaptured fish should be reported as well. The fishery must cover a relatively large part of the distribution in space and time of the stock to secure a reasonable number of recaptures for the estimation procedure. It is assumed that the tagged fish constitute a representative sample of the population, and thus have the same basic parameters as the untagged part. Models along these lines were suggested by Gulland (1955), Paulik (1963), Seber (1973) and Jones (1977). Seber (1973) presents a comprehensive discussion of the analysis of capture/recapture data.

Kleiber, Argue and Kearney (1983) suggested a model for assessment of Pacific skipjack tuna based on tagging data. This is the traditional catch curve model (Eq. 4.2.7) with modifications to take into account mortality due to tagging, shedding of tags and missing reports on recaptures. The basic equation of the model for estimation of population size, **P**, and *"attrition rate A",* (see definition below) reads:

(65) $$\mathbf{r(t) = a*b*N_o *exp(-t*A)*} \frac{C(t)}{P*A} \mathbf{* [exp(A) - 1]}$$

where:

a = fraction of short-term survivors, while **1-a** = short-term mortality, due to the trauma of being tagged **A** = attrition rate (includes mortalities (F and M) and shedding of tags, while growth out of vulnerability to the gear and migration out of the area are also considered) **b** = fraction of recaptured tags actually returned with usable recapture information **C(t)** = catch in biomass units during time period **t,** $\mathbf{N_o}$ = number of fish tagged (at time t = 0) P = standing stock in biomass units (assumed constant in time t=0), r(t) = number of tag returns during time period **t,** t = index of time period

To see that above Eq. is basically the same as the catch equation (we introduce:

(66) $\mathbf{N(t) = N_0 *exp[-(t-1)*A]}$ = number of tagged fish at the beginning of time period **t**

(67) **F(t) = C(t)/P**, fishing mortality

If we assume **a = b = 1 and A = Z** (no shedding or other type of attrition factors), after substitution and rearranging the Eq. becomes:

(68) $\mathbf{r(t) = N(t)*} \frac{F}{Z} \mathbf{*[1 - exp(-Z)]}$ i.e. the catch equation. The above description is only a short introduction of the basic equation.

Other methods:

Peterson: N = T*n/m where:

T = number of fish tagged
n = number of individuals fished
m = number of individuals tagged which were fished

$$\mathbf{e_{s\,(N)} = [T^2 n(n-m)/m^3]^{1/2}}$$ =standard error of **N**

Bailley 1952: $N = T (n+1)/(m+1)$

$$e_{s\,(N} = [\,T^2(n+1)(n-m)/(m+1)^2(m+2)]$$

Capture-tagging - recapture method will be used only for big-sized species. Being a expensive method and needing a long time for achieving, this method will be used at longer then five years.

1. Hydroacoustic method

It is used in collaboration with other coastal country (Bulgaria, IOBAS) endowed with techniques means. At the two countries littoral, Romania and Bulgaria, this method can be used only for sprat and orientation purpose for anchovy and mackerel at Bulgarian littoral, when the two species begin to make agglomerations for migration toward the wintering places.

The methodologies used will be presented by Bulgarian colleagues from IOBAS, Varna.

2. Methods of surplus yield

The surplus production methods use catch per unit of effort (for example kg of fish caught per hour trawling) as input. The data usually represent a time series of years and usually stem from sampling the commercial fishery. The models are based on the assumption that the biomass of fish in the sea is proportional to the catch per unit of effort as shown in Fig. .. An estimate of the yield is obtained by multiplying effort by catch per unit of effort.

This type of methods have an orientation role and will be used when the data of catch and effort are good and represent a long period of time. For to asses the maximum sustainable yield (MSY), the Schaefer and Fox methods will be used.

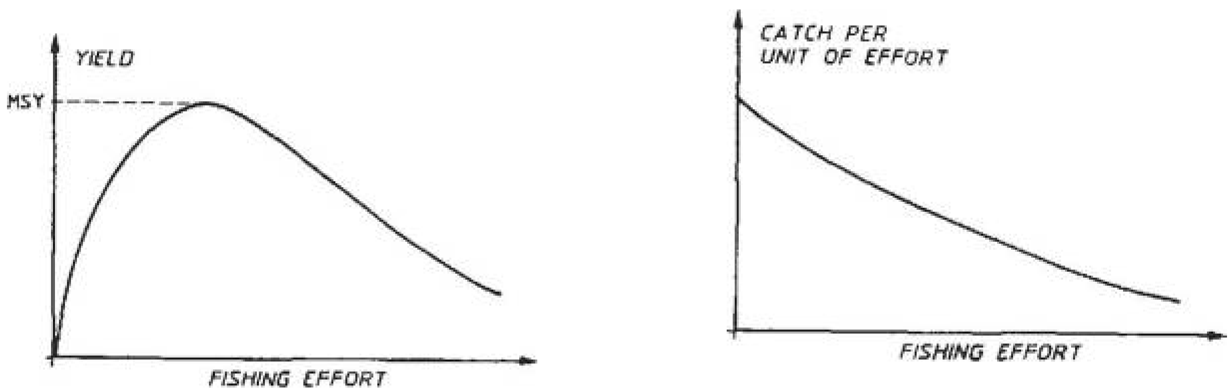


Figure 24 Surplus production model (FAO, 1992 -FTP 3066/1)

XI. ESTIMATION OF MAXIMUM SUSTAINABLE YIELD USING SURPLUS PRODUCTION MODELS

As an "holistic models" is also this chapter, wherein the stock is considered as one big unit of biomass and wherein no attempt is made to model on an age or length base. The *"surplus production models"* which are discussed in this chapter deal with the entire stock, the entire fishing effort and the total yield obtained from the stock, without entering into any details such as the growth and mortality parameters or the effect of the mesh size on the age of fish capture etc. Surplus production models were introduced by Graham (1935), but they are often referred to as "Schaefer-models" (FAO, 1992).

The objective of the application of "surplus production models" is to determine the optimum level of effort that is the effort that produces the maximum yield that can be sustained without affecting the long-term productivity of the stock, the so-called maximum sustainable yield (MSY). The theory behind the surplus production models has been reviewed by many authors, for example, Ricker (1975), Caddy (1980), Gulland (1983) and Pauly (1984).

Because holistic models are much simpler than analytical models, the data requirements are also less demanding. There is, for example, no need to determine cohorts and therefore no need for age determination. This is one of the main reasons for the relative popularity of surplus production models also in tropical fish stock assessment. Surplus production models can be applied when data are available on the yield (by species) and of the effort expended over a certain number of years. The fishing effort must have undergone substantial changes over the period covered.

Table 6 Flow of data for holistic models to assess the fish stocks

Input data or assumptions	Catch And Effort Data (no size composition data)	Research Survey Data
Processing of data using a model	Surplus production models	Swept area analysis
Output from a data processing stage	Yield as a function of effort	Total biomass of resources
	Maximum sustainable yield (MSY) for an equilibrium stock	A first (rough) estimation of the maximum sustainable yield (MSY)

1. The Schaefer and fox models

The maximum sustainable yield (MSY) can be estimated from the following input data:

f(i) = effort in year **i**, **i = 1,2,...,n**

Y/f = yield (catch in weight) per unit of effort in year **i**.

Y/f may be derived from the yield, **Y(i)**, of year **i** for the entire fishery and the corresponding effort**, f(i)**, by

Y/f = Y(i)/f(i), i = 1,2,...,n

or by direct observations on the basis of samples from the fisheries

The simplest way of expressing yield per unit of effort , **Y/f**, as a function of effort , **f**, is the linear model suggested by Schaefer (1954):

$\mathbf{Y(i)/f(i) = a + b*f(i)}$ if $\mathbf{f(i) \le a/b}$ This Eq. 9.1.2 is called the *"Schaefer model"*.

The slope, b, must be negative if the catch per unit of effort, **Y/f**, decreases for increasing effort, **f.** The intercept, **a**, is the **Y/f** value obtained just after the first boat fishes on the stock for the first time. The intercept therefore must be positive. Thus, **-a/b** is positive and **Y/f** is zero for **f = -a/b.** The model is applied only for values of the **f < -a/b.**

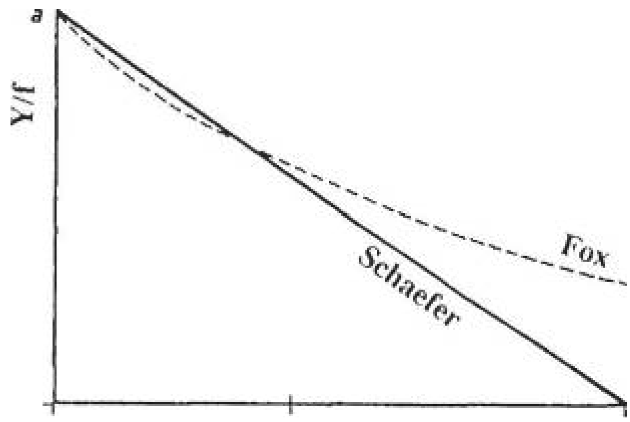


Figure 25 Illustration of the different assumptions behind the Schaefer model and the Fox model (FAO, 1992)

An alternative model was introduced by Fox (1970). It gives a curved line when **Y/f** is plotted directly on effort, **f**, but a straight line when the logarithms of **Y/f** are plotted on effort:

In (Y(i)/f(i)) = c + d*f(i) is called the *"Fox model"*, which can also be written:

Y(i)/f(i) = exp(c + d*f(i))

Both models conform to the assumption that **Y/f** declines as effort increases, but they differ in the sense that the **Schaefer model** implies one effort level for which **Y/f equals zero,** namely when **f = -a/b** whereas in the **Fox model**, **Y/f** is **greater than zero** for all values of **f**.

This can easily be seen in the plot of **Y/f** on **f** gives a straight line in case of the Schaefer model and a curved line, which approaches zero only at very high levels of effort, without ever reaching it (asymptotic) in the case of the Fox model.

We know that **CPUEw(t) = q*B(t).** Since **Y/f** is also the catch per unit of effort in weight, we can write:

Y(i)/f(i) = q*B = a + b*f(i) for the Schaefer model and **Y(i)/f(i) = q*B = exp(c + d*f(i))** for the Fox model.

where **B** is the biomass and **q** the catchability coefficient (a constant).

The biomass corresponding to **f = 0** is called the "virgin stock biomass" or the "unexploited biomass", denoted by **Bv.** Thus, replacing **Y/f by q*Bv** gives:

q*Bv = a or **Bv = a/q** (Schaefer)

q*Bv = exp(c) or **Bv = exp(c)/q** (Fox)

The Bv for the two models must be the same. When increasing **f** from zero to level **A,** the two curves are approximately equal, but to the right of A the differences become larger. Thus, the choice between the two models becomes important only when relatively large values of **f** are reached. It cannot be proved that one of the two models is superior to the other. You may choose the one you believe is the most reasonable in each particular case or the one which gives the best fit to the data. However, the **Beverton and Holt model** is more in agreement with the **Fox model**, because they have a similar curvilinear relationship between catch per_unit effort and effort and between the mean biomass per recruit **B/R and F**.

The objective is, however, to obtain an estimate of the maximum sustainable **yield (MSY)** and to determine at which level of effort **MSY** has been or will be reached. To that purpose we have to rewrite Eqs expressing the yield as a function of effort, by multiplying both sides of the equation by **f(i):**

for **Schaefer model** we obtain:

$f_{MSY} = 0.5*a/b$
$MSY = - 0.25*a^2/b$

The **MSY** and **f_{Msy}** for the **Fox model** can be calculated by formulas:
Fox $f_{MSY} = - 1/d$
$MSY = - (1/d).exp(c-1)$

2. The assumption of an equilibrium situation (FAO,1992)

To explain the concept of an equilibrium situation we consider a situation where a virgin stock starts to be exploited in, say, 1971 by, say, 1000 boats. According to the Schaefer model the yield in 1971 corresponding to 1000 boats should be **x**.

However, it turned out to be **y**, i.e. a larger value than predicted by the model. This is because when fishing started in 1971 the biomass was still the virgin stock biomass, Bv, and only after a certain period of exploitation the biomass declines.

When fishing continued in 1972 the biomass was reduced due to the removal by fishing in 1971 and the 1972 catch therefore became smaller than that of 1971. Each year the resource is reduced, the reduction being smaller the longer time has elapsed since the introduction of the 1000 boats. Eventually, the system will stabilize at **the Y/f-level x.** We say that the system has reached an **"equilibrium situation" after a "transition period".**

For the equilibrium situation the production of biomass per time unit, equals the removal by fishing, the yield per time unit, plus the amount of fish dying of natural causes.

The "equilibrium situation" in the surplus production models is comparable to the "stabilized constant parameter system" in the Beverton and Holt models

3. The biological assumptions (FAO,1992)

The biological reasoning behind the model was adequately formulated by Ricker (1975) as follows:

"1. Near maximum stock density, efficiency of reproduction is reduced, and often the actual number of recruits is less than at smaller densities. In the latter event, reducing the stock will increase recruitment.

- When food supply is limited, food is less efficiently converted into fish flesh by a large stock than by a smaller one. Each fish of the larger stock gets less food individually; hence a larger fraction is used merely to maintain life, and a smaller fraction for growth.

- An unfished stock tends to contain more older individuals, relatively, than a fished stock. This makes for decreased production, in at least two ways:

- Larger fish tend to eat larger foods, so an extra step may be inserted in the food pyramid, with consequent loss of efficiency of utilization of the basic food production.

- Older fish convert a smaller fraction of the food they eat into new flesh - partly, at least because mature fish annually divert much substance to maturing eggs and milt."

However, it is also possible to consider these models as purely empirical. For instance, if observations of Y/f plotted on f give a curve complying with the Fox model, this model may be applied without any concern for a possible biological explanation.

4. Assumptions on the catchability coefficient (FAO, 1992)

We assume that fishing mortality is proportional to effort: $\mathbf{F = q * f}$

This assumption in itself is not controversial (if **f** is a reasonable measure of effort). The problems come when **f** is measured in, for example, the number of boat days per year over a series of years. In most cases the efficiency of the boats has changed over a long period; often the boats have become larger and better equipped. Thus, 100 boat days in, say, 1978 may create a larger fishing mortality than 100 boat days in 1968. This means that q becomes a function of time or rather, a function of the technical development which is usually a function of time. It has proved very difficult to account for changes in **q**, caused by increased fishing efficiency and usually it is assumed that q remains constant. *Therefore, one should be cautious not to include too long a time series of data in the surplus production analysis*. Alternatively, changes of **q** must be taken into account. In some fisheries on small pelagic species in upwelling areas, for example, the anchoveta in Peru and Chile it occurs that the fish concentrate in small areas because of changes in the environmental conditions. In such cases there is no direct relationship between **q, f and F**, and surplus production models cannot be applied.

5. GULLAND'S FORMULA (FAO, 1992)

In this section we consider the case of poorly investigated stocks. Time series of catch and effort data are not available, but some estimates of overall biomass and the natural mortality have been obtained.

Several empirical formulas have been developed with the objective of providing a first rough estimate of the MSY based on such scanty data. These formulas have found wide application after first estimates were obtained of the standing biomass after one or a series of exploratory bottom trawl surveys and/or acoustic surveys. The first formula was developed by Gulland (1971), a modification was proposed by Cadima (in Troadec (1977) and finally a set of formulas strictly based on the Schaefer and Fox surplus production models was developed by Garcia, Sparre and Csirke (1989).

Gulland (1971) suggested the following way of estimating maximum sustainable yield:

(69) $MSY = 0.5*M*Bv$

where **Bv** is the virgin stock biomass and **M** the natural mortality.

This formula has been used especially on sparsely investigated and lightly exploited stocks. **Bv** is often estimated by the "swept area method" and **M** is often a value estimated for similar species in a sea area which is believed to be similar to the one under investigation. As Gulland's formula requires an estimate of the virgin stock biomass, **Bv**, it is in practice applicable only to unexploited stocks. There is no proper scientific justification for this equation (Gulland, pers. comm.). However, the following statements which were made already by Tiurin (1962) and Alverson and Pereyra (1969) appear reasonable:

1. MSY must depend on the virgin stock biomass**, Bv**
2. A high **M** corresponds to a high production (this is further discussed below)
3. If the **biomass = 0.5*Bv** and **F = M** under optimum exploitation above Eq. is fulfilled.

Although widely used, above Eq. has been criticized by a number of workers. Caddy and Csirke (1983) showed that the third assumption, that F equals M under optimum exploitation, does not apply in many cases, especially stocks of prey species (e.g. shrimps). Based on simulation studies, Beddington and Cooke (1983) concluded, that above Eq. generally overestimates **MSY by a factor of 2 to 3**. Thus, **replacing "0.5" by "0.2"** in Eq. might perhaps give a better (and consequently much lower) estimate of MSY.

6. *CADIMA'S FORMULA*

A generalized version of Gulland's estimator was proposed by Cadima (in Troadec, 1977) for exploited fish stocks for which only limited stock assessment data are available. Cadima's estimator has the form:

(70) $MSY=0.5*Z*\bar{B}$

where $\bar{B}$ is the average (annual) biomass and **Z** the total mortality. Since **Z=F+M** and **Y=F*** $\bar{B}$ **,** Cadima suggested that in the absence of data on Z, Eq. Gulland could be rewritten:

(71) $MSY=0.5*(Y+M*\bar{B})$

where **Y** is the total catch in a year and $\bar{B}$ is the average biomass in the same year.

As most stocks in the world are now already being exploited this equation is quite frequently used in developing and some developed fisheries, where catch and effort time series are not yet available, but where biomass estimates are occasionally obtained from, for instance, trawl or acoustic surveys.

7. *Software for surplus-production model (ASPIC)*

The surplus-production model has a long history in fishery science and has repeatedly proven useful in management of fish stocks. The appeal of production models is in large part due to their conceptual and computational simplicity. Despite that simplicity, production models incorporate an implicit recruitment function, and thus can be used for studies of sustainability. Production models have also been found especially useful in stock assessments when the age-structure of the catch cannot be estimated

Many early treatments of surplus-production models assumed that the yield taken each year could be considered the equilibrium yield (e. g., Fox 1975).

However using that “equilibrium assumption” tends to overestimate MSY when used to assess a declining stock, and it has been found problematic by several studies (Mohn 1980; Williams and Prager 2002).

The assumption was a computational convenience that is no longer needed, and ASPIC does not use it.

Earlier versions of ASPIC could fit only the logistic production model (Schaefer 1954, 1957; Pella 1967), in which the production curve (curve of surplus production vs. biomass) is symmetrical around MSY. Version 5.x also fits the generalized model of Pella and Tomlinson (1969) in the revised parameterization of Fletcher (1978).

ASPIC incorporates several extensions to classical stock-production models. One extension is that ASPIC can fit data from up to 10 data series. These may be catch–effort series (from different gears or different periods of time), catch–abundance-index series, biomass indices, or biomass estimates made independently of the production model

A second major extension is the use of bootstrapping for bias correction and construction of approximate nonparametric confidence intervals.

A third extension is that ASPIC can fit a model under the assumption that yield in each year is known more precisely than fishing effort or relative abundance; in other words, fitting can be statistically conditioned on yield, rather than on fishing effort or relative abundance.

8. *Harmonization of the ways and methods for sampling/processing data (collaboration between Romania and Bulgaria under DCF)*

9. *Sampling of catch*

In order to study the fish populations, the method of random extracted samples is used; samples represent a share from the whole population able to offer sufficient information for characterization the population.

There were established that the sample extracted for to study the biological parameters must have 200 individuals (for small-sized pelagic species: sprat, anchovy, and mackerel). For pelagic big-sized species, the number of individuals from sample depends on the circumstances (i.e. size of catch).

The Parties established that the sampling frequency must be at least one sample per week.

Table 7 Number of specimens agreed for main species sampled in each EU Black Sea country

Species	length	Weight @length	Sex-ratio @length	Maturity @length	Age
	no. of ind.	no. of ind.	no. of ind.	no. of ind.	no. of ind.
Sprat	10000	10000	10000	10000	2500
horse mackerel	1000	1000	1000	1000	250
anchovy	1500	1500	1500	1500	400
turbot	200	200	200	200	50
dogfish	50	50	50	50	-

10. *Sampling of material for determination of length frequency.*

The samples analyzing means: counting, biometry (measurements), gravimeter (weightings), sampling of otholits for aging, determination of sex and gonads maturation.

