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Some field observations on usefulness of searchlight sonar during Bluefin tuna (*Thunnus thynnus* L.) fishing activities in the Adriatic Sea

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The first field observations regarding to use of a searchlight sonar in the commercial fisheries, as well as some practical limitations that could appear are described in this paper. Some problems in sonar use, regarding to bluefin tuna purse-seine fisheries in Adriatic Sea, are presented.

The data presented in this paper was collected on board of the commercial purse-seiner while fishing bluefin tunas during July-August in the Adriatic Sea (Jabuka Pit). This fishing vessel was equipped with FURUNO CH-24 Colour PPI searchlight single-beam sonar system made for commercial purposes.

The importance of proper placement of the transducer on the hull, and disturbances that raised from its improper placement are noticed. The presence of wakes made by fishing vessels cruising over the fishing ground, were the main limitation for making acoustic observations in the surface layer. Also, in comparison to the ability of fishermen to spot the bluefin tunas close to the sea surface at more than 2000 meters, the effective ranges from 300 to 1200 meters achieved by this sonar was relatively short, and made no significant contribution to the search for fish. Under rough sea conditions (sea state: ≥4 Beauforts), it was impossible to use sonar, due to pitching and rolling of the vessel.

Key words: sonar, bluefin tuna (*Thunnus thynnus* L.), fishing, Adriatic Sea

INTRODUCTION

The bluefin tuna (*Thunnus thynnus* L.) off shore purse-seine fishing is one of the most important fishing activities on the large pelagic fish in the Adriatic Sea. Fishing season for bluefin tuna in the Adriatic Sea covers more or less the whole year, but these fishing activities are usually carried out during the warmer part of the year (May – October) when the weather conditions are favourable, i.e. good visibility and calm sea (TIČINA, 1993, 1997). In compliance with recommendations of the International Commission for the Conservation of Atlantic Tunas (ICCAT) the closure of purse seine fishery of tunas during the month of May in the Adriatic Sea has recently been noticed. Bluefin tuna fishing activities are in detail described by TIČINA (1994, 1999). Based on the TIČINA's unpublished data, the weight structure of the tuna population in the Adriatic Sea was recently described by SINOVČIĆ (1998) and SINOVČIĆ *et al.* (1999). The age structure of this part of bluefin tuna population was described by TIČINA and KAČIĆ (1998). Bluefin tuna is a species with swimbladder, and belongs to physoclist fishes. The individual specimens of tunas, as well as aggregated fish schools have relatively high target strength, usually higher than –40 dB, and can be easily detected by hydro-acoustic equipment (BERTRAND *et al.*, 1999; JOSSE *et al.*,1999).

So far, the hydro-acoustic methods in fisheries research in the Adriatic Sea have been frequently used by a number of researchers. Up to now, AZZALI (1980, 1981), AZZALI and BOMBACE (1984), AZZALI and LUNA (1988), AZZALI *et al.* (1984, 1993), as well as KAČIĆ (1980, 1981, 1983, 1988) and GRUBIŠIĆ *et al.* (1974), published a lot of papers dealing with hydro-acoustic researches in the Adriatic Sea. The common feature of the mentioned studies is the use of vertical down-looking acoustic systems (echo-sounders), and until now, no paper on practical use of sonar for fisheries purposes in the Adriatic Sea has been published.

Therefore, the aim of this paper was to test and describe usefulness as well as some practical limitations of the searchlight sonar in the commercial fisheries, particularly in bluefin tuna purse-seine fisheries in Adriatic Sea.

MATERIAL AND METHODS

The data presented in this paper was gathered on board of the commercial fishing vessel MARINERO during the months of July and August 2000. It is iron-made ship, 30 m long with 3 m draught, equipped with 447 kW powerful main engine that allows maximal cruising speed of 11 knots. The ship is equipped with FURUNO CH-24 Colour PPI searchlight sonar system. This kind of sonar is single-beam device, usually used by fishermen when searching for schools of fish (MacLENNAN and SIMMONDS, 1995). The transducer was mounted on a stalk, which extended for about one meter below the hull of the vessel, thus operating at 4 meters depth.

