Distribution and Discrimination of Anchovy, and Sprat in the Black Sea from High Frequency Sound Records

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High frequency (200 kHz) was used to identify anchovy, and sprat schools from over the entire trackline of broad-scale acoustical survey over a period of 4 years (1991-1994) in the Black Sea. Analysis of color enhanced echograms as well as trawl catches provided detailed morphological descriptions to discriminate aggregations of anchovy, and sprat together with characteristics of their habitat. Sprat showed fish school scattered in relatively, a thin layer near the bottom like semi-pelagic fish made up. Anatomy of the aggregation did not change between day and night, and there was no diel shift in the habitat. Anchovy formed the pole shaped schools as well as compact aggregation arising from bottom around the shelf break area to that as much high up as 30-70 m, during the day. Additionally, a striking point is that the anchovy in an appearance, of what looked to be pole shape school, stand ready on top of submarine steep cliff to escape down immediately in case of any disturbance to the school. There is a sharp discrimination between the schools of sprat and anchovy.

1. Introduction

For last few decades, acoustical methods for the stock assessment have scored significant goals over conventional catch methods. The concerns on acoustical methods in fishery research, and particularly in fish stock assessment and even in behavioral to etiological fields have markedly increased. Many advantages have overshadowed a few disadvantages of acoustic methods over the conventional methods. The method requires the sophisticated instrumentation, changes in design depending on the aims (field or experimental work) and high cost for data acquisition. However, acoustical applications reduce the time required for data collection and analysis, supply synoptic information, and make it possible to cover larger areas with high accuracy and reliability.

During the sea survey carried out for biomass estimation, it is not practical so easy to differ school of fish species from that of other fish species in composite fish population. This situation is one of biases done in biomass estimation for each species in sea and brings advantages of usage of acoustic toward negative end. Structure, pattern, and dynamics of schools improve the reliability of acoustic estimates and could be used for designing surveys. With regard to relationship observed between density in echo types and biomass, enhanced color echogram appearance could enable simple classification of survey into rich or poor category, and thus enable critical evaluation of acoustic biomass. Pierre and Levenez (1996) made a study for understanding the spatial distribution of fish schools. Marchall and Petitgas (1993) measured precision of acoustic fish abundance estimates by separeting the number of schools from the biomass in the schools.

Up to date, a few extensive acoustical study has been performed in the Black Sea. (Stepnowski *et al.*, 1993 and Mutlu, 1996). This study concerns acoustical discrimination of fish species abundantly found in the

Black Sea and the aim is to increase reliability in stock assessment for each species of specifically composite fish population during post-processing.

2. Material and methods

Acoustic data were collected with a facing-down 200 kHz dual-beam transducer towed just below the surface in the Turkish exclusive economic waters in the Black Sea (Fig. 1) in June 1991, on the Turkish continental shelf in January 1992 and February 1994 (Fig. 2).

A towed body was deployed off the starboard side of R/V 'Bilim'. The general towing speed was 6 to 7.5 knots. The echosounder collected the data about at about one ping per second. On each cruise, some mid-water trawl hauls (Fig. 3) were made to provide data with taxanomical composition of trawl catch as well as acoustic data recording was simultaneously made.

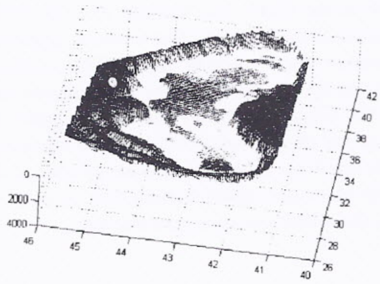
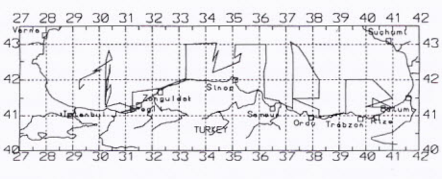
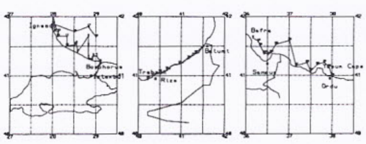


Fig. 1. Study area and the Black Sea bathymetry in 3D.



(a)



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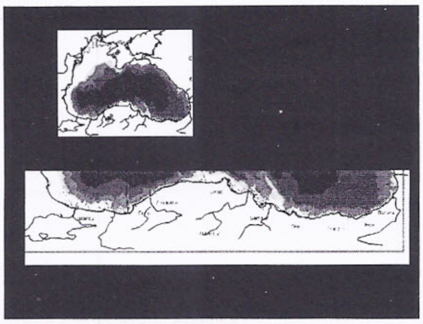


(c)

Fig. 2. The entire trackline of acoustic data collection in June 1991 (a), January 1992 (b), and January/February 1994 (c).