The characteristics determined by biometry measurements are: plastic characters (length, mass, thickness), and meristic characters (radii, scales, branchial spines).

Within these analyses, the elements necessary for growing parameter assessments are important, carrying out:

- the structure on length and age classes;
- the weight on length and age classes;
- sex ratios.

In the fishery biologic studies, the most utilized method is refers to the measurement of liniar dimensions of the fish or different component parts. Among numerous observation which can be made, the easiest is the total length. Other parameters are linked by the total length, such as mass and age, so each of them can be determinated by length data. Measurements for determination the frequency of lengths of the fishing populations are used for assessment of their population stock.

There was established that the measurements will be made on total fish length, and when is necessary the standard length, and at fork for to establish some correlation's can be made.

For small-sized species, the measurements centralization will be carried out on interval classes of 0.5 cm, the measurements being centralized at inferior cm. For instance, the species with total length comprised between 11.0 and 11.4 cm are registered in length class of 11.00 cm. For large-size species, the interval between length classes is 3 cm.

The Parties agreed as if at regional level, the Black and Mediterranean Seas, for some species will be used the centralization at nearly cm, then the new methodology will be adopted, and then the historical data will be correlated (transformed).

11. ***Collecting of material for determination of fish age.***

The samples for age determination will be collected using the stratified method, meaning providing a constant number of material - 10 individuals (preferably 5 males and 5 females) from the sample for length frequency study the for each length class.

The material used for age determination is represented basically by the otholiths, being specific for each species. The Bulgarian Party offered itself to send the Romanian Party the keys for age determination for main species from the commercial catch.

12. ***Establishing the gonads maturation degree.***

Once with the biometric measurements, the gonads are weight, both for females and males. It is indicated as these samplings to be made for the same sample collected for age determination. The gonads will be carefully collected from advanced stages females, to not hurt the ovary walls. The samples are labeled: the trawling number, the number of individual from the sample collected.

It was agreed that the scale for visual appreciation with six stages (Nikolski, ICSEAF, ICES) will be used for determination of gonads maturation stage.

13. ***Determination of spawning intensity and completion level for main pelagic species.***

The Parties established as the period for research surveys will be established by each Party in accordance with the optimal conditions specific for each geographic zone.

The Parties agreed as they will use the proper networks for sampling, for to have continuity in observation. For each station, the following data will be noted: station, date of sampling, geographic coordinates of station, water depth (m), level to which the net was launched (m), number of rotations registered on the net device (flowmeter). Also, the Parties agreed:

- The spawning intensity for main pelagic species will be determined using the BONGO net for ichtyoplanktonic sampling, using the circular method; the vessel speed - 2.5-3 Nd.
- For the species with intense spawning during the cold season (sprat), the surveys will be planned in the period December-February-March, and for the thermophilic ones (anchovy, horse mackerel, blue fish) in the period June-July-August.
- For the species spawning during the cold season, the eggs and larvae will be sampled from the whole column of water, and for the warm spawning species the sampling will be made from the water column above the thermocline.
- Two surveys/year have to be organized for to establish the completion level of main pelagic species: one in April-May, which will pursue the way of reproduction developing and laying down the eggs in the cold season, the second one in late summer (August-September-October), in order to be qualitative and quantitative inventoried the juveniles occurred following the reproduction of thermophilic species.
- Assessment of eggs, larvae and juveniles abundance will be made using the areas methods.
- The biomass of spawners will be determined using the method of daily eggs and larvae production (Parker, Sette-Ahlstrom).

14. ***Determination of growing parameters and mortality ratios.***

For determining the growing parameters and mortality ratios the following methods will be used: Gulland and Holt, Ford-Walford, Chapman, Bertalanffy, Beverton and Holt, Pauly, Rikhter and Efanov, etc.

15. The hydroclimatic parameters

The environmental conditions are the most important factor for formation and maintenance the fishing agglomerations. That is way, to study the dynamic of environmental factors in correlation with the results of fishing, for to establish their influence on the fishing. It is necessary the systematic pursue of the values registered by the hydroclimatic parameters.

The Parties agreed as during the surveys, the values of following parameters will be registered with adequate devices or visual observation:

- water temperature,
- salinity,
- wind (direction, intensity),
- the sea movement status,
- establishment of the thermocline level.

The phyto- and zooplankton sampling will be performed each survey; also the presence of sea birds and dolphins will be noted.

XII. STOCK ASSESSMENT AND DETERMINATION OF BOLOGICAL CHARACTERISTICS OF SMALL CETACEANS LIVING IN THE BLACK SEA

1. Method

Direct counting method based on onboard sightings on line transects

2. Description

Sightings were carried out along the Turkish Black Sea coast from Georgian to Bulgarian borders in the 60 km band with 4 vessels in April 1987 and July 1987. In addition to the determination of dolphin population sizes, biological characteristics and feeding habits with pond experiments and stomach analyses were performed. The research activities conducted within in the 14 blocks which each corresponds one degree of longitude in total area of 70000 km^2 . Four vessels cruised parallel to the coastal line on the 15^{th}, 30^{th}, 45^{th} and 60^{th} kms. Sightings were carried out by 2 researchers onboard at the same time working 2 hrs in each shift and counting were done by using binoculars within the 2.5 km distance range in port and starboard of the vessels' route (total in 5 kms) in good sea conditions (up to 2 beauforts) from 07:00 to 18:00 hrs. The density of dolphin populations in each block was determined by line-transect method (numbers by species in 5kmxtracked distance (km) on each line).

3. Species

Harbour porpoise (*Phocoena phocoena*)
Common dolphin (*Delphinus delphis*)
Bottlenosed dolphin (*Tursiops truncatus*)

4. Ecosystem considerations (type of data collected)

After 2 days of training of observers on how to count visible dolphins and porpoises on the surface, number of animals, starting and end points of track lines, time, weather condition, wave scale as in Beauforts, number of schools and animals in each school were recorded. In case of feeding 5 animals (2 porpoises and 3 common dolphins) were kept in the swimming pool of the university. After filling with sea water, animals were caught and transferred to the pool. After acclimatization period they were fed with fresh, frozen or trash fish. Animals were weighed at the beginning and final weights were recorded with the feed they consumed in 70 days. In case of biological studies, 25 animals (5 bottlenosed dolphins, 6 common dolphins and 14 porpoises) were sampled, sexed and dissected. 17 body and 24 skull measurements (belonging 19 animals; 5 bottlenosed dolphins, 6 common dolphins and 8 porpoises) were taken. Internal organs were examined in 25 animals and 16 measurements were performed. Ageing of animals were performed from the teeth of 13 animals (5 bottlenosed dolphins, 6 common dolphins and 2 porpoises). Skin and fat layer thickness were also measured on head, dorsal and ventral body, and tail. 11 stomachs were investigated to determine feeding habits of animals. Internal organ weights such as heart, liver, lungs and kidneys were weighed.

5. Area

The research activities conducted for the determination of dolphin stocks were carried in 14 blocks in an area of 70000 km^2 between the former USSR (Sarp) and Bulgarian (İgneada) borders.

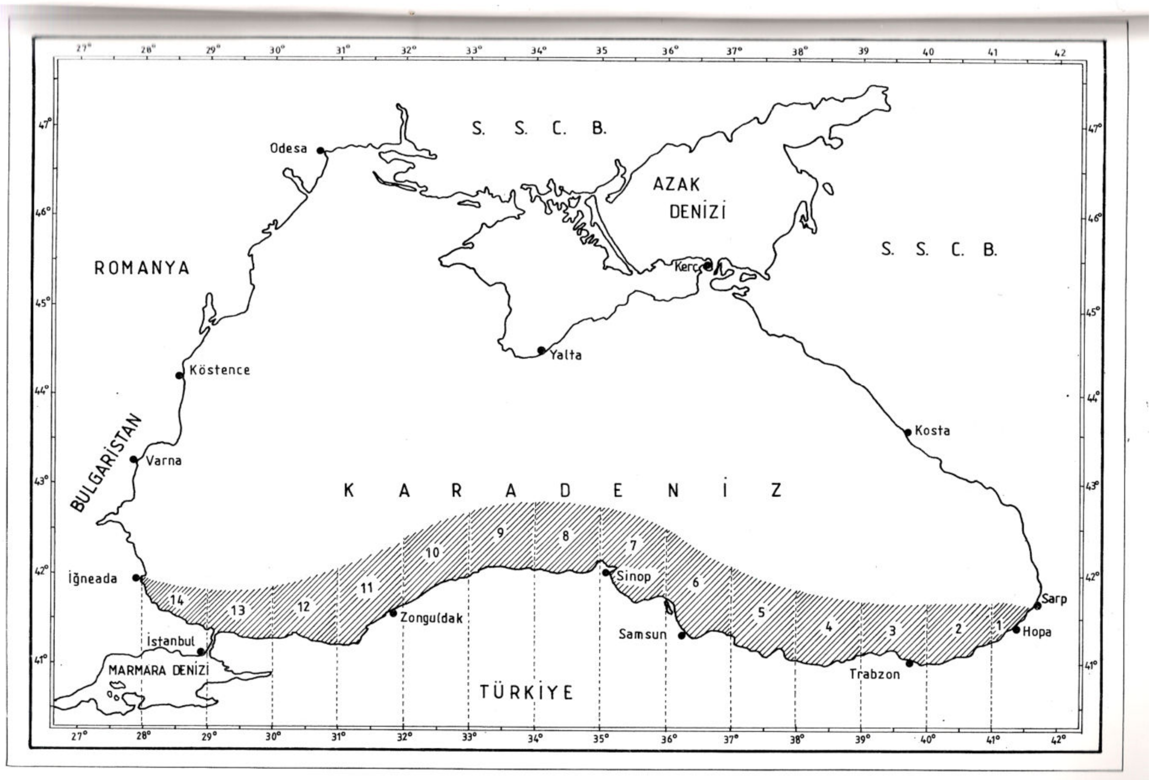


Figure 26 The research area in Anatolian coast of Turkey

6. Gear characteristics (including schemes, TTTs)

7. Mesh size, mm

8. Justifiation (for using gears)

9. Models/assessment

Direct Counting Method

$$\widehat{D_S} = \frac{n}{2LW} \qquad \bar{X} = \frac{\sum f_i . X_i}{n} \qquad \widehat{D_A} = \widehat{D_S} . \bar{X} \qquad N_I = \widehat{D_A} . A$$

(72)

Where:

$\widehat{D_S}$:	number of schools in sq. km	n:	number of schools
L:	total cruise distance (km)	W:	max. observation distance (km)
$\bar{X}$:	mean school size in numbers	D_A:	number of animals in sq. km
X_i:	size of ith school	N_i:	total animal number
f_i:	ith school frequency	A:	observed area (km^2)

Harbor porpoise (*Phocoena phocoena*) populations in the Black Sea was the most abundant species with 52.7%. This is followed by the common dolphin (*Delphinus delphis*) with 32.5% and bootlenosed dolphin (*Tursiops truncatus*) 14.8%. Common dolphin and harbor porpoise was seen almost in whole area along the coast of the Black Sea. On the other hand, bottlenosed dolphin formed dense populations especially in the Central and Western Black Sea (between Sinop and İğneada). Common dolphin was also observed at long distances off the coast, in contrary, bottlenosed dolphin and harbor porpoise live in areas close the coast and their densities become lesser with increased distance from the coast.

At the end of the study, 51226 dolphins were counted in the four surveys and the average density was 1.09 dolphins for km^{-2}. Thus, the dolphin population of the Black Sea was estimated as 454440 dolphins. Distribution maps were derived by regions.

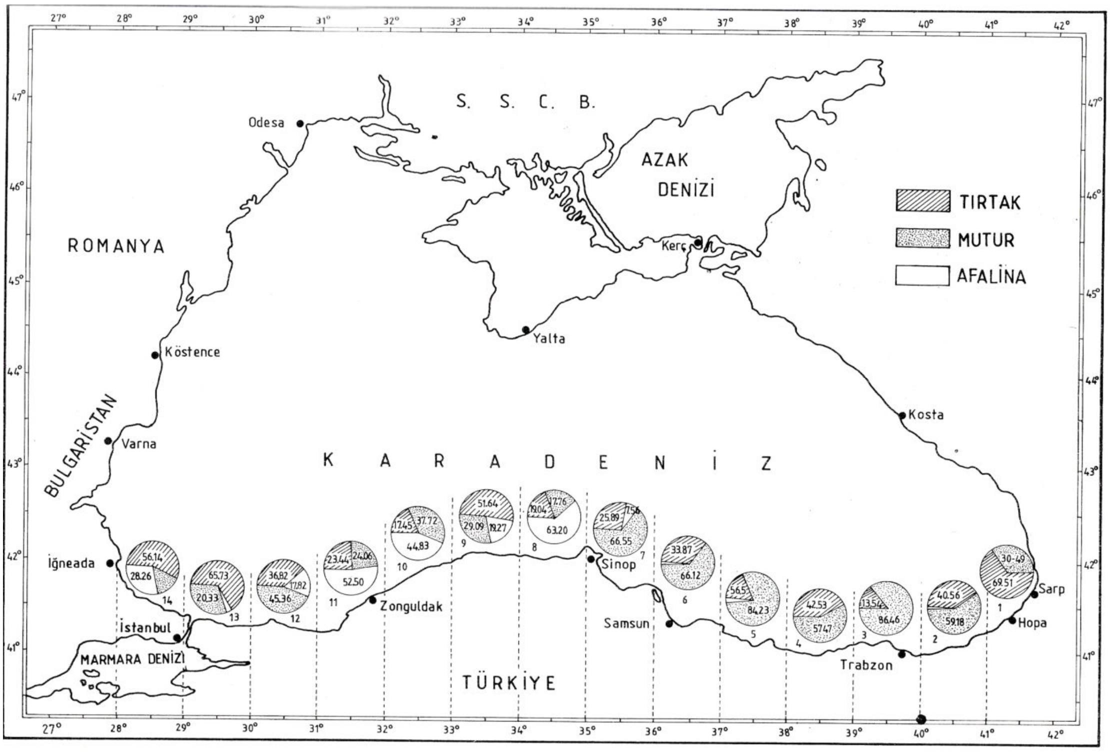


Figure 27 Small cetacean distribution alomg the Anatolian Black Sea coast of Turkey.

The ages of several dolphins were determined from teeth sections. The oldest individual was 26 years old from Tursiops, and youngest are 3 years old from three species. The mean lengths and weights are 222 cm and 163 kg for bottlenosed dolphin, 166 cm and 56 kg for common dolphin and 106 cm and 26 kg for harbour porpoise.

Sex ratio in dolphin populations is close to 1:1 ratio as in the other mammals. This ratio was found 48% for female and 52% for male in this research.

The common dolphin and bottlenosed dolphin were feeding mainly on pelagic fish while the harbour porpoise consumes primarily the benthic fish.

10. Gaps in data collection (recommendations to fill)

Small cetaceans are under full conservation. It is very difficult to obtain data. All bycatch released to the sea by the fishermen. This research was the first and the last comprehensive research. At the time of the survey, there was lacking of many technical information and access difficulties to the literature. So a technical corporation provided from Mr. William.F Perrin, Mr. Stephan Leatherwood, R. R. Reeves from La Jolla Laboratory National Marine Fisheries Service Southwest Fisheries Science Center and Mr. G. Pilleri from Switzerland Bern University mainly on the stock assessments and anatomy of small cetaceans. Actually survey was designed for 2 years but MARA insisted on the project to be ended in one year.

11. Knowledge gaps

No information flow from the fishermen. Almost there are complains about the increase in porpoise and dolphin populations in the Black Sea which consumes “their” fish.

12. Recommendations

Scientifically it can be advised that this type of studies should be carried out in the whole Black Sea seasonally with the participation of all Riparian countries. Also fishermen input should be provided as real observers on the sea by creating a data recording system convincing them as a main stakeholder in Black Sea fisheries management. On the other hand, a fishery observer program may be applied to be able to record of dolphin sightings and bycatch during fishing activities by trained junior experts assigned and funded by a project.

On the other hand vessel surveys need to be supported by the aerial surveys (photographs and films- especially for the big sized schools during their migration for food at the end of the main fishing season in Turkey)) and by the application of photo identification techniques. Training is needed for the latter.

XIII. THE WHELK *RAPANA VENOSA* GROSS 1861, STOCK ASSESSMENT IN THE SOUTH EASTERN BLACK SEA OF TURKEY

1. Method

2. Swept area

3. Description

Whelks were captured using dredge semimonthly between May 1991 and November 1991. The samples were captured by one 20 min haul with dredge towed by a 24 m research vessel (R/V SURAT 1 of CFRI) at 5-30 m depth (<10; 10-20 and >20m). Dredge velocity was approximately at 2-3 knots. Samplings in a certain areas were done by SCUBA diving in the rocky and shallower habitats where dredging is not available. The whelks were captured by in these areas and counted.

Mean biomass per km^2 were estimated for each sub-area using the swept-area method the equation proposed by Gulland 1969 and 1977; Ricker 1973.

4. Species

Rapa whelk, *Rapana venosa (*Synm. *Rapana thomasiana)*

5. Ecosystem considerations (type of data collected)

Shell length (SL), shell width (SW) and aperture length (AL) were measured with a Vernier caliper to the nearest 0.01 mm and soft parts were weighted (shell–free body weight) to the nearest 0.01 g. Whelks were measured to the nearest mm from the apex to the end of the siphonal canal. The sex individual whelk was identified based on the color of the gonad (yellowish for females and brownish for males).

6. Area (maps, coordinates)

The six sub-areas (Surmene, 40˚ 55'N 40˚ 09'E, Araklı, 40˚ 56'N 40˚ 03'E, Yomra, 40˚ 57'N 39˚ 50'E, Havaalanı, 40˚ 59'N 39˚ 49'E, Ormanokulu, 41˚ 00'N 39˚ 40'E, and Salacik, 41˚03'N 39˚ 32'E) were identified in the southeastern Black Sea of Turkey. The bottom type of all stations was sandy. These sub-areas are fed by Surmene, Araklı and Değirmendere streams.

7. Gear characteristics (including schemes, TTTs)

Dredge used at the surveys is 3 m in length, and 0.4 m height, with a 1 m, 40 mm mesh sized net bag.

Figure 28 Rapana dredge

8. Mesh size, mm

40 mm.

9. Justification (for using gears)

10. Models/Assessment

The whelk stock size is estimated by the swept area method. Total abundance was estimated from the CPUE data obtained from samplings in different locations and time

The stock results using dredge in the sandy area;
Stock size was estimated between 18 tons and 160 tons. Mean cpue 38523 whelks/km^2. In summer mean cpue was 42012 whelks/km^{-2}.
The stock results using diving in the rocky areas;
Stock size in the rocky areas was estimated between 2 tons and 0.6 tons.
The total stock results both rocky areas and sandy areas;
Stock size in the rocky and sandy areas was estimated as 1420 tons.

11. ***Gaps in data collection (recommendations to fill)***

The number of sampling stations must be more.
The selectivity of dredge must be studied.

12. Knowledge gaps

Gaps on biological data;
- Determination maturation stage of whelk to calculate first maturity length and spawning stock biomass
- Age estimation to use the other stock models (VPA and statistical catch-at-age methods etc.)
- Commercial fisheries data (Total catch, Catch per Unit effort)
- The presence imposex in Rapa whelk

13. Recommendations

The Rapa whelk stocks must monitored continuously because of its impact on endemic species mainly on the Mediterranean mussel *Mytilus galloprovincialis* and baby clam *Venus gallina/Chamella gallina* due to absence of natural predator in the Black Sea (i.e. sea stars) and high food competition with other benthic fauna (i.e. turbot, plaice and solea). Other impact is oriented by the fishing gear used to harvest whelk in the Turkish coasts. Dredges are harmful for bottom flora and fauna have high bycatch rates. So it is better to use more environmentally friendly harvesting methods like pots or traps in whelk fishery.