In this research, transceiver that worked at frequency of 60 kHz with output power of 1.2 kW was used. Beamwidth, measured at standard –3dB level, was 15 degrees in horizontal plane, and 12 degrees in vertical plane. During the searching activities, the beam automatically moved in 6 degrees consecutive steps in horizontal direction. Each sector 30 degrees wide in horizontal plane has been acoustically sampled by approximately 240 pings during the fish searching operation. Tilt angle of the transducer was controlled manually with precision of ±1 degree. With aim to search fish schools near the sea surface, transducer angle has been maintained usually between 0 and 2 degrees. The pulse-length was changed in the range from 2.6 to 15.6 ms, according to the desired effective range applied. In total, during this research, we made approximately 140 hour of acoustic observations, during daytime only.

The sonar system used in this research allows rejecting interference from ultrasonic equipment such an echo sounder, sonar, etc. on board of other boats as well as those on board of own ship. The propagation loss of sound in water was compensated by using the Time Varied Gain function (TVG). TVG function provided in this sonar was able to compensate propagation losses up to 1000 meters approximately.

Study area

Analysing data from marine environmental database of the Adriatic Sea (MEDAS) (DADIĆ and IVANKOVIĆ, 2001) from 1950 to 2000 year, during July-August period, it was found that surface temperature in this area varied between 20.50-25.80 ºC, with average values of 22.95 ºC (SD=1.194) in July and 24.28 ºC (SD=1.053) in August. In the same time, salinity varied between 37.32-38.71 psu, with average values of 38.26 psu (SD=0.226) in July and 38.07 psu (SD=0.446) in August. On field observations on temperature, measured by thermo sensor of the sonar, showed that temperature at approximately 3 m sea depth during daytime varied mostly between 25-26 ºC.

RESULTS AND DISCUSSION

Upon arrival on the fishing ground, fishing activities began by searching for bluefin tuna schools (TIČINA, 1994, 1999). According to fishermen's experience, not all bluefin tuna schools are favourable to be fished, but only those near the sea surface. Currently, the fishermen used to search for bluefin tuna schools observing the sea surface by naked eye or using binoculars.

As the first, the importance of adequate placement of transducer was noted. By direct underwater observation, we found out that stalk with transducer was situated approximately on the second third of the vessel hull length, and 0.8 meter off the vessel keel on the starboard side, below the engine room. Due to inadequate placement of transducer, the observed noise level was very high, especially along the longest vessel axis at speed higher than 5 knots. For this reason, it was impossible to make valid acoustic observations in the sectors between 345 and 015 degrees as well as between 165 and 195 degrees regarding to the vessel heading. Dominant sources of noise in those sectors were propeller, engine and hull vibrations. In addition to this, the wake produced by the ship itself is always very strong reflecting "object" that does not allow acoustic observations in the sector between 170-190 degrees regarding to the heading line of the cruising ship. The significant increase of the noise level was noticed as the vessel speed and number of engine cycles per minute (rpm) increased. This made a very serious limitation when the sonar is going to be used for following the movement of a fish school ahead of the cruising vessel. However, it could be improved by placing the transducer more ahead, toward the bow of the vessel.

In the other sectors, where it was possible to make acoustic observations we noticed that maximum distance that can be observed by sonar on the starboard and port side, depends mostly upon the speed of vessel and weather conditions. It was noticed as follows:

a) <u>Vessel stopped</u> (speed: 0-1 knots)

We found that the best sonar operating conditions were when the vessel was stopped, engine worked slowly and the sea surface was calm (sea state: 0-1 Beauforts). Due to the fact that the main engine worked at minimum power there were little noise produced by vessel itself, and the best signal-to-noise ratio was achived. It was possible to make acoustic observations up to 1200 meters from the port and starboard side. Because the fish schools were searched for close to the sea surface, the sounding beam was tilted horizontally (transducer angle: 0–2 degrees). In this position of the transducer, the sound waves spread through the surface layer only. Time Varied Gain (TVG) time was set on maximum, and gain between 90-100% of the maximum gain. With slightly rough sea surface (sea state: 2 Beauforts), the effective range of observation decreased to 800 meters, due to a noise caused by unwanted echo-signals generated by surface reflections and air bubbles near the surface. The unwanted surface reflections (Fig. 1) were easily eliminated by adjusting Time Varied Gain (TVG) level. Under rough sea conditions (sea state 3-4 Beauforts), it was very difficult to make acoustic observations at distance more than 400-600 meters, and sometimes the maximum range was less than 300 meters. Those ranges were determinate by pitching and rolling of the vessel itself. At the same time, gain and TVG time were adjusted (decreased). The maximum distances observed by sonar and optimal parameter settings of the equipment searching for fish schools in the surface layer, when the vessel was stopped, are shown in Table 1.

