

Interaction between small pelagic purse seine fishery and its top predators - case study in the eastern Adriatic Sea

Barbara ZORICA¹, Vanja ČIKEŠ KEČ^{1*}, Kristijan ZANKI², Leon GRUBIŠIĆ¹
and Tanja ŠEGVIĆ-BUBIĆ¹

¹*Institute of Oceanography and Fisheries,
Šetalište I. Meštrovića 63, 21000 Split, Croatia*

²*Sardina d.o.o., Ulica Ratac 1, 21400 Postira, Croatia*

**Corresponding author, e-mail: cikes@izor.hr*

Due to very good collaboration with one commercial purse seiner, using “Srdelara” and operating in fishing zone G, preliminary data concerning the interaction between small pelagic purse seine fishery and its predators were obtained. According to the notes taken by experience observer on-board in period from year 2013 to 2016, seems that tunas, dolphins and swordfish were the faithful companions of purse seiner fisherman with abundance of 68.6%, 22.0% and 9.4%, respectively. Although they were present all year round, their monthly pattern of appearance indicated that less tunas were recorded in May-June, more dolphins were noted from July to October while swordfish were mostly abundant in winter (January-March). Within the investigated period, slightly increasing trend of tuna and dolphins’ appearance was recorded, although statistically not significant. Analysing possible correlation between purse seine catches and predator’s abundances, revealed that appearance of tuna had negative impact on the catches (dispersion of schools), while realised catches in presence of dolphins were quite good so it seems that they tend to round up small pelagic fish schools.

Key words: sardine, anchovy, tuna, swordfish, dolphins, eastern Mediterranean

INTRODUCTION

Regardless the size, small pelagic fish species, or more precise its biomass levels, represent one of the major natural factors that ensures the stable functioning of the marine ecosystem in its entirety. Globally it is well documented that biomass levels of small pelagic fish, especially sardine and anchovy as main representatives, significantly fluctuate over the years. Those oscillations are in line with their

biological and ecological features - short-lived and fast-growing fish whose annual recruitment pulse is mainly environmentally driven.

From ecological perspective, small pelagic fish species enable the energy transfer from lower to higher trophic levels (CURY *et al.*, 2000)-small pelagic fish species are frequent and substantial prey for many marine top predators like tuna and tuna like species and marine mammals. Hence, the presence of predators during a fishing operation and their interaction with the

fisheries is expected and in some cases even documented (SILVA *et al.*, 2002; CERTAIN *et al.*, 2011; MARÇALO *et al.*, 2015).

Beside their ecological importance, small pelagic fish have substantial role in the economy of the fishing industry. In Mediterranean fisheries, small pelagic fish species accounted for approximately 47.7% (2005-2014; <http://www.fao.org/gfcm/data/capture-production-statistics>) while in Adriatic Sea, their portion in overall marine catches were 74% (average over the period 2005-2014, Fishstat+). The share of small pelagics in the total catches of the Republic of Croatia, obtained on a whole Croatian fishing ground, was around 76% (statistical data issued by the Croatian Bureau of Statistics from 2013 to 2016). Those catches are mainly obtained with the purse seine net "Srdelara", which is traditionally used for catching sardine (*Sardina pilchardus*) and other types of small pelagic species along the eastern Adriatic Sea.

In order to perceive and comprehend the complexity of pelagic ecosystem, an integrated approach is needed for ecosystem based fisheries management where all available information regarding the biological, ecological and economical aspects of small pelagic fish will be included. Thus, the aim of the present research was to provide information regarding the interactions between small pelagic fish predators and purse seine fishery by counting (i) the main predators and their temporal occurrence during the fishing operation done with the purse seine "Srdelara" and (ii) the correlation patterns of predator abundance and purse seine catches within the fishing zone G. Although findings achieved throughout this study are preliminary, they should move us closer to an ecosystem-based management that ensure better conservation and management of fish species whether they were a prey or a predator.

MATERIAL AND METHODS

All data used within this study were obtained from one commercial purse seine fishing vessel that has a licences for fishing gear "Srdelara" with minimum diagonal mesh size of 14 mm.

As this kind of fishing gear is working during the night, artificial lights are used for gathering fish schools which are afterward surrounded by the net and caught. Croatian fishing sea has been administratively divided into smaller units (11) in which fishing with the purse seine net is allowed all year round except January due to fishing band (NN, 2005).

For the period of January 2013 to December 2016, we analysed only the catch data that were obtained from the logbooks and the occurrence of top predators around the vessel that was assessed visually at sea surface or detected on echo sounder during the fishing operation within fishing zone G. Fisherman with high level of experience were employed in predators' observation.