XIV. STOCK ASSESSMENTS IN THE BLACK SEA

1. Method

Hydroacoustic surveys were carried out on the routes as "zig-zags" from shore to the offshore and vice versa not exceeding 10 Nm on each of the legs on the area that anchovy migration was expected. The nearest depth to the shore was limited at 15-18 m. The offshore area was limited generally up to 200 m. depth but it was accepted as 500 m. in the Eastern Black Sea. If fish schools detected surveys conducted till the detected schools finished.

The speed of the vessel was fixed at 6-8 knots considering the stabilization of transducer under the haul, parasite level and cruise coasts (Cruise time fuel cost).

2. Description

Project was supported by NATO, State Planning Organization, TUBITAK and MARA. Field surveys were carried out by METU and CFRI.

Main objectives of the projects were to estimate to stock abundances of commercially important pelagic and demersal fish species in the Black Sea coastal waters of Turkey. Hydroacoustic method was used for pelagic and swept area method with bottom trawl used for demersal species. In addition to market samplings and egg and larval surveys were also conducted.

3. Species

Anchovy

4. Ecosystem considerations (type of data collected)

Hydroacoustic data on track lines
Depth and GPS data
Physical and chemical parameters (temperature, salinity, chlorophyll-a, etc.)

5. Area (maps, coordinates)

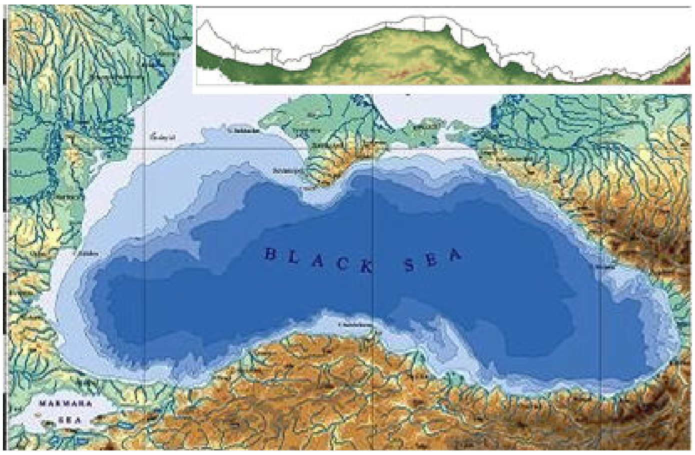


Figure 29 Survey area (from Georgian to Bulgarian borders)

6. Gear characteristics (including shemes, TTTs)

Mid-water trawl was used to sample anchovy and horse mackerel

7. Mesh size, mm

8. Justification (for using gears)

Anchovy and horse mackerel populations were sampled to provide input data for applied models where needed (L_∞, k, t_0 and mortality rates).

9. Models/Assessment

BIOSONICS brand named acoustic system was used in the surveys. Biomass estimations were summarized as follows;

Table 8 Assessed biomass, survey period and fishing season of anchovy.

Survey period	Fishing season	Instantaneous Biomass (A)	Corrected Biomass (A) x spawning #*)
Nov/Dec. 1989	1989/90	31 000 ton	31*10= 310 000 tons
Feb 1990	1989/90	28 000 ton	28*10= 280 000 tons
Dec 1990	1990/91	14 800 ton	15*10= 150 000 tons
Jan 1992	1991/92	36 000 ton	36*10= 360 000 tons
Jan 1993	1992/93	?	
Jan 1994	1993/94	12 000 ton	12*10= 120 000 tons

*Spawning was completed 5-10 times

10. Gaps in data collection (recommendations to fill)

Timing failures in survey planning

Bad hydrological and weather conditions

Migration of anchovy under the depth limits of the area that research vessel able to work

Existence of small fishing vessels and settled nets in coastal area preventing survey operations.

Insensitive bathymetric maps

Survey design failures as not to cover before and after competition of migration period of anchovy (recruitment occurs in five-ten times in wintering period)

Sound (vibration) isolation problem from vessel which interferes with the acoustic signals

11. Knowledge gaps

A continuous monitoring as necessary to follow up the variation of the migration time and route together with the Riparian countries,

Anchovy is spawning in the EEZ of Turkey. There is a knowledge deficiency on the discrimination of local and migrating stocks,

In order to conduct surveys in near coastal waters in most safety conditions more sensitive bathymetry maps are needed.

12. Recommendations

Wintering stocks should be assessed and mapped by means of their densities annually,

More sensitive bathymetric maps should be prepared,

The list of anchovy vessels and their fishing efforts need to be derived,

Landings have to be recorded more preciously,

Eggs and larval surveys are needed to estimate recruitment,

Material and method harmonization is needed among BS Countries,

Data collection system should be established in order to provide physical and chemical time series data

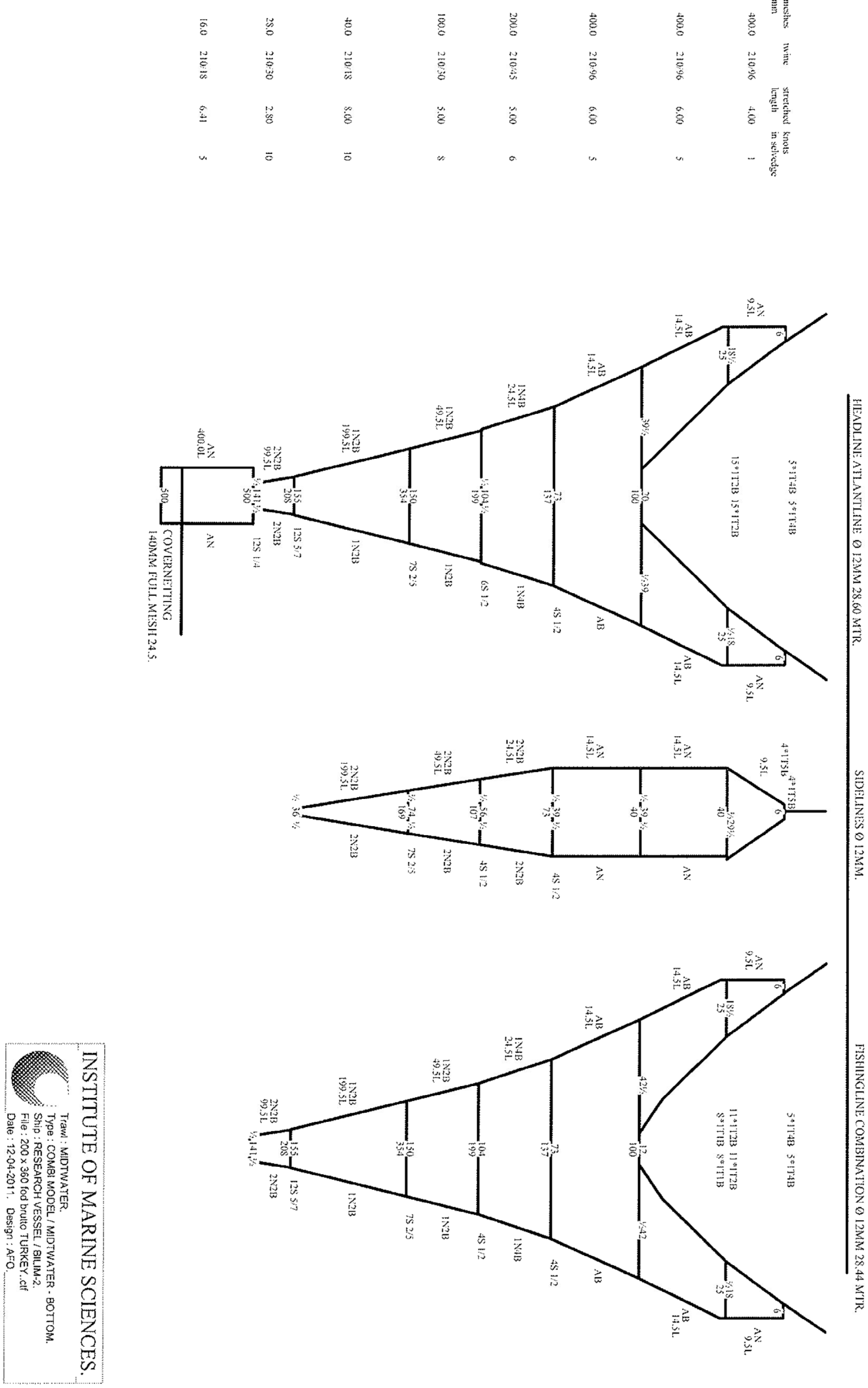


Figure 30 Midwater (OTM) trawl scheme IMS, Turkey

XV. STOCK ASSESSMENTS FOR DEMERSAL SPECIES

1. Method

Swept area

2. Description

In early 1990's several surveys were conducted with bottom trawl nets in the Black Sea by two research vessels. Stock abundances of demersal species were estimated by swept area method (Clark, 1981). Growth and mortality data obtained from the samples of trawl nets content.

Table 9 Timing and area of research with R/V Bilim and R/V Surat-1

Time	**Research vessel**	**Area**
April 1990	R/V Bilim	Whole Black Sea
September 1990	R/V Bilim	Whole Black Sea
October 1990	R/V Surat-1	Eastern Black Sea
September 1991	R/V Surat-1	Eastern Black Sea
October 1992	R/V Surat-1	Eastern Black Sea

<u>On board data</u>

-Geographical area, Depth of trawl net
-Vessel speed, trawling time
-Total catch weight, Total weight of each demersal fish species
-Length composition of fish species, individual length and weight data

Biomass was estimated using the formulae to stratified samples (mainly in wide continental shelf areas);

(73) $$B = \left(\frac{A}{a * q}\right) * \bar{y} \qquad B = \sum B_i = \sum \frac{A}{a * q} * \bar{y}$$

Where; B: biomass, A: research area (km^2), a: swept area by net (km^2) q: catchability coefficient

$\bar{y}$: mean catch (kg)

For demersal species maximum sustainable yields (MSY) and yield per recruit (Y/R) models were also used.

3. Species

Demersal species (Whiting, Red mullets, Turbot, etc.)

4. Ecosystem considerations (type of data collected)

Physical and chemical parameters (temperature, salinity, chlorophyll-a) dta were collected. Satellite images were also used to provide chlorophyll-a values in survey area.

5. Area (maps, coordinates)

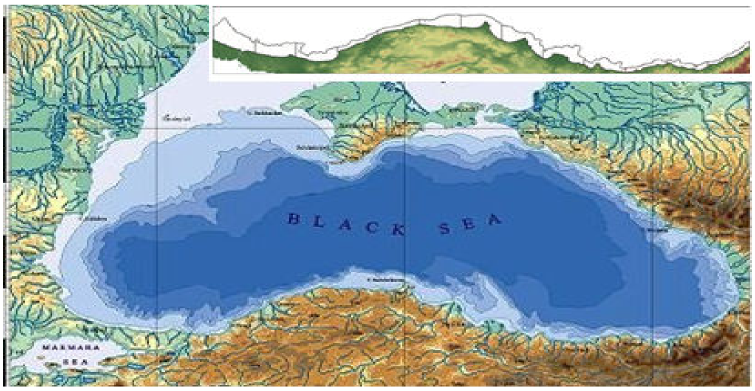


Figure 31 Area of research

Surveys were conducted in Turkish Black Sea Coasts between Bulgarian to Georgian borders in 1990, and Sinop to Georgian border in 1990 to 1993.

6. Gear characteristics (including schemes, TTTs)

7. Mesh size, mm

12 mm mesh size in codend

8. Justification (for using gears)

9. Models/Assesment

Table 10 Biomass estimations (tons) in spring 1990 surveys in Eastern Black Sea (Sinop-Bafra Cape) and Western Black Sea (İgneada-Sinop)

Species	Western Black Sea R/V BİLİM	Eastern Black Sea R/VSURAT-1	Black Sea total
Pelagic fish	60.1	223.7	283.8
Semi pelagic fish	1.3	236.1	237.4
Demersal fish	1 661.0	7 128.9	8 789.9
Red mullet	26	2 267	-
Turbot	205	26	-
Whiting	1 042	4 504	-
Elasmobranches	620.0	646.6	1266.6
Shellfish	97.1	70.5	167.6
Total	2 439.5	8305.8	10745.3

Table 11 Biomass estimations (tons) in autumn 1990 surveys in Eastern Black Sea (Sinop-Bafra Cape) and Western Black Sea (İgneada-Sinop)

Species	Western Black Sea R/V BİLİM	Eastern Black Sea R/VSURAT-1	Black Sea total
Pelagic fish	66.4	7.0	73.4
Semi pelagic fish	-	17.5	17.5
Demersal fish	773.2	5451.2	6224.4
Red mullet	0	2058	-
Turbot	56	222	-
Whiting	715	2027	-
Elasmobranches	437.7	10835.3*	11 273.0*
Shellfish	16.8	36.3	53.1
Total	1294.1	16 347.3 (8 897.0)	17 641.4 (10 191.1)

Table 12 Biomass estimations (tons) from autumn 1991 and 1992 from Sinop to Georgian border

Species	1991	1992
Pelagic fish	44.8	76.6
Semi pelagic fish	73.1	50.0
Demersal fish	21 693.9	40 050.8
Red mullet	1 028	4 027
Turbot	410	766
Whiting	18 300	32 075
Elasmobranches	2 216.8	4 779.0
Shellfish	223.3	623.7
Total	24 251.9	45 580.1

10. Gaps in data collection (recommendations to fill)

There is lack of sensitive bathymetry maps in Turkey. Existing maps have only hundred meter depth contours so, survey team were not be able to have trawl samples in the area having 100-120 m depth.

During the survey period there was lack of digital maps.

Due not to have net sounders on the trawl net, the opening height, catchability rate could not be estimated, therefore assumptions were used (catchability coefficient assumed as 1).

Assessments do not cover jellyfish and dogfish.

Assessments were the minimum biomass estimation due to q=1.

Due to high variance in the estimations of biomass in different periods and locations may cause over or under biomass assessment.

11. Knowledge gaps

Insufficient bathymetrical maps.

12. Recommendations

Demersal surveys should be carried out twice in a year,

Trawling has never been permitted in the Eastern Black Sea.

The use of dredge for Rapana must be prohibited by encouraging fishermen to use alternative fishing gear such as pots.

After biomass and MSY estimations quota system should be applied in trawl fisheries,

Net sounders are the essential component of trawl surveys. Research institutes need to be supported.

Standard trawl nets need to be designed for the surveys.

Physical and chemical parameters of sea water should be continuously recorded as a national policy,

Landings should be effectively inspected and fishermen will be obliged to record fishing effort data as well as catch data by species,

Sampling from landings is very important for biological studies to monitor the changes in stock for this purposes a new sampling protocols need to be established,

Material and method uniformity should be provided among BS Countries.

XVI. RESEARCH ON SOME POPULATION PARAMETERS OF *ANADARA CORNEA*, REEVE, 1844 IN THE SOUTH-EASTERN BLACK SEA

1. Method

Swept area

2. Description

Dregging were carried out at different localities and depths at 10m, 15m and 25m with 1.5 km/h (1 knot) towing speed for 20 mins. Towing time was started as the dredge touched to the bottom and ended as the steel cable started to haul. If the sample size is under 50 all the contents were counted and weighed, if it is more all the net content was weighed and small units not less than 50 individuals were sampled, weighed and counted to estimate the total amount taken in the net. CPUE values estimated from monthly surveys.

3. Species

Anadara cornea (Scapharca cornea, Scapharca inequalvis are the synonyms)

4. Ecosystem considerations (type of data collected)

Anadara cornea is one of the invasive species for the Black Sea. It is the major filter feeder in the Black Sea ecosystem after the collapse of the mussel stocks. In this survey it was concluded that the impact of collapse in fisheries were still visible and the distribution of Anadara from west to the south was continuing in all coastal waters of the Black Sea. Besides weight and number of individuals in each dredge contents, length, weight, volume, dry meat weights of the samples were measured from September 1993 to June 1994.

5. Area (maps, coordinates)

Surveys were carried out in the within the coordinates of 38^0 23’ 38’’N -40^0 55’ 32’’ E and 40^0 44’ 09’’- 41^0 05’ 49’’ (off Giresun, Trabzon and Rize).

6. Gear characteristics (including schemes, TTTs)

Rapana dredges were used in the research made of galvanized steel bars designed as letter "H" view from front with mouth opening 3 m in length and 40 m height. There are 3 steel tiny ropes used to connect the both sides of mouth from upper and lower sides to attach dredge net. By this way if it may turn down during towing, both sides may be functional. Nets are made of classical diagonal mesh shape, 22 mm stretched size from reciprocal knot to knot. Two pieces of chains used to reinforce upper and lower parts attached to the mouth in order to provide dredge towing in mud and sand deeper up to 10 cms. Also steel frame donated with slides from four corners as in skiing boards to permit dredge slide on every type of bottoms.

7. Mesh size, mm

22mm from knot to knot in a stretched mesh

8. Justification (for using gears)

9. Models/Assessment

Stock size was estimated using swept area method (area-abundance density). Areas estimated by using national navigation maps with the scale of 1:100 000 (maps # 141, 142 and 13) using KP-90 model PLA COM digital plan meters. As a result the survey area inhabited by Anadara was estimated for the area between Giresun and Pazar was 226.5 km^2; sub areas for Giresun-Trabzon, Trabzon–Rize and Rize–Pazar were estimated as 94.5 km^2, 89 km^2 and 45 km^2, respectively.

Total biomass was calculated as 186 tons and mean biomass as 0.022± 0.006 ind./m^2 in total of 226.5 km^2 survey area after 39 dredge hauls. Confidence limits of the stock size (at 95 % probability level) was 3 171 000-6 115 500 individuals. Stock abundances by regions can be summarized as 0.015±0.001 ind/m^2 for Giresun-Trabzon region, 0.025±0.005 ind/m^2 for Trabzon-Rize and finally 0.023±0.002 ind/m^2 for Rize –Pazar. Trabzon is the most abundant region with the stock size of 2 million 225 thousand individuals (estimated biomass is 82 tons). It is followed by Giresun (1 million 388 thousand ind., 62 tons) and Rize (1 million 35 thousand ind., 32 tons).

Mean length, weight, width and thickness were calculated as 36.62mm, 37.43g, 46.98mm and 33.54mm, respectively. Lengt-weight relationship equation was derived as $W= 0.0033L^{2.581}$. Condition index was estimated as 3.81 (Dry meat weight/Total shell weight). The relationship between dry meat weight and length was derived as $DMW= 0.0038L^{1.473}$. Mean stock density was 0.022 ind./m^2 in the survey area.

10. Gaps in data collection (recommendations to fill)

Anadara is very sensitive to temperature changes and it is very difficult to sample them in winter season especially in December and January. In case of stock assessment studies it can be advice that surveys which will be held on reproduction period in late spring and summer months; mainly in reproduction season will be sufficient.

11. Knowledge gaps

None

12. Recommendations

There is no domestic consumption anadara from Turkey but it can be exported to Asian country as an alternative product to rapana. As to provide new incomes to artisanal fishermen by using traps/pots being non-native species a special attention should be given to monitoring the changes in stock size and distribution pattern in the whole Black Sea. Therefore, stock assessment surveys should be carried out together with rapana.

XVII. ICHTHYOPLANKTON SURVEYS IN THE SOUTH-EASTERN BLACK SEA

1. Method

Egg and larval surveys (Pelagic Ichthyoplankton)

2. Description

Two types of plankton sampler were used; vertical (57 cm radius, 330 µm mesh sized WP-II type) and horizontal (50x50cm mouth opening, 500 µm meshed size which is designed for "Surface Sampling"). Two types of sampling were applied for the vertical sampling; one is for 50 to surface and the second from 25 to surface. Horizontal samplings lasted 5-15 min depending upon the sample density. Method described by Smith and Richardson (1977) have been used in sampling and calculations. In order to get rid of scattering effect of propeller, samples were towed from the starboard of the vessel. Samples were transferred into the 1 lt of sampling jars and added on formaldehyde (37 %) as to reach 5% final concentration in the jar.