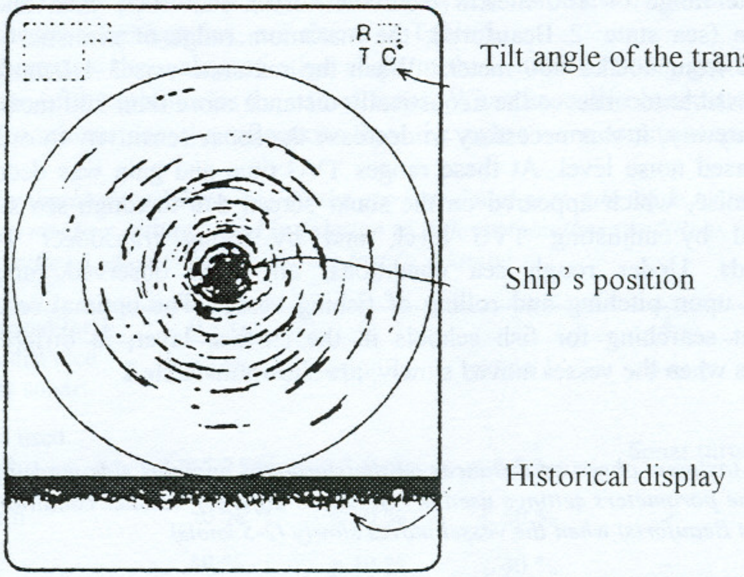

Fig.1. Unwanted echoes caused by surface turbulence on the sonar screen

Table 1. Maximum observed distances on the starboard and port side made by sonar and the parameters settings used in relation to different weather conditions (sea state in Beauforts) when the vessel was stopped

Sea state (Beaufort):	0 - 1	2	3	4	> 4
Maximum distance observed by sonar:	1200 m	800 m	400-600 m	≤ 300 m	0 m
Parameters used:					
Pulse length	15.6 ms	10.4 ms	5.2-7.8 ms	≤ 3.9 ms	Sonar turned off
Output Gain	90-100 %	70-80 %	60-70 %	50 %	-
TVG-time	90-100 %	70-80 %	60-70 %	50 %	-
TVG-level	40-50 %	60-70 %	70-80 %	90-100 %	-
Transducer angle	0°	0°	1°	2°	-

b) <u>Vessel moves slowly</u> (speed: 2-5 knots)

While the vessel moved slowly, we noticed that noise produced by vessel itself increased, particularly along the longest vessel axis, thus negatively affecting on signal-to-noise ratio. If the sea surface was calm (sea state: 0-1 Beauforts), it was possible to make the acoustic observations on the both sides of the vessel within the range of 800 meters from the vessel. However, even under slightly rough sea (sea state: 2 Beauforts), the maximum range of acoustic observations decreased from 800 to 600 meters. When the sea state was 3-4 Beauforts, it was hardly possible to observe the acoustically distance more than 300 meters from the vessel. Anyway, it was necessary to decrease the sonar sensitivity in order to avoid the increased noise level. At these ranges TVG time and gain was decreased. The surface noise, which appeared on the sonar screen due to rough sea surface, was eliminated by adjusting TVG level, and by tilting transducer 1-2 degrees downwards. Under rough sea conditions, all those observed ranges mostly depended upon pitching and rolling of fishing vessel. The optimal settings of the equipment searching for fish schools in the surface layer, at different weather conditions when the vessel moved slowly, are shown in Table 2.