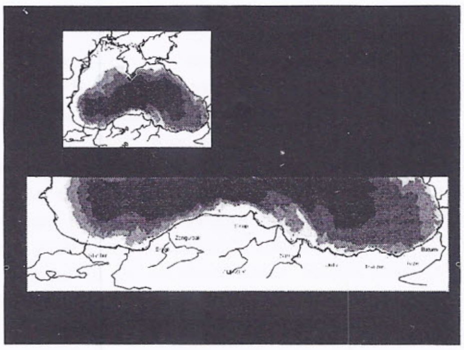


Fig. 3. Locations (Red line) where the mid-trawls were deployed in the Black Sea.

Real-time processing of acoustic records was made with BioSonics echo-integration software (BioSonics Echo Signal Processor; ESP, version 2.00, Model 221 Echo Integrator). Before processing row data recorded on Digital Audio Tape (DAT), background and ambient noise levels were visually fixed through scope of the ESP. Regarding to curve of the noise changing in vertical range (depth), the observed noise threshold was set to each strata. Back-scattering cross section per kilograms (σ_{bs}) was fixed constant at 1. The spatial resolution was about a distance integrated per 5 second pings during real-time run. So finally, the outputs were converted to volume backscattering strength (MBS) via the following equation:

$$sv= A*V^2 \qquad (1)$$

where A is scaling factor (Stepnowski et al, 1993), and V^2 is filtered and sum up output voltage coming from ESP,

$$Sv = 10 * \log_{10}(sv) \quad (2)$$

gives volume backscattering strength, regardless of σ_{bs}.

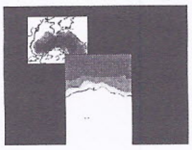
In other words, Sv is the target strength in a cubic meter.

MATLAB code was used in post-processing of MBS to get color enhanced echogram.

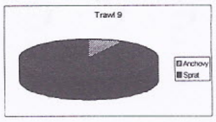
3. Results and discussion

High frequency (200 kHz) was used to identify the Black Sea anchovy, and sprat schools from over the entire trackline of broad-scale acoustical survey over a period of 4 years (1991-1994) in the Black Sea (Bingel et al, 1993, 1995). Since anchovy was predominant along the Turkish coast only in winter due to wintering of anchovy, winter cruises were mostly subjected to this study. Summer entire acoustic survey did not display significant signature of anchovy school formed along the coast because the northern coast of the Black Sea represented feeding ground for anchovy. Analysis of color enhanced echograms as well as trawl catches provided detailed morphological descriptions to discriminate aggregations of anchovy, and sprat together with characteristics of their habitat.

Anchovy formed the pole shaped schools as well as compact aggregation arising from bottom around the shelf break area to that as much high up as 60-90 m, during the day. Relatively, big size anchovy school with an acoustic cross of 0.8-1 nautical miles long and 40-70 m high was observed in suspension in the water column near off the continental shelf. Such school appeared to be very dense and compact and displayed higher volume backscattering and darker color on echogram. Local fishermen claimed that daily anchovy shifted its school further toward the 10-20 m deep-bottom so the habitat occurred at shoaled bottom at night. The school was entirely and homogeneously scattered from bottom to surface at night. Bingel et al (1995) and Stepnowski et al. (1993) reported that anchovy schools dispersed in water column were found mixed with small size organisms, and jellies. Additionally, a striking point is that the anchovy in an appearance, of what looked to be pole shape school, stand ready on top of submarine steep cliff to escape down immediately in case of any disturbance to the school (Fig. 4). Local fishermen postulated such schooling behaviour that the anchovy school could be ready to go down to deeper when purse-seine was deployed over the school.



(a)



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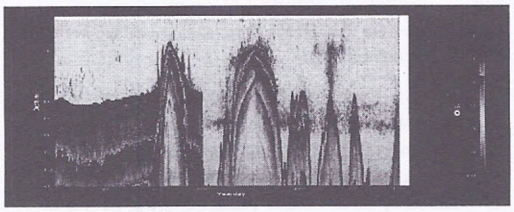
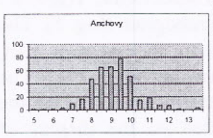


(c) | |

Trawl release Trawl recovery



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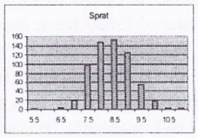
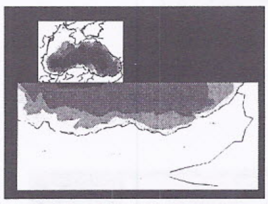
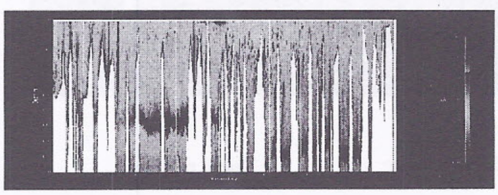


(e)

Fig. 4. Catch composition (b) of trawl 9 and corresponding acoustic trackline (a) and echogram (c), length distribution of the catch (d, e) (Catch amount anchovy is relatively high as compared with other trawls).