Samples were classified in the laboratory using 2mm, 1mm, 0.5mm and 0.330mm sieves by species after washing away mud and other waste material. Then, species identification were done under stereomicroscope using the keys given by Arım (1957), Dekhnik (1973), Russell (1976), Mater and Coker (2002), Yuksek and Gucu (1994).

Development of the embrio was followed by 6 stages given by Dekhnik (1973).

3. Species

Anchovy
Horse mackerel
Sprat
Red mullet

4. Ecosystem considerations (type of data collected)

Temperature, salinity and dissolved O^2 were measured by G.O Idronout 316 CTD Probe. Secchi disk measurements were also performed.

5. Area (maps, coordinates)

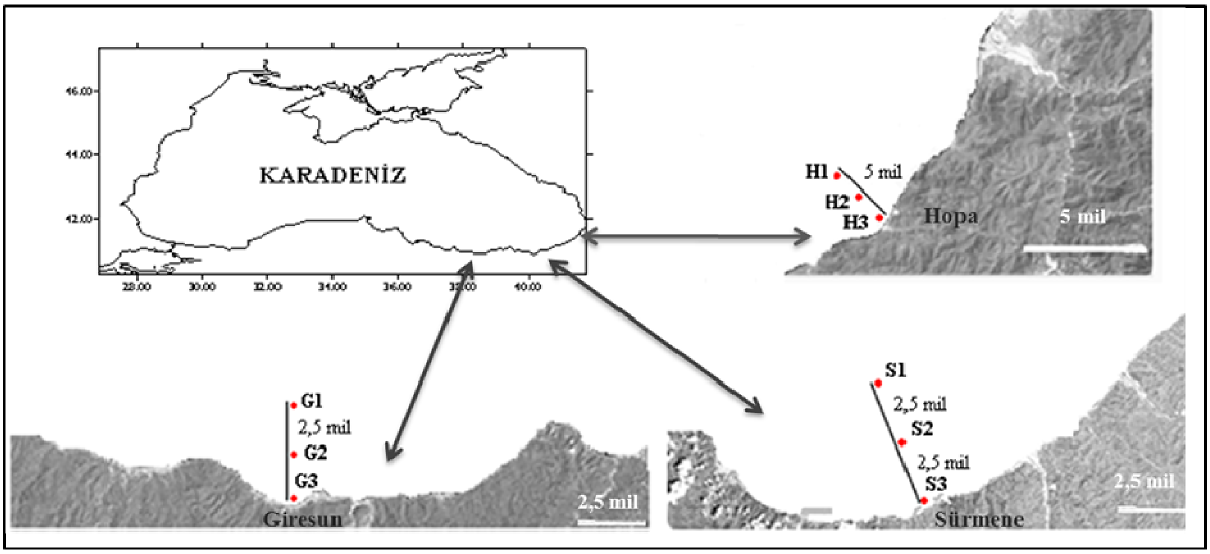


Figure 32 South-eastern Black Sea Coasts (Giresun-Hopa)

Table 13 Georgraphical coordinates of investigation.

	Surmene	Hopa	Giresun
1.Station	40° 59' 00" N-40° 10' 00" E	41° 29' 00" N-41° 23' 00" E	41° 00' 00" N-38° 24' 00" E
2. Station	40° 57' 00" N-40° 10' 30" E	41° 26' 30" N-41° 24' 30" E	40° 57' 30" N-38° 24' 00" E
3. Station	40° 55' 30" N-40° 11' 30" E	41° 25' 10" N-41° 25' 00" E	40° 55' 30" N-38° 22' 30" E
4. Station	40° 55' 10" N-40° 11' 00" E	41° 24' 30" N-41° 25' 30" E	40° 55' 00" N-38° 22' 45" E

6. Gear characteristics (including schemes, TTTs)

Given in the "Description" section

7. Mesh size, mm

8. Justification (for using gears)

9. Models/Assessment

Preliminary outputs of the surveys regarding egg and larval abundance are given below:

Table 14 Eggs and larvae research in the corresponding area by species.

			Winter, 2009		Spring, 2009		Summer 1, 2009		Summer 2, 2009		Autumn, 2009	
			Egg	**Larvae**	**Egg**	**Larvae**	**Egg**	**Larvae**	**Egg**	**Larvae**	**Egg**	**Larvae**
Sprat	Hopa	H.	26,94	1,88	-	-	-	-	-	-	1,50	1,79
		V.	74,50	36,51	-	-	-	-	-	-	9,67	0,00
	Sürmene	H.	5,54	18,67	-	-	-	-	-	-	0,00	0,00
		V.	11,28	20,45	-	-	-	-	-	-	10,11	4,98
	Giresun	H.	5,04	34,66	-	-	-	-	-	-	1,71	1,67
		V.	10,60	11,12	-	-	-	-	-	-	42,50	9,13
Anchovy	Hopa	H.	-	-	1,08	0,00	1000,92	7,14	2687,17	60,48	-	-
		V.	-	-	0,00	0,00	57,65	23,40	322,94	515,96	-	-
	Sürmene	H.	-	-	0,74	0,00	229,91	3,56	1454,00	171,62	-	-
		V.	-	-	0,00	0,00	97,75	72,84	332,39	416,76	-	-
	Giresun	H.	-	-	2,37	0,00	700,78	7,64	2879,70	180,34	-	-
		V.	-	-	0,00	0,00	NS	NS	372,95	1044,32	-	-
Red mullet	Hopa	H.	-	-	-	-	710,84	2,38	48,62	1,26	-	-
		V.	-	-	-	-	5,756	6,24	10,62	10,62	-	-
	Sürmene	H.	-	-	-	-	0	2,28	62,85	2,79	-	-
		V.	-	-	-	-	0	0	9,95	5,93	-	-
	Giresun	H.	-	-	-	-	22,84	0	9,64	13,09	-	-
		V.	-	-	-	-	NS	NS	0	0	-	-
Horse mackerel	Hopa	H.	-	-	-	-	48,42	0	23,91	1,45	-	-
		V.	-	-	-	-	8,84	5,05	16,60	14,95	-	-
	Sürmene	H.	-	-	-	-	244,95	1,10	58,05	0	-	-
		V.	-	-	-	-	25,19	0	5,37	12,12	-	-
	Giresun	H.	-	-	-	-	141,63	0	0	0	-	-
		V.	-	-	-	-	NS	NS	0	14,49	-	-

10. Gaps in data collection (recommendations to fill)

There is no national intention (research program) for the implementation of egg and larval surveys,

Financial deficiencies (limited university funds were used in the survey on limited stations (locations) with a few staff),

Lack of experienced staff,

Limited visual egg and larval identification keys for endemic species,

11. Knowledge gaps

Lack of detailed identification keys,

There are limited surveys in certain areas of the southern Black Sea (Sinop, area near the Bosporus entrance, Trabzon-Rize region,

Existence of limited references especially for the Black Sea.

12. Recommendations

There is strong need towards the implementation of national program on egg and larval surveys,

Monitoring studies should be carried out to predict the productivity of coming fishing season,

Surveys should be enlarged towards the whole Turkish Black Sea coast,

A national data bank is needed supported by the individual surveys and international data bank is essential for the future.

XVIII. ESTIMATION OF DEMERSAL STOK ABUNDANCES IN THE WESTERN BLACK SEA COAST OF TURKEY

1. Method

Swept area

2. Description

Biomass estimations (kg) per square km in fishing and no fishing zones were performed according to Sparre and Venema (1992);

(74) $$\overline{x}_i = \frac{\sum_{j=1}^{n_i} x_{i,j}}{\sum_{j=1}^{n_i} SA_{i,j}}$$

where; j stratum; $x_{i,j}$; number or weight of species in the i[th] survey in j[th] stratum, $SA_{i,j}$; swept area in each i[th] operation in j[th] stratum. Variance of the estimation of calculated by;

(75) $$S_{x_i}^{\ 2} = \frac{1}{n_i - 1}\sum_{j=1}^{n_i} SA_{i,j}\left(\frac{x_{i,j}}{A_{i,j}} - \overline{x}_i\right)^2$$

Standard deviation (sd=√var) and coefficient of variation (CV%=(sd/mean index)*100) are also estimated. Growth (L_∞, K,t_0), mortality (Z, M, F) and exploitation rate (E=F/Z) are also estimated by Pauly (1984) and Sparre and Venema (1992).

The best sampling period was selected as April15-May 15 which is the migration period of spawning stock to the near shore and late September-late October as recruitment season.

Basic parameters determined for the standard trawling operations are;

12. Survey season/ month, (2) sampling area, (3) number of surveys, (4) sub-sampling stations and their numeration, (5) Trawl gear desing/model, (6) Codend mesh size and material, (7) Operation time and duration, (8) vessel speed, (9) sub-sample no/size, (10) biometric measurements of target species, Length-frequency distributions, individual length-weight, sex, gonadal maturation, otolith readings.

Data coming from experimental surveys and commercial fisheries will be analyzed together to assess;

(2) CPUE by species (kg/day) in target and non-targeted landings (Phiri and Shirakihara, 1999). (2) Biomass (B) (kg/km^2) in closed and open trawl areas (Sparre and Venema, 1992) (3) determination of bycatch quantitity (Stratoudakis et al., 1999; Ye, 2002;

Diamond, 2003). (4) Growth parameters (L_∞, K and t_0), mortality coefficients (Z, M, F) and exploitation rate (E) (Pauly 1984; Sparre and Venema, 1992). (5) Aging (Otolith readings, morphometric measurements, relationship between otolith size and fish growth (Paukert and Willis, 2001; Kamukuru et al., 2005).

3. *Species*

Whiting, red mullet, turbot, and other demersal species,

4. *Ecosystem considerations (type of data collected)*

Time and duration of trawl operations in each station and sub-layers, effort, catch (quantity, length, weight) by species, laboratory studies (otolith removal of certain sized, otolith measurements, gonad maturation stages)

5. *Area (maps, coordinates)*

Surveys have been carried out in the Fishery Statistics Sub-areas (K1-K3-K5-K7) in the western Black Sea using stratified sampling procedures which each of the sub layer corresponds 5x5 km areas and applicable to GIS. 3 depth layers (Stratum 1 (0-30 m), Stratum 2 (30-60 m) and Stratum 3 (60-100 m) are used in each of the sub areas. Towing time is 30 mins and vessel speed is 1.8 knots. Number of sampling stations is 40.

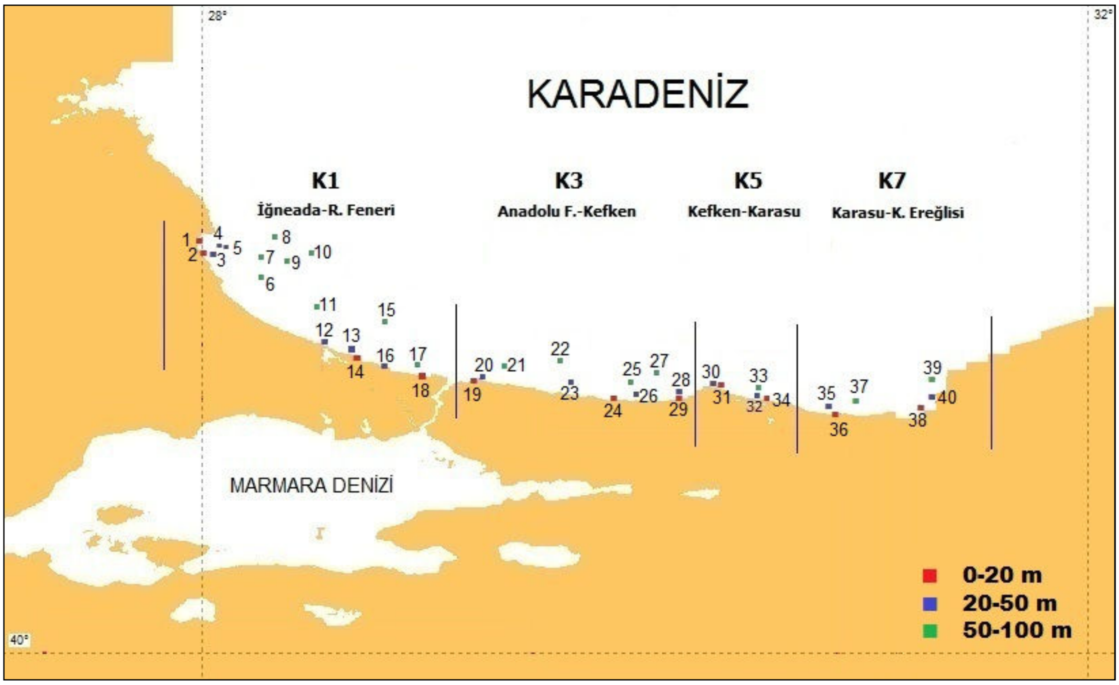


Figure 33 Sample stations along the Turkish Black Sea coast.

6. *Gear characteristics (including schemes, TTTs)*

Sketch of the trawl has not drawn yet. Mesh size in the cod end is 12 mm.

7. *Research vessel*

Trawl surveys are carried out by R/V YUNUS of Istanbul University Faculty of Marine Science (OAL: 32 m., Width: 6.80 m., grosstonnage: 136 GRT, draft 3.30 m, power of main engine: 510 HP, auxillary engine: 180 HP, speed: 10 nM/hr).

Figure 34 R/V Yunus

8. Justification (for using gears)

-

9. Models/Assessment

Biomass/stock abundance will be estimated with the equation given above.

10. Gaps in data collection (recommendations to fill)

-

11. Knowledge gaps

Lack of research staff by means of quality and quantity may be effective on the success of field studies, data quality and the assessment at the end.

12. Recommendations

The field studies in the survey conducted in the last two years/three seasons. In order to make better assessments, monitoring activities has been recommended due to provide time series data and to understand variation of the seasonal dynamics effectively.

13. Progress level of the project

Project will be implemented in three years starting from 2010. The surveys in first year (2011) were realized by İstanbul University funds. A total of 39 surveys and 56 species were sampled (31 osteichtyes, 4 chondrichtes, 5 shellfish, 12 mollusk, 3 echinoderms and 1 tunicata) in the period of 28 May-5 June.

In autumn surveys there were only 21 surveys due to weather conditions. Assessments will be completed in 2013

XIX. MONITORING THE TRAWL FISHERIES IN THE BLACK SEA

1. *Method*

Swept area

2. *Description*

Biomass estimations (kg) per square km in fishing and no fishing zones were performed according to Sparre and Venema (1992);

$$\overline{x}_i = \frac{\sum_{j=1}^{n_i} x_{i,j}}{\sum_{j=1}^{n_i} SA_{i,j}} \qquad (76)$$

Where; j stratum; $x_{i,j}$; number or weight of species in the i^{th} survey in j^{th} stratum, $SA_{i,j}$; swept area in each i^{th} operation in j^{th} stratum. Variance of the estimation of calculated by;

$$S_{x_i}^{\ 2} = \frac{1}{n_i - 1}\sum_{j=1}^{n_i} SA_{i,j}\left(\frac{x_{i,j}}{A_{i,j}} - \overline{x}_i\right)^2 \qquad (77)$$

Standard deviation (sd=√var) and coefficient of variation (CV%=(sd/mean index)*100) are also estimated. Growth (L_∞, K,t_0), mortality (Z, M, F) and exploitation rate (E=F/Z) are also estimated by Pauly (1984) and Sparre and Venema (1992).

3. *Species*

Whiting, Red mullet, Turbot and other demersal species

4. *Ecosystem considerations (type of data collected)*

Surveys are conducted in to sub-geographical areas. First one is the Samsun continental shelf area which is intensively exploited over long time period and the other one is the Ordu region which is used only for artisanal fisheries. One of the main aim of the project is to compare the abundance of demersal macro fauna within two neighbor sub-regions by means of different seasons and different depth ranges in order to conclude fishing efficiency on benthic ecosystem.

Time and duration of trawl operations in each station and sub-layers, effort, catch (quantity, length, weight) by species, laboratory studies (otolith removal of certain sized, otolith measurements, gonad maturation stages)

5. *Area (maps, coordinates)*

Survey area is given in the map below

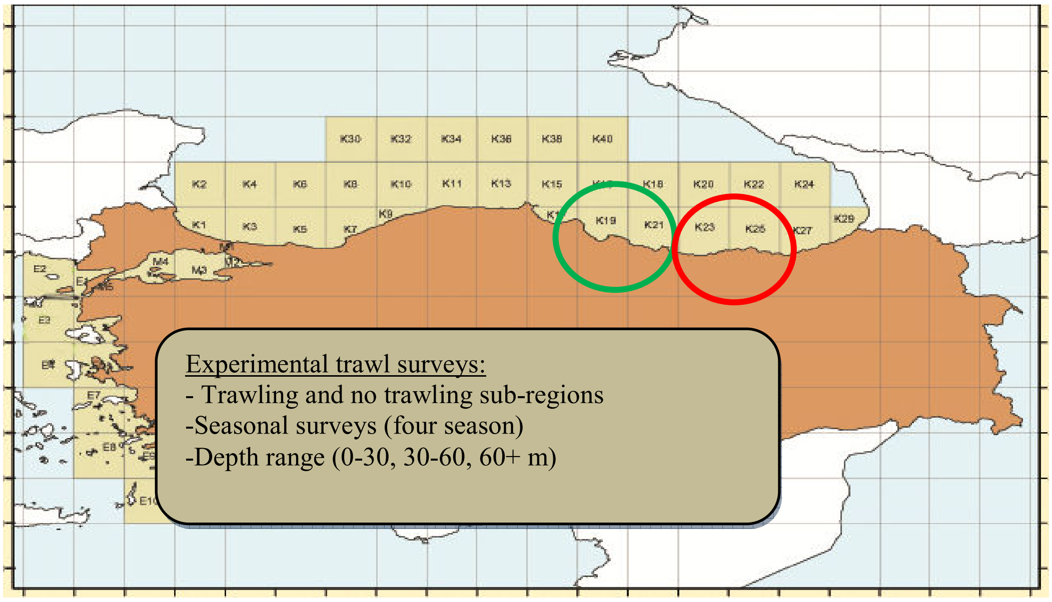


Figure 35 Experimental trawling area scheme.

6. Gear characteristics (including schemes, TTTs)

Sketch of the trawl has not drawn yet. Mesh size in the cod end is 12 mm.

7. Research vessel

R/V "SURAT-1" of CFRI (Age: 28,OAL: 24 m, Width: 6.57 m, gross tonnage: 76.38 GRT, Engine: 365 HP, speed: 8 knot) is used in the surveys.

Figure 36 Fishing vessel trawling.

8. Justification (for using gears)

9. Models/Assessment

Biomass/stock abundance will be estimated with the equation given above.

10. Gaps in data collection (recommendations to fill)

11. Knowledge gaps

Lack of research staff by means of quality and quantity may be effective on the success of field studies, data quality and the assessment at the end.

12. Recommendations

The field studies in the survey conducted in the last two year/two seasons. In order to make better assessments, monitoring activities has been recommended due to provide time series data and to understand variation of the seasonal dynamics effectively.

13. Progress level of the project

A total of 153 trawling operations were done in 2010 and 2011.Physical and chemical measurements of the water column (80 m) were done by CTD probe in each sampling stations. Assessments will be completed in 2012.

XX. A PRELIMINARY STUDY ON STOCK ASSESSMENT OF STRIPED VENUS *CHAMELEA GALLINA* LINNAEUS, 1758) IN WESTERN BLACK SEA (SINOP-CIDE-KASTAMONU-TURKEY)

1. Method

Swept area

2. Description

In order to estimate striped venus stocks by swept area method, hydraulic dredges are used in the project supported by MFAL between 01.01.2011-30.06.2013. It is the main gear used to harvest this species in the Black Sea. Vessel speed is fixed about 2 knots and water pressure to hydraulic dredge is 2 bars, time is taken 3 minutes at various depths and localities. Main task is to determine the abundance of striped venus per square km. per h.