Table 2. Maximum observed distances on the starboard and port side made by sonar and the parameters settings used in relation to different weather conditions (sea state in Beauforts) when the vessel moves slowly (2-5 knots)

Sea state (Beaufort):	0 - 1	2	3	4	> 4
Maximum distance observed by sonar:	800 m	600 m	300-400 m	< 300 m	0 m
Parameters used:					
Pulse length	10.4 ms	7.8 ms	3.9-5.2 ms	< 3.9 ms	Sonar turne d off
Output Gain	70-80 %	60-70 %	50 %	≤ 50 %	-
TVG-time	70-80 %	70-80 %	50 %	≤ 40 %	-
TVG-level	60-70 %	80-90 %	90-100%	90-100 %	-
Transducer angle	0°	0°	1°	2°	-

c) <u>Vessel moving fast</u> (speed: > 5 knots)

In these conditions, it was very difficult to obtain quality of the sonar picture on the screen due to very high level of noise produced by the vessel itself, causing serious decrease of the signal-to-noise ratio. When the sea surface was more or less calm (i.e. sea state up to 2 Beauforts), the maximum effective range on the starboard and port side was 300-400 meters only. The gain applied at these ranges was about 50% of its maximum value, and TVG time was still reduced. Also, it was necessary to decrease sensitivity of the equipment even at these short ranges. Further decreasing in equipment sensitivity would result in loosing the most of wanted fish echoes, making the sonar absolutely useless in searching for bluefin tuna schools. Under rough sea conditions (sea state: ≥ 4 Beauforts) any use of sonar was absolutely impossible, due to rolling and pitching of the vessel itself.

The optimal settings of the equipment searching for fish schools in the surface layer, when the vessel moves fast, are shown in Table 3.

Furthermore, the wakes of other ships in the crowded fishing ground were a serious cause of disturbance in the use of sonar. When acoustic observations were made along the sea surface, the reflections from the wakes were dominant and

Table 3. Maximum observed distances on the starboard and port side made by sonar and the parameters settings used in relation to different weather conditions (sea state in Beauforts) when the vessel moves fast (> 5 knots)

Sea state (Beaufort):	0 - 1	2	3	4	> 4
Maximum distance observed by sonar:	300-400 m	< 300 m	< 300 m	0 m	0 m
Parameters used:				Sonar turned off	
Pulse length	3.9-5.2 ms	< 3.9 ms	< 3.9 ms		
Output Gain	50 %	≤ 50 %	≤ 50 %	-	-
TVG-time	50 %	≤ 40 %	≤ 40 %	-	-
TVG-level	90-100%	90-100 %	90-100 %	-	-
Transducer angle	0°	1°	2°	-	-

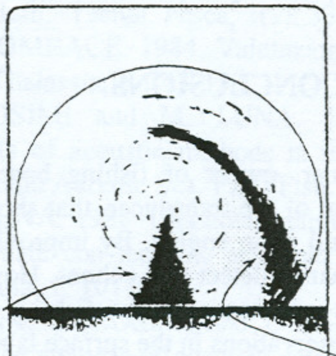

Fig. 2. The propellers noise in the surface layer displayed on the sonar screen

interfered with observation of wanted echoes. Since the wake appears on the screen as continuous thick line (Fig. 2), it can easily be distinguished from a fish school. But on the other hand, the wake contains numerous air bubbles that attenuate ultrasonic energy, it often made difficult or impossible to sound beyond the wake.

For this reason, when observing a net set by another fishing vessel, the floating line of the net just set can not be seeing. Its position was approximated with a circle that made wake of the ship that set the net. Also, at the beginning it was difficult to observe a fish school in the net, but after some time it can be easily done (Fig. 3).

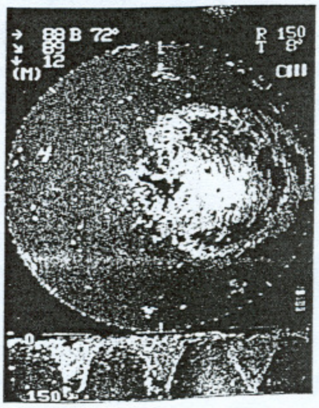

Fig. 3. Sonar picture of the fish school closed in the net.

CONCLUSIONS

When purchasing a sonar, owner of fishing boat must pay maximum attention on the proper placement of the transducer, that should be mounted as far as possible from the propeller and main engine. By improving the signal to noise ratio, increases the ability of sonar to detect fish echoes. However, the presence of wakes made by fishing vessels cruising over the fishing ground, are the main limitation for making acoustic observations in the surface layer.

In comparison to the ability of fishermen to spot the bluefin tunas close to the sea surface at more than 2000 meters, the effective ranges of 300-1200 meters achieved by this sonar were relatively short, and made no significant contribution to the search for fish during daytime. On the other hand, sonar offers possibility to detect the fish in deeper mid-water layers that can not be done by observing the sea surface by eye. However, fishermen have no interest in detection of fish at this depth, because it is not possible to catch these, often fast swimming tunas.