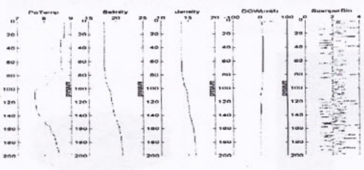


(a)



(b)16:01 23152 04:15//10:00 23:05

CTD cast

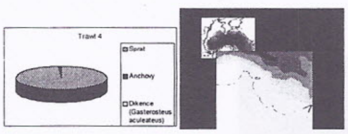


(c)

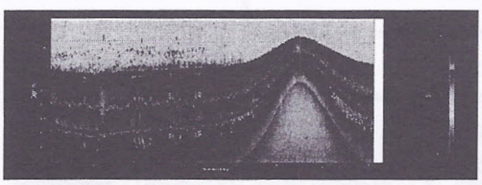
Fig. 5. Wintering ground (a) of main population of anchovy (b) in the Black Sea and vertical profile of CTD measurements (c).

Anchovy appeared likely to be stronger scatterer than sprat with regard to formation of dispersed school of sprat in relative to compact school of anchovy. Anchovy school generally reflected higher echo energy as much as up to a volume backscattering of -60 to –45 dB as ranged in a color of dark red to dark grey and black on echogram. Wintering and fishing ground of anchovy were recorded to be around Ordu, Trabzon , and Rize, east of Ordu from the echogram (Fig. 5). The region is relatively warmer than the western part, which is more favourable for anchovy life. The anchovy were observed over a rough bottom where the fish was predominantly recorded on the display of echogram (Fig. 5).

Sprat showed fish school scattered in relatively, a thin layer near the bottom like semi-pelagic fish made up. The school reflects lower echo (-70 to –65 dB in a color range of light red to dark red, and grey) than that anchovy sound back (Fig. 6).

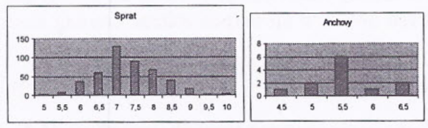


(a) (b)



(c) | |

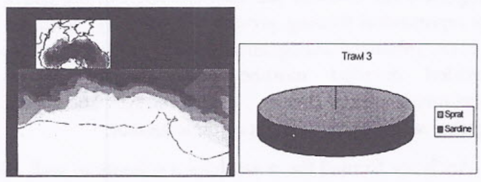
Trawl release Trawl recovery



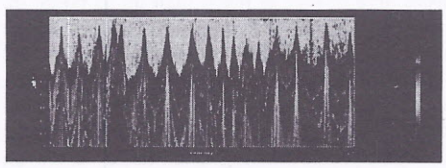
(d) (e)

Fig. 6. School pattern and trawl catch composed mostly of sprat and little amount of anchovy (b) with their length distributions (d, e) and near-bottom school of sprat on echogram(c).

Sprat widespread on the continental shelf of the Turkish Black Sea and prefer cold water of the sea. This study showed that main spreading area of sprat was from Eregli to Samsun, and was distributed over a flat bottom in contrast to anchovy. Those areas are areas having widest coastal shelf of the Turkish Black Sea. Bingel et al. (1993) substantiated that the highest biomass of sprat was found between Eregli and Sinop with extension to Samsun. Catch of trawls 3 and 4 deployed between Eregli and Samsun was composed of large amount of sprat, and little of anchovy and sardine (Figs. 6 and 7).



(a) (b)



04:40 12:51 18:10

← _________1.5 days _________-> (c)

Fig. 7. Continous acoustical records (c) showing main ground (a) of sprat population along the Turkish coast of the Black Sea.

4. Conclusions

Anchovy displayed a compact and dense school in a familiar vertical lineation signature generally arising from rough bottom in the Black Sea while sprat had loose and dispersed school close to flat bottom, resulting in that there is a sharp discrimination between the schools of sprat and anchovy. Those distinct patterns performed bioacoustictans to estimate absolute biomass more precisely by tagging the school during post-processing with MATLAB code.

5. Acknowledgements

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