Equation of Sparre and Venema (1992) and Avєar (2005) is used to calculate the area swept in one hour;

$a=D*h*X_2$, where a: Area swept by dredge (km^2), D: Distance swept (km), h: Dredge length (km), X_2: Cathability coefficient of dredge (it is related with the rate of individuals remained in the dredge to the amount enters, also shows the selectivity, it is accepted as 0.5). Swept distance is calculated by.

D=V*t : where; V: speed of the vessel during operation and t: Operation time.

Yield of biomass per square km in different sub areas regarding different depths (4 sub layers as 0-5m, 5-10m, 10-15m ve 15-20 m) is calculated by;

B=cw/a*q (Saville, 1977; FAO, 1980; Avєar, 2005)

where B:Yield in unit area (kg/km^2), cw: mean yield calculated from experimental dredgings (kg), a:swept area (km^2) and q: cathability coefficient (=0.5 as an assuption).

Total stock abundance is estimated by:

$N = (n . A) /a$ (Gulland, 1969 ve 1977; Ricker, 1973),

where N: population size (kg), A: Total area surveyed (km^2), a: dredged (swept) area (km^2) and n: mean quantity of catch (kg).

Length-weight, length-heigth and length- width relationships also are derived.

Ageing will be done by observing thin sectioned shells and used for estimate age-length and age weight parameters.

Natural and Total Instantaneous mortality rates are calculated. F= 0 due to the survey location is no fishing zone. M is calculated by using Pauly's equation;

$$\log(M) = -0{,}0066 - 0{,}279 \log(L_\infty) + 0{,}6543 \log(K) + 0{,}463 \log(T)$$

where; L_∞ and K VB growth parameters, T: Annual mean bottom temperature (C^0).

Exploitation rate is estimated by $E = F/Z$ (after the location is open for fishing), where F: Instantaneous fishing mortality rate (yr^{-1}) and Z: Instantaneous total mortality rate (yr^{-1}).

3. *Species*

Striped venus *Chamaela gallina*
Rapana and other mollusca sharing the same habitat

Figure 37 Mussels from the Black Sea

4. *Ecosystem considerations (type of data collected)*

Main aim of the survey is to provide data in order to better management os striped venus stocks in Sarıkum-Cide area using a fishing vessel and fishing gear of fisherman operating in 4 sub layers 0-5m, 5-10m, 10-15m ve 15-20 m. arasındaki alanlarda yapılmaktadır.

Survey region is divided 5 subareas as Cide (Tosun Cape-Kerenpe Cape), Inebolu (Kerenpe Cape-Çatalzeytin), Turkeli (Turkeli-Ayancık), Ayancik (Ayancık-Gebelit) and Sarikum (Gebelit-Inceburun). Total of 172 dredge hauling is planned. Stock assessment sampling will be performed in reproduction season (July) and other samplings in other months (February, May, September, November) will be done for population studies using traditional dredges (20 dredgins from each of sub areas and layers).

Figure 38 Mechanical dredge.

Stock estimations and stock parameters will be compared with other regions.

Samples (about 2 kg) from different sub areas and layers are transferred to the laboratory to count and weight. Then, individual length, height, width, total weight and shell weight, wet meat weight are recorded. Sub samples of shell are taken for each length groups for age determination.

5. Area (maps, coordinates)

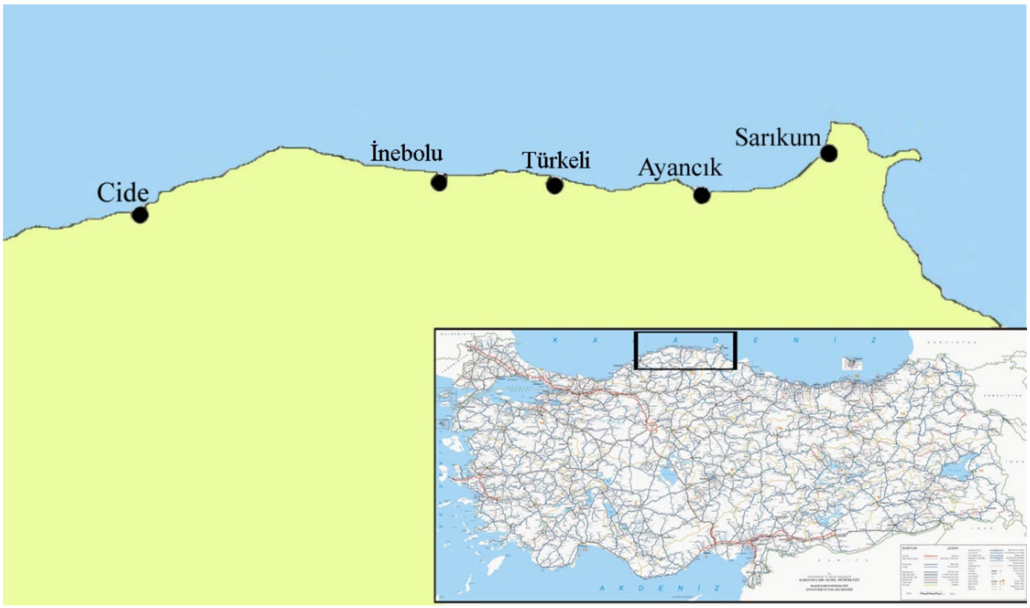


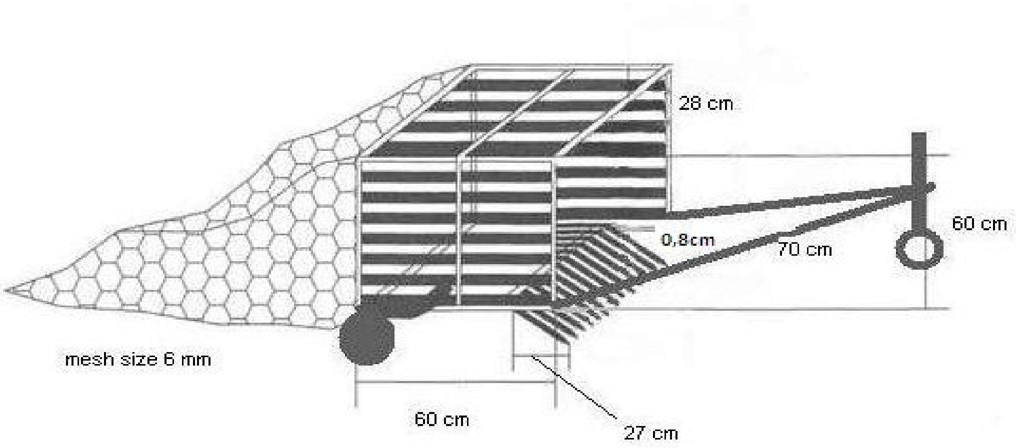
Figure 39 Sampling stations.

Research area is located between the coordinates of N:41º51’940’’E:32º51’860’’ and N:42º01’440’’E:34º54’150’’, at 0-20m depths.

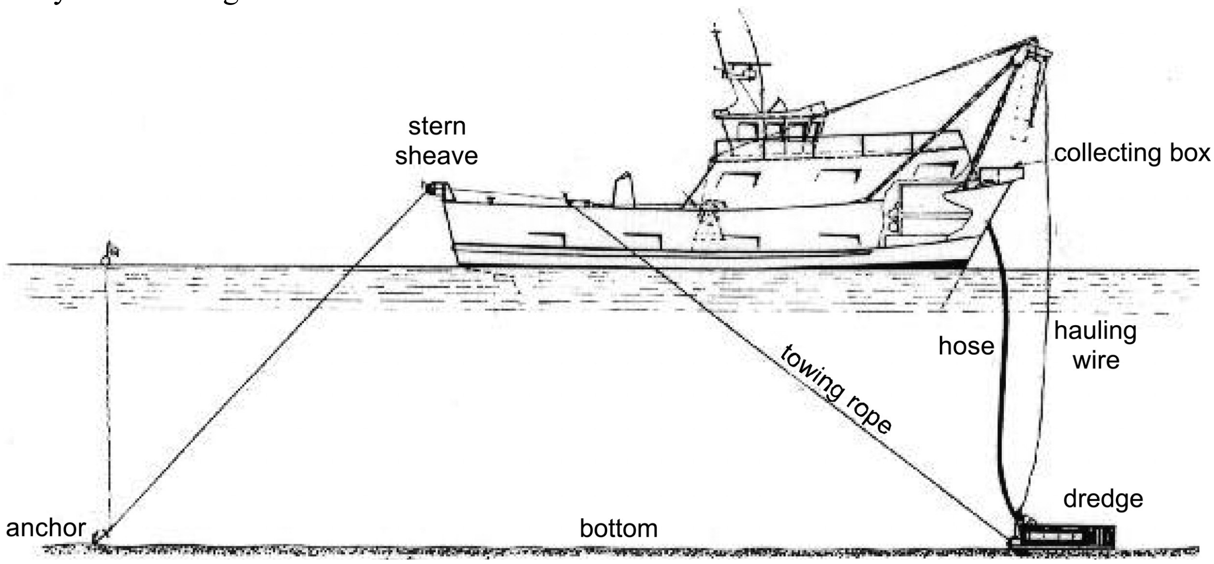
6. Gear characteristics (including schemes, TTTs)

7. Mesh size, mm

Mechanical (traditional) dredge: Mouth opening measures: 60*60*28cm knife length 27 cm, mesh size 6 mm.



A.Hydraulic dredge:



B.

Height: 20 cm, Length: 170 cm, Width: 300 cm, Sieve distance: 8.5 mm

Figure 40 Scheme of the A.hydraulic dredge and B.operational position.

8. *Justification (for using gears)*

The reason to use different dredges:

Hydraulic dredge is the best gear for stock assessments due to operational availability in large areas,

Due to high costs of hydraulic mechanical dredge is preferred for population studies

9. *Gaps in data collection (recommendations to fill)*

Financial problems enforced the project to be carried out with the vessels and gears of fishermen, and a second survey in summer would have been better for stock assessment,

Temperature, salinity and Ph of the sea water are the physical parameters measured in the survey. But there is lacking of suspended solid materials, chlorophyll-a, dissolved O_2 data.

10. Knowledge gaps

11. Recommendations

Considering the commercial value of this species, regular monitoring surveys are needed.

XXI. STOCK ASSESSMENT OF BLACK SEA ANCHOVY USING ACOUSTIC METHOD AND ESTABLISHING A MONITORING MODEL FOR NATIONAL FISHERIES DATA COLLECTION PROGRAM

1. Method

Hydroacoustic survey

2. Description

Two research vessels (RV SURAT-1 and BİLİM II) are used in the surveys equipped with transducers (38 kHz). There is a consensus on the use of this frequency among Mediterranean countries with the protocol MEDIAS.

Project duration is 4 years. All data related wintering migration of anchovy will be transferred to GIS. Surveys will covers the fishing season between October and March.

Besides acoustic data, midwater trawling will be done to obtained biological data on anchovy and will be supported by the data provided from the samples obtained from commercial fishing vessels in the survey area.

The main aims of the project are to assess the anchovy stocks by hydroacoustic method and to establish a monitoring model for data collection program of Turkey in order to rational use of achovy population.

3. Species

Engraulis encrasicolus ponticus
Engraulis encrasicolus maeticus
Horse mackerel
Sprat
Sardine

4. Ecosystem considerations (type of data collected)

Hydroacoustic data
Midwater trawl data on the line parallel to acoustic tracks,
Vertical temperature, salinity and flouresance profiles,
Satellite data on temperature, chlorophyll-a from SeaWiffs and Modis-Aqua
Market sampling
Physical and chemical parameters os sea water (temperature, salinity, clorphyll-a, dissolved oxygene, turbidity, pH)

5. *Area (maps, coordinates)*

It was aimed to carry out the Project in all EEZ of Turkey but limited up to 200 m depth contour in general. For the specific purposes for the investigation of probable wintering areas beyond 200 m depth, two lines off 50 to 75 nM in western, central and eastern Black Sea region in the first year of survey (2012). Pre-determined tracking lines for acoustic surveys are given below:

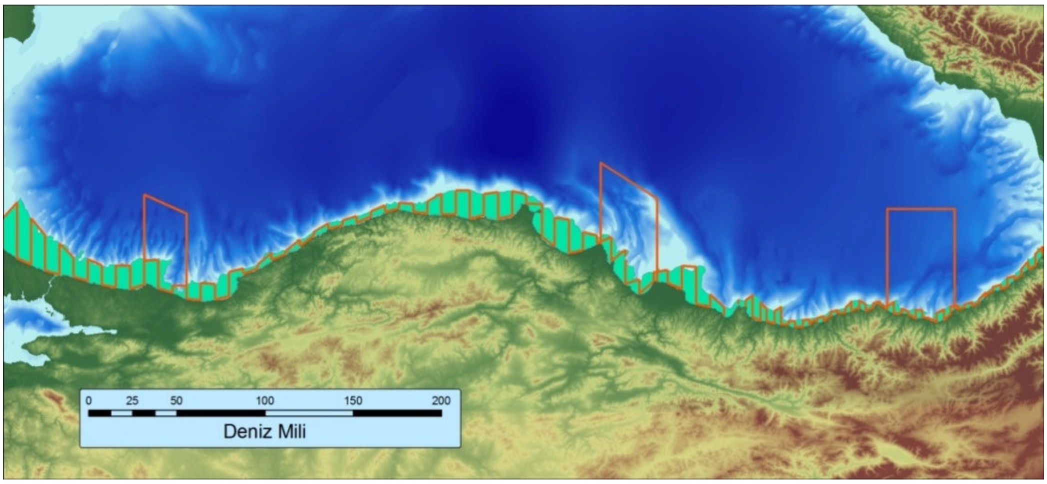


Figure 41 Sampling stations.

6. *Gear characteristics (including schemes, TTTs)*

Skectch of midwater trawl net (will be used with net sounder)

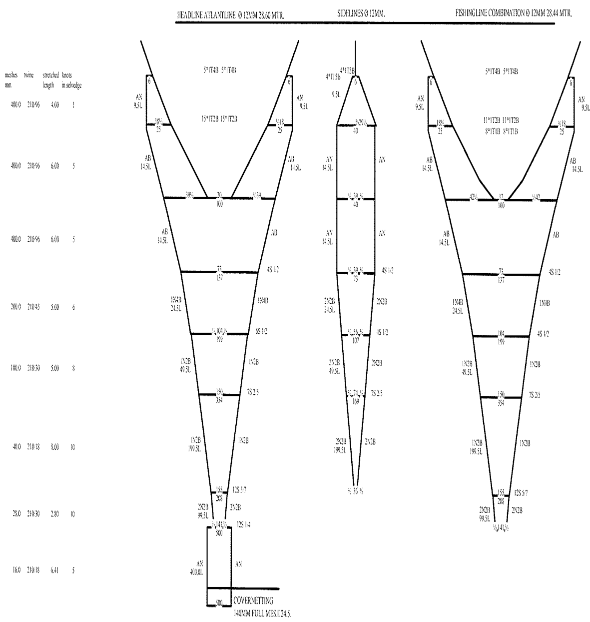


Figure 42 Characteristics of the research trawl.

7. *Mesh size, mm*

20/16 Mid 20/16 Mesh Wing Research Trawl 3.25M mesh #240

1.63M #84, .81M #60, 496.4mm #42, 203.2mm #42,
101.6mm #36, & 50mm #21 Nylon netting.
16mm Stable Braid riblines, breastlines, mini bridles
16mm Stable Braid headrope, 13mm Stable corner ropes, 9mm chain footrope.

8. Justification (for using gears)

9. Models/Assessment

In order to collect "true" echos (which may vary to time, location and reflection energy), calibration is very essential. In order to realize this all data related with place and angle of the transducer, instrument-system (gain) characteristics, environmental parameters which will be effect echo signals (speed, absorption coefficient) will be determined and recorded to the system before each cruise. Calibration will be done by the immersion of a sphere (copper or tungsten) which the target strength (TS) is known into the ensonified volume. Main aim is to assess TS strength truly by the system if there is difference between TS and reading values variation will be calculated and system recalibrated.

After saving daily, acoustic data will be filtered starting from area scattering coefficient which is equivalent to echo energy (dB) reflected from fish schools. Then distance x depth matrixes will be prepared as echograms which show surface bottom fish schools and other particles in the water column.

Additonally, there may be noises from other sources, parasites and water bubble reflections need to be separated.

Nautical area scattering coefficient (NASC) and target strength (TS) will be evaluated to calculate fish biomass. Filtration process will be applied by three stages;

Determination of threshold value (60 db for 120 kHz),

Surface and bottom lines,

Determination of the grids (Elementary Distance Sampling Unit-EDSU).

The next stage will be identifitaion and discrimination of the schools using filtered echos by EchoView software.

Statistical classification of the schools belonging each species will be defined by depth, width, length, perimeter, density, scattering rate of acoustic energy, mean reflection power, depth of sea, etc. (Simmonds and MacLennan, 2006).

Artificial Neural Network model will be used to define species according to the four different classification elements for anchovy, horse mackerel, whiting and sprat. Model uses school determinators as input parameters.

Table 15 ArtificialNeural Network parameters and remarks.

Parameter	**Rermarks**
Sv mean	Acoustic energy structure of the school
NASC	Standardized of reflection power to 1 nM (may be an indicator for school biomass)
Depth mean	Depth of sea where school is found
Corrected length	School length
Corrected thickness	School thickness
Corrected perimeter	Total perimeter of school
Corrected area	Total area covered by school
Image compactness	Additive compactness of the signals reflected by schools
Exclude below line range mean	Corrected depth of sea

Wintering areas will be determined using MEDIAS protocol (0.5 nM) by total anchovy NASC and longtitude and latitudes and by areal extrapolation analysis to map fish densities in different locations.

SURBA + (Survey based assessment) model will be used for the stock evaluations.

10. Gaps in data collection (recommendations to fill)

11. Knowledge gaps

12. Recommendations

XXII. GENERAL RECOMMENDATIONS:

The best method for demersal stocks is swept area by bottom trawl for whiting, red mullet and turbot. In case of Rapana, Anadara and mussels same method will be used by dredges.

Acoustic surveys is one of the best method for small pelagic but it is very time depended to migratory behavior of targeted species and many environmental interferences. It needs to be supported at least one of other stock assessment methods such as VPA or cohort, or egg and larval surveys.

BS countries need to be harmonized on data collection, sampling and record of landings as well as implementation of stock assessment methods especially on the common species exploited in their territorial waters.

A data base network is very essential to share the data and experiences gained in previous researches.

For the big fisheries ie anchovy, common research surveys should be carried out.

Monitoring studies, fishery indicators are very essential to be determined by common intentions (ie egg and larval abundances, CPUE, mortality rates from research samples).

Surveliance and control services in landing ports, at sea and in markets need to be carried out effectively.

XXIII. STOCK ASSESSMENTS FOR ANADROMOUS AND DEMERSAL FISH SPECIES BY SCIENTIFIC SURVEYS IN UKRAINE

Research Institute YugNIRO has more than half a century experience on assessment of fisheries stocks and environmental conditions in the Black Sea region by means of scientific surveys. This summary gives the short description of methods and results of the Black Sea MLR stock assessment by scientific surveys YugNIRO made after 1990, when our institute became Ukrainian.

1. Method

The area (swept area) method for assessment of fish stocks according to bottom trawl surveys data was first developed in the Soviet Union in the late 1960s and used in the Sea of Azov. For over forty years, YugNIRO have been using this method for stock assessment of pelagic and demersal fish species of the Black Sea. Research survey of demersal fish species are made by bottom trawls, in rare cases - midwater trawls.

2. *Description*

The stock abundance (N or B) is calculated with a common formula (Mayskiy, 1967):

N (B) = x · S/ s · q, where (1)

x is the mean catch at a given station,
S is the area of the survey,
s is the area covered by the given gear,
q is the catchability coefficient.
The trawling area is calculated with the following formula:
s = v · t · l, where (2)
v is the trawling velocity, m/min;
t is the trawling time, min;
l is the length of the trawl horizontal opening, m.