Based on the above presented results it can be concluded that under the giving circumstances this kind of sonar has not proved very useful during daytime fish searching activities in the bluefin tuna purse-seine fishery in the Adriatic Sea. However, the sonar could allow searching for bluefin tunas in night-time also.

Additionally, sonar can be used to guide the setting of the purse seine net around the fish school in unfavourable meteorological conditions that are prohibitive for vessels not equipped with sonar. Also, it is necessary to take into account that searching for the fish manually and aurally by sonar could improve some results described in this paper.

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REFERENCES

AZZALI, M. 1980. Summary of the results of the research project "Evaluation of pelagic resources using electroacoustic instruments" from 1975 to 1980. FAO Fish. Rep., 239: 33-42.

AZZALI, M. 1981. Comparazione circa la distribuzione e la stimma di biomassa di sardine effetuata nel 1976 e 1977 con metodi elettroacustici in alto e medio Adriatico. Quad. Lab. Tecnol. Pesca, 3(1): 33-48.

AZZALI, M. and G. BOMBACE. 1984. Valutazione e valorizzazione delle risorse pelagiche. Nova Thalassia, 6: 343-350.

AZZALI, M., G. COSIMI and M. LUNA. 1984. Some applications and preliminary results of acoustic methods in monitoring pelagic resources in the North and Middle Adriatic Sea. FAO Fish. Rep., 290: 201-214.

AZZALI, M. and M. LUNA. 1988. Una nota preliminare sulle risorse pelagiche nei mari Italiani, stimate con tecniche acustiche. Atti seminari per la pesca e l'aquacoltura, Roma, 1: 101-107.

AZZALI, M., M. LUNA, G. COSIMI and J. KALINOWSKI. 1993. Models of fish-patterns for the analysis of acoustic data with particular reference to the Adriatic Sea. In: G.T. Sakagawa (Editor). Assessment Methodologies and Management. Oxford & IBH Publishing Co. Pvt. Ltd.,pp. 183-186.

BERTRAND, A., E. JOSSE and J. MASSÉ. 1999. In situ acoustic target strength measurements of bigeye (*Thunnus obesus*) and yelowfin tuna (*Thunnus albacares*) by coupling split-beam echosounder observations and sonic tracking. ICES J. Mar. Sci., 56: 51-60.

DADIĆ, V. and D. IVANKOVIĆ. 2001. Marine environmental database of the Adriatic Sea (MEDAS). Institute of Oceanography and Fisheries, Split. WEB: www.izor.hr/medas.

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REFERENCES

AZZALI, M. 1980. Summary of the results of the research project "Evaluation of pelagic resources using electroacoustic instruments" from 1975 to 1980. FAO Fish. Rep., 239: 33-42.

AZZALI, M. 1981. Comparazione circa la distribuzione e la stimma di biomassa di sardine effetuata nel 1976 e 1977 con metodi elettroacustici in alto e medio Adriatico. Quad. Lab. Tecnol. Pesca, 3(1): 33-48.

AZZALI, M. and G. BOMBACE. 1984. Valutazione e valorizzazione delle risorse pelagiche. Nova Thalassia, 6: 343-350.

AZZALI, M., G. COSIMI and M. LUNA. 1984. Some applications and preliminary results of acoustic methods in monitoring pelagic resources in the North and Middle Adriatic Sea. FAO Fish. Rep., 290: 201-214.

AZZALI, M. and M. LUNA. 1988. Una nota preliminare sulle risorse pelagiche nei mari Italiani, stimate con tecniche acustiche. Atti seminari per la pesca e l'aquacoltura, Roma, 1: 101-107.

AZZALI, M., M. LUNA, G. COSIMI and J. KALINOWSKI. 1993. Models of fish-patterns for the analysis of acoustic data with particular reference to the Adriatic Sea. In: G.T. Sakagawa (Editor). Assessment Methodologies and Management. Oxford & IBH Publishing Co. Pvt. Ltd.,pp. 183-186.

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DADIĆ, V. and D. IVANKOVIĆ. 2001. Marine environmental database of the Adriatic Sea (MEDAS). Institute of Oceanography and Fisheries, Split. WEB: www.izor.hr/medas.