The length of the trawl horizontal opening (i.e. distance between the boards) depends on the trawl size and resistance, the board performance, as well as the trawl length, and could be determined with the help of the following techniques:

1. To test the angle (α) between warps with the known length (a): $l = 2a \cdot \sin(\alpha/2)$
2. To tie buoys to the boards and measure the distance between the buoys floating on the surface.
3. To tie the trawl boards with threads of the definite length and observe at what length the thread does not break.

Table A1 summarizes catchability coefficients for anadromous and demersal fishes; these coefficients were estimated through direct and indirect counts.

Tables 16 Catchability coefficients for anadromous and demersal fishes

Species, gears	q=0,1	q=0,15	q=0,25	q=0,275	q=0,3	q=0,5
Acipenser gueldenstaedtii, bottom trawl	-	-	-	-	-	+
A. stellatus, bottom trawl	-	-	-	-	-	+
Huso huso, bottom trawl	-	-	-	-	-	+
Raja clavata, bottom trawl	-	-	-	-	+	-
Dasyatis pastinaca, bottom trawl	-	-	-	-	+	-
Squalus acanthias, bottom trawl	-	-	-	+	-	-
– *Merlangius merlangus*, bottom trawl	-	-	+	-	-	-
Mullus barbatus, bottom trawl	-	-	+	-	-	-
Psetta maxima maeotica, bottom trawl	-	+	-	-	-	-
Psetta maxima maeotica, midwater trawl	+	-	-	-	-	-

Traditionally, the mean catch at a given station is computed as the arithmetic mean of catches taken at all the surveyed stations:

$$x = \frac{\sum_{i=1}^{n} x_i}{n}, \quad (3)$$

where

x_i is the catch at a station and n is the number of the surveyed stations.

Here, the essential condition for use of the arithmetic mean is that fish is uniformly or normally distributed over the entire sea area. But as a rule, catches at the stations were distributed asymmetrically. Therefore, we usually use one of the following methods (Methodology of fishery…, 2005):

1. Transformation of the asymmetric distribution to the normal one.
2. Rule of "three σs".
3. α - truncation.
4. The α - winsorization method.

Another approach to the stock assessment without computation of the mean catch is the isolines method. This technique allows for drawing isolines of areas with the same density of the fish distribution.

With both these approaches, the input data are taken from the data base which comprises observations collected during trawl surveys.

3. *Species*

Anadromous and demersal species (*Acipenseridae*, Whiting, Turbot, *Rajiformes*, Dogfish, Turbot, and Red mullets)

4. *Ecosystem considerations (type of data collected)*

Oceanographic and Marine Meteorology parameters data were collected.

5. *Area (maps, coordinates)*

Surveys of *Acipenseridae* were carried out exclusively in Ukrainian waters of the North-Western part of the sea – in Karkinitsky Bay and adjacent water area (Fig. A1).

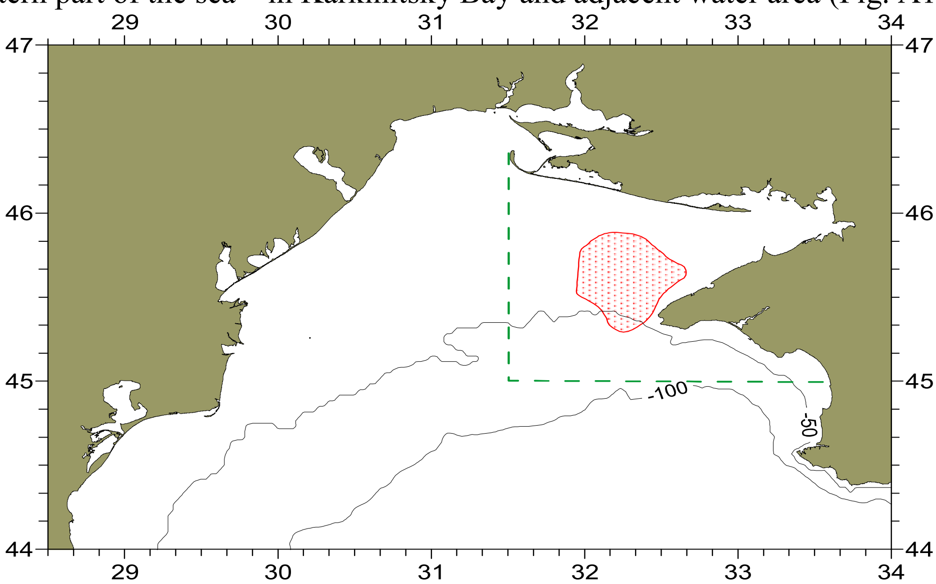


Figure 43 Surveys area of *Acipenseridae*

Surveys of demersal fishes were conducted in the former USSR' shelf waters of the Black Sea (before 1993) and exclusively in Ukrainian waters (1993-2008). In some sub-areas North-Western, Crimean, North-Eastern, North-Caucasian, Georgian sited were allocated (Fig A2).

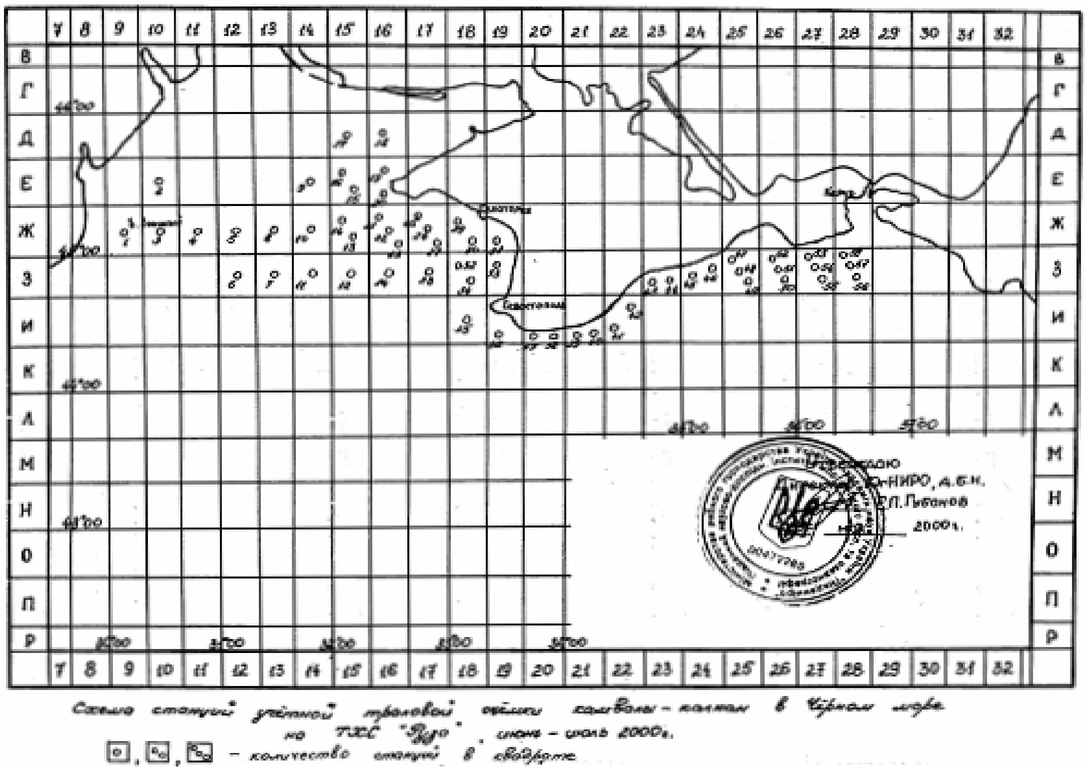


Figure 44 Surveys area for turbot stock assessment in Ukrainian waters

6. Gear characteristics (including schemes, TTTs)

As a rule, we used 24.6 meter bottom trawls. In some surveys midwater trawls 52/264 m were used. Trawls speed was usually 2.8-3.2 knots.

7. Mesh size, mm

Mesh size in the codend: was 6.5-8 mm.

8. Justification (for using gear)

Obviously, for best results when assessing stocks of demersal species, bottom trawling should be used. The use of midwater trawls allows catching sites of the shelf with heavy bottom topography, but in general their catchability is lower than that of bottom trawls.

9. Models/Assessment

Table A2-A4 summarizes biomass of anadromous and demersal fishes for catchability coefficients which have been used for the anadromous and demersal species (Shlyakhov, Akselev, 1993; Shlyakhov V. A., Lushnikova, 1995; Shlyakhov, 1997; Shlyakhov, Charova, 2003; Shlyakhov, Daskalov, 2008); these coefficients were estimated through direct and indirect counts.

Table 17. Biomass of anadromous and demersal fishes estimations (tons) in 1991surveys in the Black Sea*

Species	Area**	S, km^2	q=0,1	q=0,15	q=0,25	q=0,275	q=0,3	q=0,5
March 1991								
APG	NW	1800	-	-	-	-	-	25300
APE	NW	1800	-	-	-	-	-	6900
HUH	NW	1800	-	-	-	-	-	2500
September 1991								
DGS	GEO	740	-	-	-	6989	-	-
	CAU, NE, CRI	6860	-	-	-	14511	-	-
RJC	GEO, CAU, NE, CRI	7600	-	-	-	-	4800	-
STI	GEO, CAU, NE, CRI	7600	-	-	-	-	4700	-
October 1991								
TUR	NW	41830	-	7000	-	-	-	-
	CRI	600	-	1267	-	-	-	-
	NE	4540	-	5533	-	-	-	-
	CAU	1310	-	667	-	-	-	-
	GEO	740	-	333	-	-	-	-

*Species: APG – *Acipenser gueldenstaedtii*, APE – *A. stellatus*, HUH – *Huso huso*, RJC – *Raja clavata*, STI – *Dasyatis pastinaca*, DGS – *Squalus acanthias*, WHG – *Merlangius merlangus*, MUT – *Mullus barbatus*, TUR – *Psetta maxima maeotica*;
**Area: NW – North-Western, CRI – Crimea, NE –North-Eastern, CAU – Caucasian, GEO – Georgian

10. Gaps in data collection

After 1991, surveys of demersal fish species were conducted on different types of vessels. In some cases, midwater trawls were used. Surveys were not conducted every year. From 2002 to the present, surveys have been carried out on fishing vessels unsuitable for research at the expense of the ship-owners, which greatly reduced the quality of the collecting data obtained. For qualified data collection in marine expeditions, enough well-trained young professionals were not available. Accordingly, the reliability of holistic methods dropped.

11. Knowledge gaps

The absence of direct estimates of catchability coefficients of all the fishing gear used.

Table 18. Biomass of anadromous and demersal fishes estimations (tons) in 1992-1993 surveys in the Black Sea*

Species	Area	S, km^2	q=0,1	q=0,15	q=0,25	q=0,275	q=0,3	q=0,5
March-April 1992								
APG	NW	1900	-	-	-	-	-	36700
APE	NW	1900	-	-	-	-	-	4300
HUH	NW	1900	-	-	-	-	-	1800
September-October 1992								
WHG	NW	41830	-	-	70700	-	-	-
	CRI	600	-	-	600	-	-	-
	NE	4540	-	-	19100	-	-	-
	CAU	1310	-	-	17100	-	-	-
RJC	NW, CRI, NE	46970	-	-	-	-	7700	-
	CAU	1310	-	-	-	-	600	-
STI	NW, CRI, NE	46970	-	-	-	-	4000	-
	CAU	1310	-	-	-	-	0100	-
DGS	NW, CRI	42430	-	-	-	48200	-	-
	NE, CAU, GEO	5850	-	-	-	15100	-	-
TUR	NW	41830	-	7400	-	-	-	-
	CRI	600	-	420	-	-	-	-
	NE	4540	-	4200	-	-	-	-
	CAU	1310	-	220	-	-	-	-
MUT	NW	20680	-	-	840	-	-	-
	CRI	150	-	-	40	-	-	-
	NE	2880	-	-	1170	-	-	-
	CAU	520	-	-	550	-	-	-
March-April 1993								
APG	NW	1570	-	-	-	-	-	16300
APE	NW	1570	-	-	-	-	-	4100
HUH	NW	1570	-	-	-	-	-	2000
April-May 1993								
DGS	NW	12420	-	-	-	16874	-	-
	NE	2880	-	-	-	13326	-	-
September 1993								
TUR	NW	9550	-	7610	-	-	-	-
	CRI	450	-	600	-	-	-	-

* Abbreviations as in Table. A2

Table 19. Biomass of anadromous and demersal fishes estimations (tons) in 1993-1998 surveys in the Black Sea*

Species	Area	S, km^2	q=0,1	q=0,15	q=0,25	q=0,275	q=0,3	q=0,5
				March 1994				
APG	NW	580	-	-	-	-	-	3220
APE	NW	580	-	-	-	-	-	1280
				April-May 1994				
DGS	NW, CRI, NE	20200	-	-	-	36,000	-	-
RJC	NW, CRI, NE	20200	-	-	-	-	0,900	-
TUR	NW, CRI, NE	20200	-	8210		-	-	-
				November-December 1994				
APG	NW	580	-	-	-	-	-	2560
APE	NW	580	-	-	-	-	-	790
				February-March 1998				
APG	NW	2030	-	-	-	-	-	6270
APE	NW	2030	-	-	-	-	-	1560
HUH	NW	2030	-	-	-	-	-	290
				September 1998				
WHG	NW, CRI, NE	22290	-	-	34200	-	-	-
DGS	NW, CRI, NE	22290	-	-	-	-	32000	-
RJC	NW, CRI, NE	22290	-	-	-	-	1400	-
TUR	NW, CRI, NE	22290	-	8400	-	-	-	-
				June-July 2001				
TUR	NW, CRI, NE	17300	-	9900	-	-	-	-
				June-July 2002				
TUR	NW, CRI, NE	17300	-	10000	-	-	-	-
				September 2003				
TUR	NW, CRI, NE	17300	-	10000	-	-	-	-
				September-October 2004				
TUR	NW	10300	-	8370	-	-	-	-
	CRI, NE	3400	-	450	-	-	-	-
				September-October 2005				
TUR	NW	17300	10006	-	-	-	-	-
	CRI, NE	3400	195	-	-	-	-	-
				June 2006				
TUR	NW	17300	9505	-	-	-	-	-
	CRI, NE	1185	990	-	-	-	-	-
				February-March 2008				
APG	NW	4200	-	-	-	-	-	120
APE	NW	4200	-	-	-	-	-	340
HUH	NW	4200	-	-	-	-	-	560

* Abbreviations as in Table.

12. Recommendations

Demersal surveys should be carried out every year.

Surveys of demersal species must be carried out using standard gear and from the board of a similar of vessels.

All surveys should be accompaned by oceanographical parameters at least in the near boottom layer of water column in a place of trawling.

The implementation of these recommendations is not possible without an increase of state support for marine research of YugNIRO.

XXIV. STOCK ASSESSMENTS OF PELAGIC STOCKS BY HYDROACOUSTIC SURVEYS

1. Method

Hydroacoustic method of biomass assessment of the dense fish aggregations using an echointegrator.

2. Description

This method is based on using a specific device – an echointegrator, which sums up echo sounder signals, reflected from fish aggregations. While carrying out the YugNIRO surveys, calibrated echo sounders EK-50 and EK-400 for scientific research and echointegrators QD made by companies “SIMRAD” and also “SIORS” (USSR) were used (Artemov, Chashchin,.1982; Manual of Hydroacoustic…, 1984) Determination of the fish target strength was made by fishing of their aggregations, using midwater trawls with calibrated trawl probe, sewn into the trawl net bag (fig. B1).

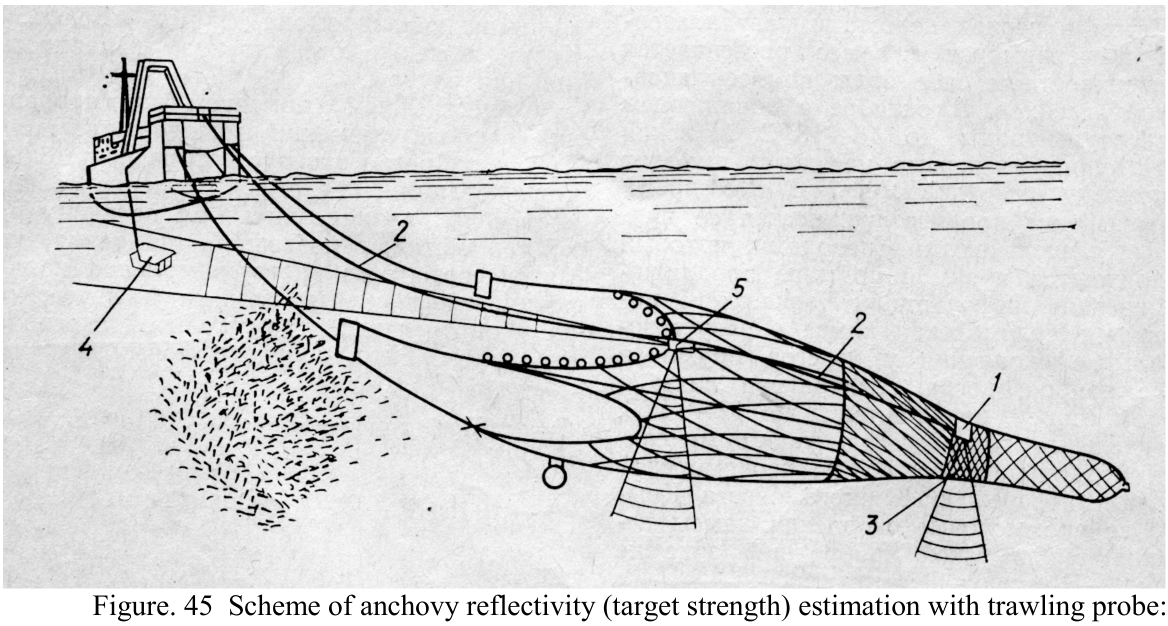


Figure. 45 Scheme of anchovy reflectivity (target strength) estimation with trawling probe: 1 - trawling probe vibrator; 2 – probe cable; 3 – close-meshed insertion; 4 – receiver of trawling probe “Furuno”; 5 - trawling probe “Furuno”.

In order to define the margins of fish aggregations distribution, preliminary reconnaissance survey was conducted. While carrying out the main survey, the vessel covered the area of fish aggregations distribution using tacks: the denser the aggregations were, the more often tacks were used. The detected aggregations with the echointegrator averaged means were drawn onto the tablet, sites with close values were combined into strata.

3. Species

Anchovy, sprat

4. Ecosystem considerations (type of data collected)

While carrying out hydroacoustic surveys, vertical and horizontal distribution of water temperature was assessed.

5. Area (maps, coordinates)

The anchovy surveys were conducted in the South-Eastern Black Sea near the coasts of Georgia (fig. B2). The sprat surveys were mainly conducted in the North-Western Black Sea (fig. B3).

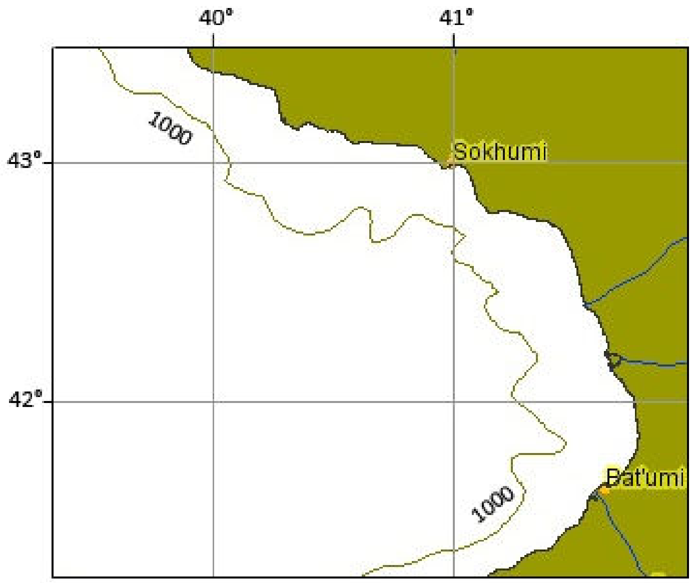


Figure 46 The area of anchovy hydroacoustic surveys (Sukhumi-Batumi)

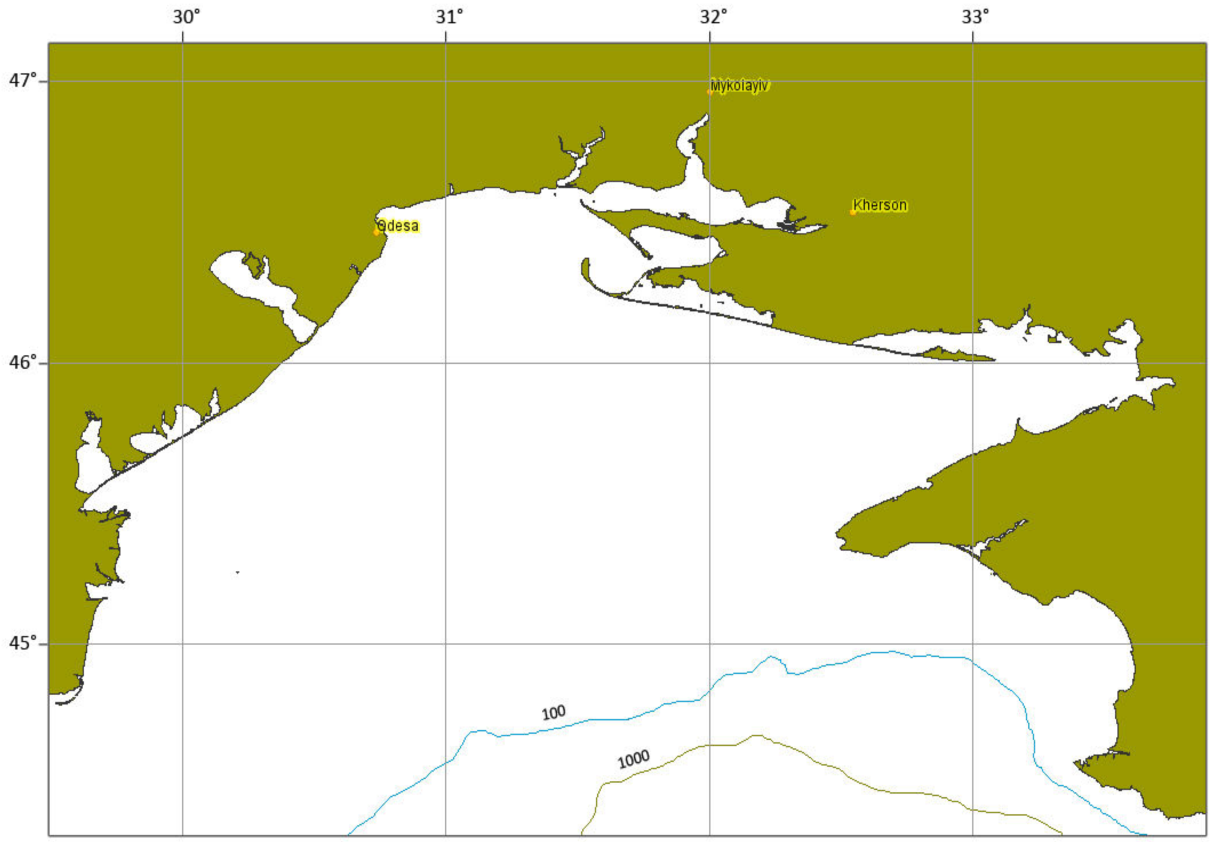


Figure 47 The area of sprat hydroacoustic surveys (North-Western Black Sea)

6. Gear characteristics (including schemes, TTTs)

Midwater trawls of common constructions were used for aggregations fishing.

A special trawl with elongate codend was used to determine target strength of fish in the aggregations.

7. Mesh size, mm

Mesh size in the codend was 6.5 mm.

8. Justification (for using gears)

Trawling was necessary for determining species and size-weight composition of the fish aggregations.

9. Models/Assessment

Aggregations biomass at a certain area (**B**) was calculated with to the formula:

B = k·m·I·S, were

k – calculated parameter, covering features and operating mode of the used device and fish target strength in aggregations;

m – average fish mass;

I – averaged values of the echointegrator readings;

S – aggregations area.

The data on the conducted in 1990-2003 hydroacoustic surveys are given in Table. B1.

10. Gaps in data collection (recommendations to fill)

The anchovy and sprat aggregations are characterized by considerable changes in behaviour during the day. Unfortunately, while conducting the surveys, fish behaviour changes were not studied at different times of the day. It gives grounds to doubt that optimal time was chosen for every survey. In order to dispose any doubts, it is recommended to conduct the research of fish bahaviour changes at different times of the day before conducting any further surveys, and according to the obtained results, plan the survey time.

Complete cessation of the hydroacoustic surveys in Ukraine became a great disadvantage for the data collection. In order to recommence them, the state should provide an appropriate research vessel, grant financing for the equipment purchase and expeditions, and train a highly qualified sonarman.

11. Knowledge gaps

The anchovy aggregations can be of high density. Due to this fact, the energy of the received echo signals is greatly absorbed, which results in less strength of the echo signals, reflected from the aggregation. This leads to underestimation of fish aggregations biomass, which cannot be currently defined due to the knowledge gap.

Table 20 The YugNIRO hydroacoustic surveys of pelagic fish in 1990-2003

Time	Species	Area	Biomass of agglomerations, thousand tons
Winter of 1990-1991	anchovy	Georgia	0 (commercial aggregations were absent)
April-June 1991	sprat	Shelf of the USSR and Romania	70
January 1992	sprat	Georgia	165
May-beginning of June 1992	sprat	Northern part of the sea	100
August 1992	sprat	Northern part of the sea	285
End of May-beginning of September 1993	sprat	Northern part of the sea	The surveys were carried out at local areas, so the biomass assessment is not given.
End of September 1994	sprat	At the Crimean coasts	40
December 1994	Azov anchovy	At the coasts of North Caucasus	133
June-August 1995	sprat	Ukrainian shelf	100
September-October 1997	sprat	At the Crimean coasts (area of Sevastopol-Evpatoriya)	The survey was carried out at the local area, so the biomass assessment is not given.
1997 1998	anchovy	Georgia	190
1998-1999	anchovy	Georgia	350
May-July 1999	sprat		
November 1999	Azov anchovy	At the coasts of North Caucasus	34
December 1999	anchovy	Georgia	380
February 2000	anchovy	Georgia	200
December 2000	anchovy	Georgia	280
November 2001	Azov anchovy	At the coasts of North Caucasus	16
December 2001	anchovy	Georgia	250
May-June 2002	sprat	Ukrainian shelf	700
December 2002 – March 2003	anchovy	Georgia	250

12. Recommendations

It is recommended to recommence hydroacoustic surveys of anchovy, sprat and horse mackerel in Ukraine.

It is recommended to recommence collaboration activities between Ukraine and Georgia on hydroacoustic surveys of anchovy and horse mackerel at the coasts of Georgia.

It is recommended to conduct horse mackerel and anchovy surveys in December-January and sprat surveys – in May-June.

It is rational to conduct preliminary reconnaissance survey and research of fish behavior changes during the day before each record survey. The obtained results will optimally assist in arranging the survey.

It is rational to accompany hydroacoustic surveys with the research of horizontal and vertical distribution of water temperature.

XXV. STOCK ASSESSMENTS BY ICHTHYOPLANKTON SURVEYS IN THE BLACK SEA

1. Method

The assessment of number of pelagic fish eggs and larvae using the fishing data by ichthyoplankton nets, while carrying out ichthyoplankton surveys, was made by area methods. Spawning stock assessments were carried out according to data of YugNIRO ichthyoplankton surveys by Sette- Ahlstrom' method and Parker' method. In the Black Sea Sette-Ahlstrom method was first used in 1985 (Arkhipov et al,1987), the method of Parker - in 1988 (Arkhipov et al, 1991).

2. Description

2.1. Method ichthyoplankton surveys

At each station of the ichthyoplankton survey the vessel, following its gyration, conducted oblique fishing by the Bongo net (fig. C1) at the water layer of 0-25 m (for fish spawning in summer) or of 0-100 m (for fish spawning in winter).

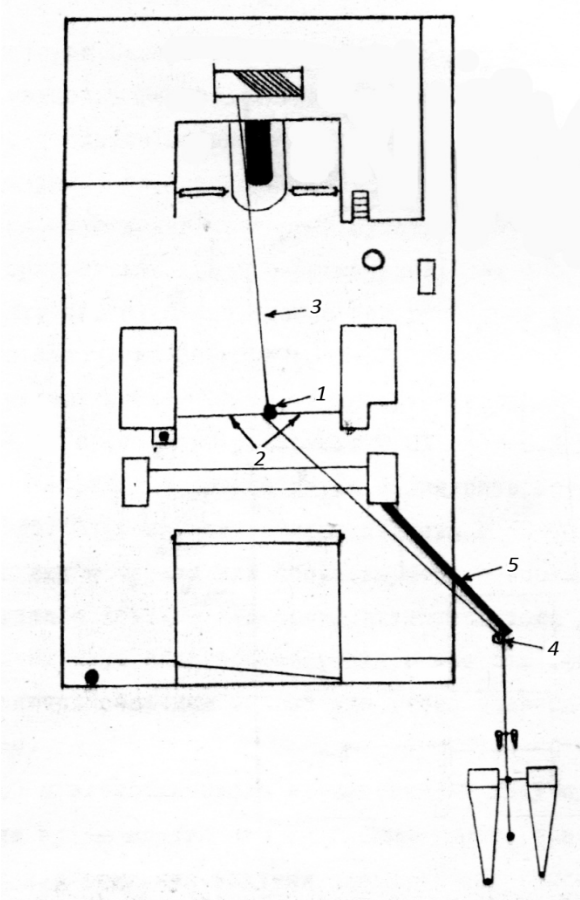


Figure 48 The scheme of equipping of a vessel class of SRTM (with stern trawling) to work with Bongo net: 1 - block-count, 2 - procrastinations, 3 - cable Ø 7-9 mm, 4 - regular blocks, 5 - cargo boom.

The Bongo net consists of two net bags, their catch being combined into one sample for each station. The collected ichthyoplankton samples were fixed in the 3-4% formalin solution. Number of eggs was determined in the laboratory according to species and developmental stages of those eggs. Eggs number calculation was conducted using the area method. Catchability coefficient was accepted as 1.

Using the catching data for the area unit at each station, the whole survey area was divided into parts with close values. Afterwards an average catch for each part was estimated and, according to its area, total eggs number was calculated. Then numbers of eggs at the whole survey area were summed.

2.2. Method Sette and Ahlstrom

Sette-Ahlstrom method is based on ichthyoplankton surveys covering the whole spawning area and the entire spawning period. It is designed to provide direct estimates of spawning stock.

Spawning stock biomass (**B**) is determined by the formula:

$$\mathbf{B = P \cdot m / F \cdot n}$$ where,

P is the amount of eggs launched in the breeding season,

m is average weight of spawners,

F is average individual fecundity,

n is sex ratio.

The amount of eggs launched in the breeding season was determined from the equation:

$$\mathbf{P = (P'_1 \cdot t_1 + P'_2 \cdot t_2 + P'_3 \cdot t_3) / t'}$$ where,

$\mathbf{P'_1, P'_2, P'_3}$ is the total production of eggs in each survey (assuming that the daily production of eggs, determined taking into account the mortality rate, remains constant throughout the survey and half of the intervals between adjacent surveys),

$\mathbf{t_1, t_2, t_3}$ is duration of the surveys plus half the interval between surveys (number of days before the start or end of the spawning period),

t' is duration of egg maturation (presumed by us to be equal to 1.5 days)

To estimate **P'** the number of eggs in the layer 0-25 m was determined. According to the daily stations mortality rate of eggs during the transition from I-II to III-IV stages of development was calculated. Duration of breeding season presumed to be equal to 110 days (Arkhipov et al, 1987). $\mathbf{t_1}$, $\mathbf{t_2}$, $\mathbf{t_3}$, **m** and **n** are determined by the actual data in surveys.

2.3. Method PARKER

The PARKER method is based on data of the only ichthyoplankton survey, so it is less expensive than the SETTE-AHLSTROM method. The method of Parker estimated the biomass of the spawning stock of the ichthyoplankton survey area.

Spawning stock biomass (**B**) is determined by the formula:

$$\mathbf{B = P/a \cdot b \cdot c}$$ where,

P is the daily egg production (24 hours) in the survey,
a is the relative portion fecundity (number of eggs launched / ton),
b is the percentage of females that are daily spawning,
c is the percentage of females in the spawning agglomeration.

To calculate **P** using accounting data eggs in various stages of its development (from ichthyoplankton survey), duration of egg maturation (presumed by us to be equal to 1.5 days) and mortality rate of eggs during the transition from I to II, II to III and III to IV stages of development. **a, b, c** are determined by the actual data in survey.

3. Species

Anchovy, horse mackerel, red mullet, sprat, whiting

4. Ecosystem considerations (type of data collected)

While conducting ichthyoplankton surveys, vertical and horizontal distribution of water column temperature, salinity parameters, oxygen and nutrients concentrations were assessed.

Biological state of adult fish was studied: size-weight, sex and age composition, eggs production.

5. Area (maps, coordinates)

Ichthyoplankton surveys of fish, spawning in summer, were carried out:

- in 1991 – in all the waters under jurisdiction of the USSR, Bulgaria and Romania;
- in 1992 – in the waters under jurisdiction of Ukraine and Russia;

- in 1993 – in the waters adjacent to the Crimean Peninsula.

Ichthyoplankton surveys of fish, spawning in winter, were carried out in 1991: in February – in the waters of the USSR, in April-May – in all the waters under jurisdiction of the USSR and Romania.

6. Gear characteristics (including schemes, TTTs)

he Bongo net consists of two metal pipes, 61 cm in diameter, fixed to the towing cable. Bags with mill gas are fixed to the pipes (fig. C2). In the center of the inlet pipes the device for water flow measurement is attached by the cord, it is used to calculate the volume of colated water.

To catch adult specimens in order to study their biological state, midwater trawls of common construction were used.

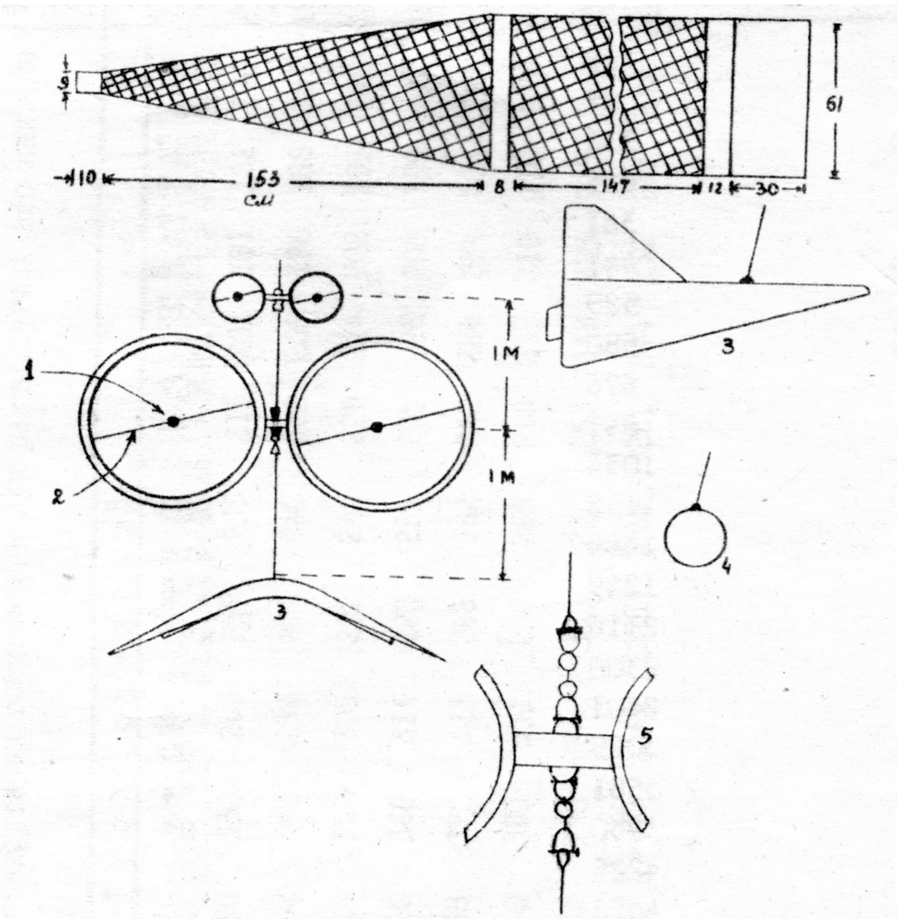


Figure 49 The scheme of network Bongo net design: 1 - counter flow of water, 2 - nylon thread, 3 - V-shaped plate-load 1.2 m long, used for trawling at a speed more than 3 knots, 4 - load with weight of 45 kg, used in trawling at a speed less than 3 knots, 5 - magnified image of fastening a cable to the Bongo net

7. Mesh size, mm

The Bongo nets, used at the surveys, were made of mill gas # 21, which corresponds to the mesh size 336 micron.

In midwater trawls, used to catch adult fish, mesh size in the codend was 6.5 mm.

8. Justification (for using gears)

While conducting oblique fishing, the Bongo net allows calculating eggs and larvae number in the whole water column, where they are distributed.

Trawling was necessary to determine the species of spawning fish and study their biological state (size-weigh, sex and age composition, eggs production).

9. Models/Assessment

The data on the YugNIRO ichthyoplankton surveys (after 1990) are given in table C1.

Table 21 YugNIRO ichthyoplankton surveys of the Black Sea fish in 1991-1995

Time	Species	Area	Biomass of spawners, thousand tons
February 1991	Sprat, whiting	Waters of the USSR	-
April-May 1991	Sprat, whiting	Waters of the USSR and Romania	-
End of May-end of August 1991	Anchovy, horse mackerel, Red mullet	Waters of the USSR, Romania, Bulgaria	Anchovy: 116 (Sette and Ahlstrom method) and 68 (Parker's method); Horse mackerel – 4,7
End of May-end of August 1992	Anchovy, horse mackerel, Red mullet	Waters of Ukraine and Russia	Anchovy: 18 (Parker's method)
End of May-end of June 1993	Anchovy, horse mackerel, Red mullet	At the Crimean coasts	-
Mid June; end of July-beginning of August 1995	Anchovy, horse mackerel, Red mullet	Waters of Ukraine	Anchovy: 96 (Parker's method)

10. Gaps in data collection (recommendations to fill)

While conducting the surveys, there were gaps in data on survival rate (or mortality) of eggs at different stages of development. Assessment of survival rate influences greatly the assessment of spawning stock, estimated by the eggs production. Thus, inaccurate assessments of eggs survival rate result in considerable errors in the spawning stock assessment.

Besides, the data on biological state of spawning fish were obtained not for all the survey areas, which can also lead to the increase of errors in spawning stock assessment.

However, complete cessation of ichthyoplankton surveys in Ukraine became the greatest drawback in data collection. To recommence them, the state should provide an appropriate research vessel and grant financing for the expeditions.

11. Knowledge gaps

Availability of systematic error in the assessment of spawning stock by the eggs production is still unclear. The assessments, obtained earlier, give grounds to doubt that such errors do exist.

12. Recommendations

It is recommended to recommence in Ukraine ichthyoplankton surveys of fish spawning in summer and winter.

It is recommended to conduct ichthyoplankton surveys of fish spawning in summer from the end of May to August, and of fish spawning in winter - in December-March.

While conducting ichthyoplankton surveys, it is necessary to combine - adult fish catches in all the survey areas in order to study species and biological state (size-weigh, sex and age composition, larvae production) of the spawning fish with determining of eggs survival rate at different stages of their development, as the survival rate changes considerably with the years and environmental conditions.

It is extremely important to accompany ichthyoplankton surveys with the research of horizontal and vertical distribution of water column parameters and hydrometeorological parameters.