GRUBIŠIĆ, F., I. KAČIĆ and P. CETINIĆ. 1974. Procjena količine male plave ribe u zapadnoistarskim vodama primjenom lebdeće koće i ultrazvučne detekcije. Acta Adriat., 16(6): 119-123.

JOSSE, E., A. BERTRAND and L. DAGORN. 1999. An acoustic approach to study tuna aggregated around fish aggregating devices in French Polynesia: methods and validation. Aquat. Living Resour., 12(5): 303-313.

KAČIĆ, I. 1980. Pelagic fish in the Adriatic - distribution and stock assessment. FAO Fish. Rep., 239: 21-31.

KAČIĆ, I. 1981. Pelagic fish in the northern Adriatic - distribution and movements. FAO Fish. Rep., 253: 131.

KAČIĆ, I. 1983. Distribution and quantity of small pelagic fish in the eastern Adriatic - comparison and results. FAO Fish. Rep., 290: 217-221.

KAČIĆ, I. 1988. Acoustic survey in the eastern Adriatic in 1986. FAO Fish. Rep., 394: 103-105.

MacLENNAN, D.N. and E.J. SIMMONDS. 1995. Fisheries acoustics. Chapman & Hall. London, UK, 325 pp.

SINOVČIĆ, G. 1998. Tuna catch in the eastern Adriatic. ICCAT, Coll. Vol. Sci. Pap., 48(3): 317-318.

SINOVČIĆ, G., M. FRANIČEVIĆ and V. ALEGRIA. 1999. The bluefin tuna fishing in the eastern part of the Adriatic Sea. ICCAT, Coll. Vol. Sci. Pap., 49(2): 222-225.

TIČINA, V. 1993. Lov tunja u istočnom Jadranu. Morsko ribarstvo, 45(1): 20-22.

TIČINA, V. 1994. Morfološka i prehrambena obilježja i lov tunja (*Thunnus thynnus* L.) u Jadranskome moru. Sveučilište u Zagrebu (Magistarski rad), 84 pp.

TIČINA, V. 1997. Bluefin tuna (*Thunnus thynnus* L.) purse-seine fishing in the eastern Adriatic sea. ICCAT Coll. Vol. Sci. Pap., 46(2): 126-128.

TIČINA, V. 1999. Tunj (*Thunnus thynnus* Linnaeus, 1758.) – biologija, lov, gospodarenje i zaštita. Pomorski Zbornik, 37(1): 209-221.

TIČINA, V and I. KAČIĆ. 1998. Preliminary data on age determination of bluefin tuna (*Thunnus thynnus* L.) caught in the Adriatic Sea. Rapp.Comm. int. Mer Médit., 35(2): 486-487.

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Neka opažanja o korisnosti sonara prilikom lova tunja (*Thunnus thynnus* L.) u Jadranskome moru

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SAŽETAK

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U ovome su radu po prvi put opisana izravna terenska opažanja o korištenju sonarom tijekom komercijalnoga tunolova, kao i neka praktična ograničenja za njegovu uporabu, na području Jadranskoga mora. Podaci koji se iznose u ovom radu prikupljeni su izravno na ribarskomu brodu – tunolovcu plivaričaru za vrijeme tunolova tijekom srpnja i kolovoza u Jabučkoj kotlini. Ribarski je brod bio opremljen sonarom marke FURUNO CH-24 Colour PPI, namijenjen za uporabu tijekom komercijalnog ribolova. Zamijećena je važnost pravilne ugradnje pretvarača na trupu broda, i opisane su smetnje koje mogu nastati poradi nepravilnog smještanja pretvarača. Glavna smetnja pri pretraživanju površinskog sloja mora bile su mnogobrojne «brazde» nastale kretanjem ribarskih brodova na ribolovnome području. Osim toga, u usporedbi sa sposobnošću ribara da zapaze tunje na površini mora na udaljenostima većim od 2000 metara, mogućnosti ultrazvučne detekcije ribe sa sonarom na udaljenostima 300-1200 metara nisu bile značajne tijekom ribolovnih aktivnosti traženja ribljih plova tijekom dana. U slučajevima jače uzburkanosti mora ($\geq$4 Beaufoura), poradi pojačanog valjanja broda, nije bilo moguće koristiti se sonarom.

Ključne riječi: sonar, tunj (*Thunnus thynnus* L.), ribolov, Jadransko more

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