XXVI. FRY (JUVENILE) SURVEYS IN THE BLACK SEA

1. Method

Research of distribution and number of juveniles (fry) using trawling.

2. Description

As a research catching gear, pelagic trawl of N.N. Danilevskiy construction was used (fig. D1). This trawl is used for fishing in the upper layer of water 5 m deep. Trawling is conducted at a slight gyration, length of the trawl warps is 80 m (up to the stern), trawling speed is about 2.5 knots. The codend with catch is raised onto the block and thoroughly washed, so that larvae and fry were washed into the lower codend part. Then the codend is unbound above the jar with water, rinsed, large fish and jellyfish are withdrawn, larvae and fry are colated through the gas.

The catch data are drawn onto the map, number of larvae and fry are determined by the area method. Catchability coefficient was accepted as 1.

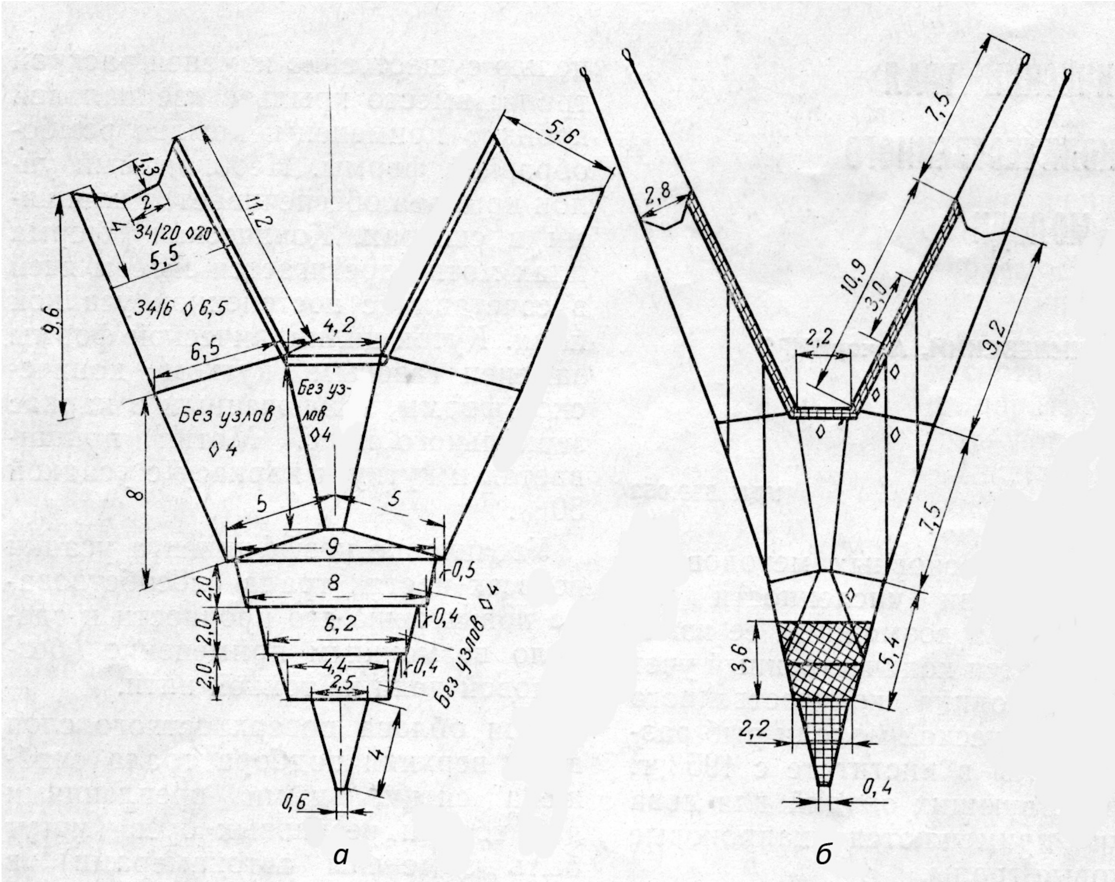


Figure 50 23-meter symmetrical juvenile pelagic Danilevskiy's trawl: a - cutting, b - in fit

3. Species

Anchovy, horse mackerel, red mullet, sprat, whiting

4. Ecosystem considerations (type of data collected)

Oceanographic (temperature, salinity, and standard hydrochemistry – nutrients, oxygen, pH) and Marine Meteorology parameters (sea surface atmosphere pressure, air temperature, wind direction an velocity, wave height, etc.) data were collected and processing in accordance with: Manual on hydrological work…1977; Instruction marine hydrometeorological stations…, 1991. While conducting fry surveys, zooplankton development (including gelatinous plankton) was estimated, samples of juveniles were collected for further research of their nutrition.

5. Area (maps, coordinates)

Fry survey of fish, spawning in summer, was conducted in 1991 in the waters of the USSR, Romania and Bulgaria (fig. D2), in 1992 – in the waters of Ukraine and Russia. Fry survey of fish, spawning in winter, was conducted in 1991 in the waters of the USSR and Romania (fig. D3), in 1992 – in the waters of Ukraine and Russia. Thus, the area of fry surveys in 1992 was significantly reduced to compare with the year 1991.

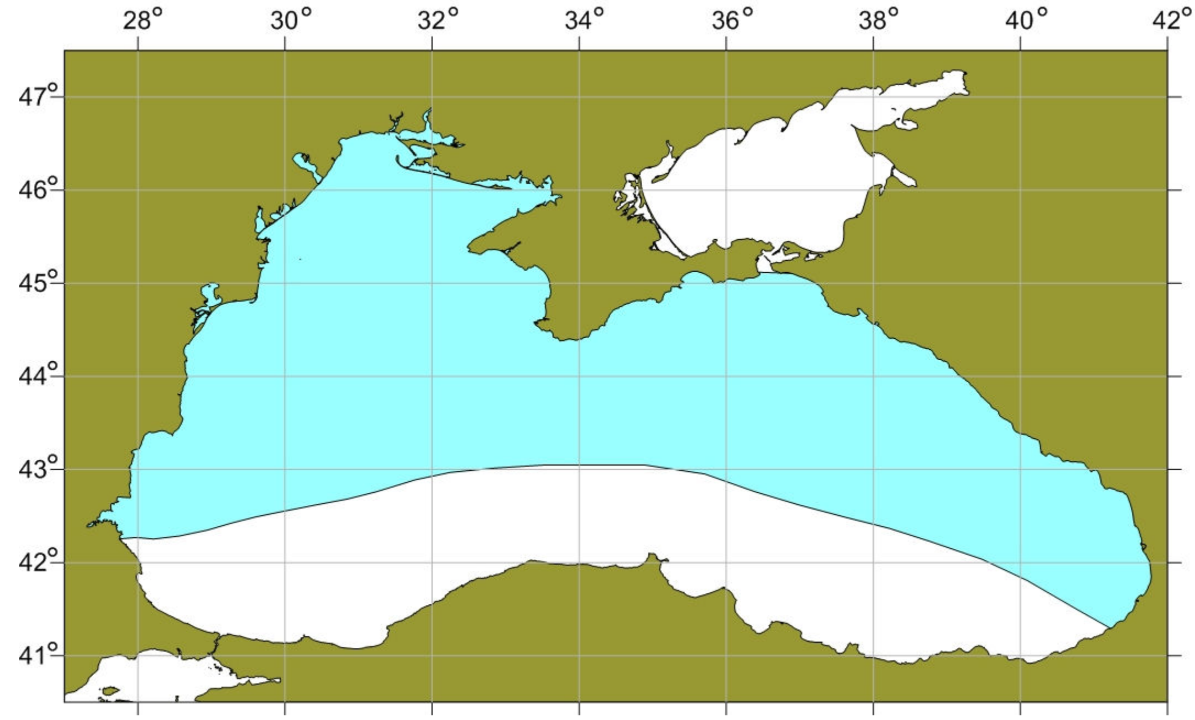


Figure 51 The area of fry survey of fish spawning in summer (1991)

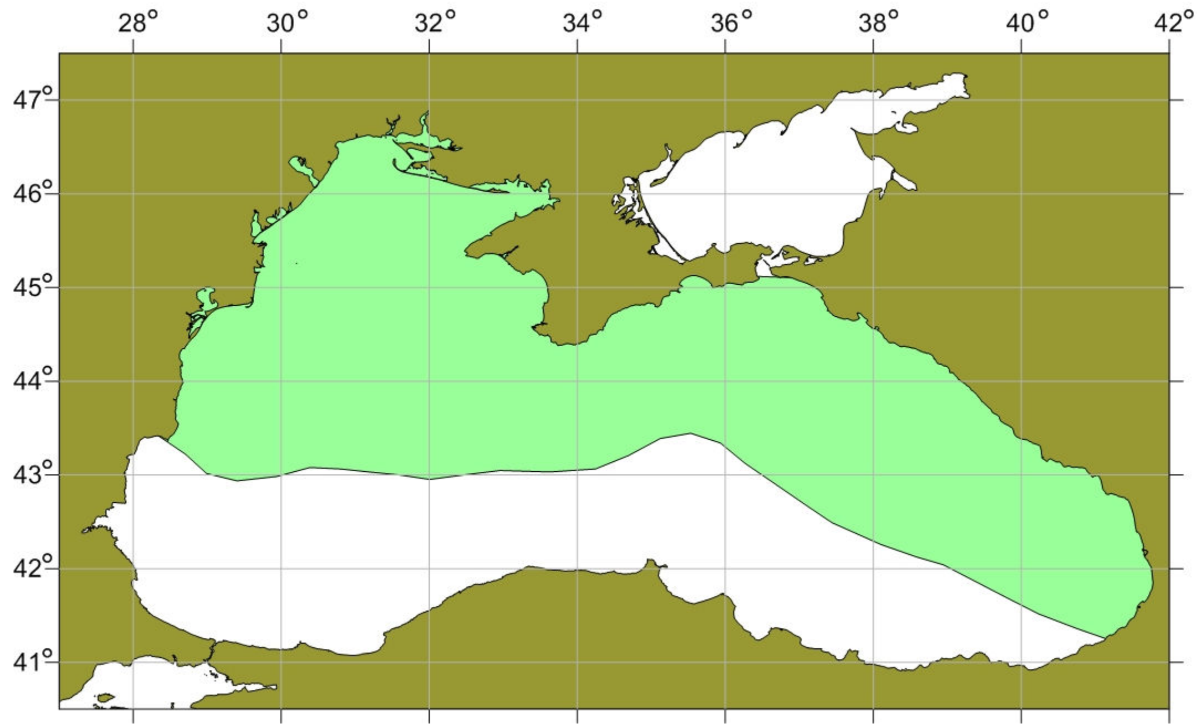


Figure 52 The area of fry survey of fish spawning in winter (1991)

6. Gear characteristics (including schemes, TTTs)

The trawl of N.N. Danilevskiy construction is a 23-m symmetrical pelagic trawl (fig. D1). In order to provide high catching efficiency of fry, the main parts of the trawl are made of nodeless nylon with a small mesh size, and the codend is made of capronic gas. In order to provide fishing in the surface layer the trawl upper line is supported by special fastening for eight drift buoys in the braid. The lower line is loaded under every buoy by the chain sections, 7 kg each. The elongate ends of both lines are fixed to pelagic trawl boards.

7. Mesh size, mm

Nodeless net has a mesh size of 3-4 mm, and the codend is made of gas # 11 (mesh size – 750 micron).

8. Justification (for using gear)

Using the trawl with a small-mesh net part and gas codend allowed decreasing record trawl selectivity with regard to the fry size. Catchibility of the trawl increases due to the fact that the trawl catches even the upper surface layer, where there is the most juvenile concentration. Thus, it increases accuracy of the obtained data.

9. Models/Assessment

Calculating the number by the area method according to the survey data is given in the section A.

The data on the YugNIRO fry (juvenile) surveys (after 1990) are given in table D1.

Table 22 The YugNIRO fry (juvenile) surveys of the Black Sea fish in 1991-1995

Time	Species	Area	Abundance
April-May 1991	Larvae and fry of the fish spawning in winter (sprat, whiting)	Waters of the USSR and Romania	Sprat – 93.4 billion; whiting – 6.0 billion.
July-August 1991	Larvae and fry of the fish spawning in summer (anchovy, horse mackerel, red mullet)	Waters of the USSR, Romania and Bulgaria	Anchovy – 5.6 billion; horse mackerel – 0.4 billion; red mullet – 0.05 billion
April-May 1992	Larvae and fry of the fish spawning in winter (sprat, whiting)	Waters of Ukraine and Russia	Sprat – 193.1 billion; whiting – 12.6 billion
July-August 1992	Larvae and fry of the fish spawning in summer (anchovy, horse mackerel, red mullet)	Waters of Ukraine and Russia	Anchovy – 3.2 billion; horse mackerel – 0.2 billion; red mullet – 0.01 billion
End of July-beginning of August 1995	Anchovy, horse mackerel, red mullet	Waters of Ukraine	Anchovy – 2.2 billion; horse mackerel – 0.6 billion; red mullet – 0.5 billion

10. Gaps in data collection (recommendations to fill)

While conducting the surveys, possible changes in the juvenile behaviour during the day were not studied. Such research can be carried out using the retrospective data. In case the changes occur and are essential, assessment of the fry number, obtained earlier, should be updated.

Complete cessation of the fry (juvenile) surveys in Ukraine became a great drawback for the data collection. In order to recommence them, the state should provide an appropriate research vessel and grant financing for the expeditions.

11. Knowledge gaps

A great gap in our knowledge is lack of data on vertical distribution of juvenile of fish spawning in winter, that is why scientific grounds of the data, obtained by fishing of water surface layer only are not clear (it is suggested that sprat and whiting fry can occur in the whole water column, which is not polluted by hydrogen sulfide).

The data on vertical distribution of juvenile of fish spawning in summer are also scarce.

12. Recommendations

It is recommended to recommence in Ukraine fry surveys of fish spawning in summer and winter.

It is recommended to conduct fry (juvenile) surveys of fish spawning in summer in July-August, and of fish spawning in winter – in April-May.

It is rational to conduct preliminary reconnaissance survey and studies of changes in fish behaviour during the day before each record survey. The obtained results can assist in optimal arrangement of the survey.

It is rational to accompany fry surveys with the research of horizontal and vertical distribution of water temperature and studies on zooplankton development (including gelatinous plankton) and fry nutrition.

XXVII. STOCK ASSESSMENTS FOR MUSSELS *MYTILUS GALLOPROVINCIALIS* BY SCIENTIFIC SURVEYS

1. Method

The area (isolines) method according to benthic surveys data.

2. Desription

Benthic surveys were carried out in the North-Western of the Black Sea, Karkinitsky Bay in September 1991-1994 using Peterson or “Ocean” grab (Zolotarev et al., 1994). At the bank, "Mezhvodnoe" at each station, two samples were taken, the "Tetis-2” - one sample. The distance between adjacent stations was 1 mile. Surveys range is covered in depth from 10 to 40 m.

The assessment of the mussel biomass was held by isolines method. Isolines drew through the points with a specific biomass (g / m^2) 5, 500, 1,000, 2,000, >2,000 or 100, 200, 500, 1000, >1000. For each range average specific biomass and area were calculated. The biomass range was determined by the multiplication of their values. The summation of the range of biomass gave a total biomass of the survey area.

3. Species

Mussel, *Mytilus galloprovicialis*

4. Ecosystem considerations (type of data collected)

Length and weight of mussels were measured. The length series were grouped in steps of 5 mm. Commercial size mussels (50 mm) were counted especially. In addition to the mussels the composition of benthic biocoenoses was determined in surveys. In the benthic surveys, the extent of anthropogenic sedimentation (in cm) of banks was assessed. (Terentyev, 2003).

5. Area (maps, coordinates)

The two sub-areas (mussel banks "Tetis-2" and "Mezhvodnoe") were identified in the North-Western Black Sea, Karkinitsky Bay (Fig E1).

6. Gear characteristics (including schemes, TTTs)

Petersen grab used at the surveys had an area capture of bottom ground equal to the 0.1 m^2, "Ocean" grab – 0.25 m^2.

7. Mesh size, mm

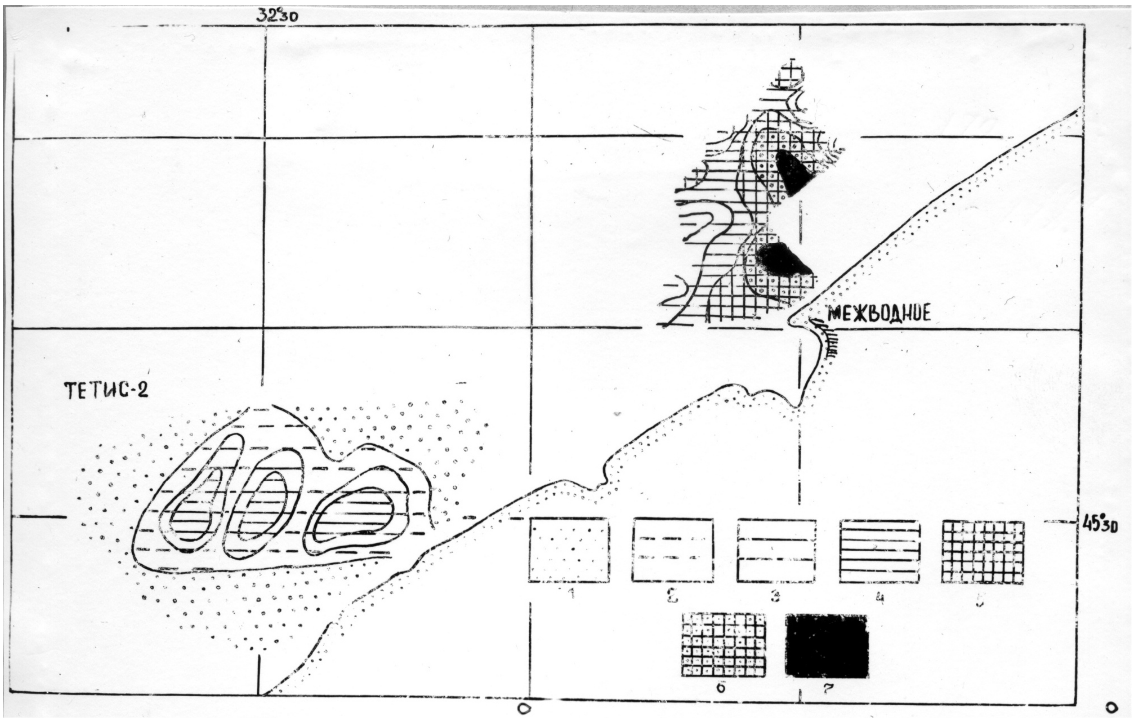


Figure 53 Surveys area for mussels in the North-Western Black Sea, Karkinitsky Bay

8. Justification (for using gear)

9. Models/Assessment

The mussel biomass is estimated by the area (isolines) method. Total and commercial abundance of mussel was estimated from surveys samplings (Table E1).

Table 23 Biomass of mussel estimations (tons) in 1991-1994 surveys in the Karkinitsky Bay of the Black Sea (banks)

Year	S, km^2	Total biomass, t	Commercial biomass, t
mussel bank "Tetis-2"			
1992	117	76700	9100
1993	106	100008	15127
1994	127	44959	4281
mussel bank "Mezhvodnoe"			
1991	95	91700	38800
1992	81	77000	38900
1993	79	96425	34573
1994	52	122706	44830

10. Gaps in data collection (recommendations to fill)

In the 1991-1994 benthic mussel surveys of banks were covered with a variety of areas. After 1994 surveys began to be conducted not every year. Number of stations in the benthic surveys decreased so that the biomass estimates were not reliable.

11. Knowledge gaps

- Gaps on hydrological data (seasonal variations in velocity and direction of local currents);
- There is no assessment of IUU harvesting of mussels.

12. Recommendations

Full-scale benthic surveys should be conducted annually. They must be accompanied by regular seasonal hydrological observations. It is recommended to investigate IUU fishing on the banks of mussels.

The implementation of these recommendations is not possible without an increase in state support for marine research of YugNIRO.

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