All collected data, as catch of small pelagic fish species (MP), number of each observed predator - tuna (T), dolphins (D) and swordfish (I), were analysed annually and during the whole investigated period. In order to obtain (dis)similarities in observed pelagic community, Principal Component Analysis (PCA) was applied. Hence, obtained data sets were normalised and processed using the PRIMER software package (Plymouth Marine Laboratories, UK; CLARKE, 1993; CLARKE & WARWICK, 1994).

RESULTS AND DISCUSSION

During the investigated period, fishing activity with purse seine "Srdelara" in fishing zone G (NN 144/2005) was recorded all year round with exception in January when the official fishing ban for purse seine fisheries was in force. Mean monthly portions of the catches observed inter or intra annually revealed that the lowest catches were obtained in spring. Afterwards, catches of observed purse seiner started to raise and reached its maximum values in autumn (September, December) (Fig. 1). Although, catches of investigated purse seiner represented in overall "Srdelara" catches of fishing zone G and whole fishing ground were 7% and 1%, respectively, they oscillated in a same manner over the years.

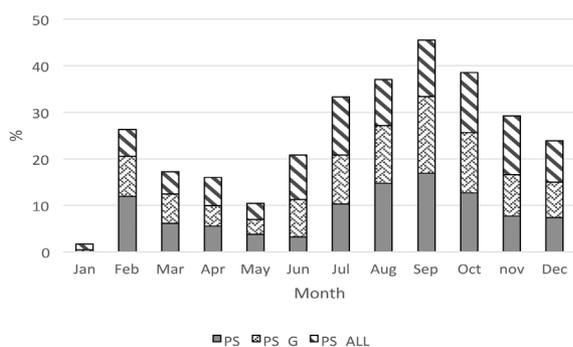


Fig. 1. Proportion of total monthly catches in overall catches for whole investigated period (2013-2016) obtained with purse seine “Srdelara” by involved commercial vessel (PS), all purse seiners fishing in fishing zone G (PS_G) and all purse seiners fishing in whole Croatian fishing ground (PS_ALL)

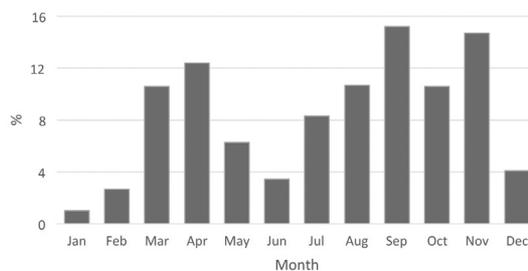
Observed monthly pattern of catches realised by purse seine “Srdelara” were in line with previous study done by KRALJEVIĆ *et al.* (2014). Taking into account that in the catches of “Srdelara” share of sardine is more than 72% and that sardine after spawning, which happens from late autumn and last till the beginning of spring in the offshore areas of central Adriatic, turns towards the inshore waters (channel areas of central Adriatic; in this case fishing zone G) where it becomes available to the fishery (ŠKRIVANIĆ & ZAVODNIK, 1973; SINOVIĆ *et al.*, 2009).

Bearing in mind ecological perspective of small pelagic fish species, the presence of its predators near purse seine fishing operation was expected and noted. Namely, during our study three predators – swordfish, dolphin and tuna appeared each year throughout the whole investigated period.

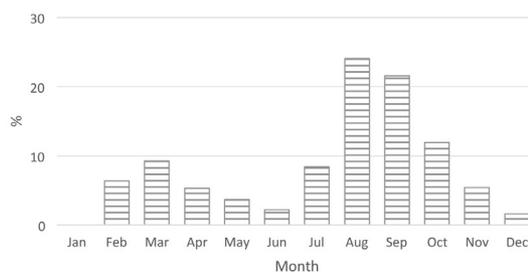
Tuna was the most abundant one (68.6%), while abundance of dolphins and swordfish accounted for 22% and 9.4%, respectively. Appearance of each predator during purse seine fishing operation showed its monthly pattern (Fig. 2). Within the period of 2013 to 2016, the greatest number of tuna were observed by the end of summer and at the beginning of the autumn (September, November), then its abundance decreased along the winter months. As soon as spring started, the occurrence of tuna started to increase till May and June when its

appearance diminished again (Fig. 2a). Although tuna presence was recorded through the year, its lower occurrence in May and June could be connected with tuna spawning migration to open sea waters, where this fishing gears do not operate (JARDAS, 1996; DŽOIĆ *et al.*, 2017).

a.



b.



c.

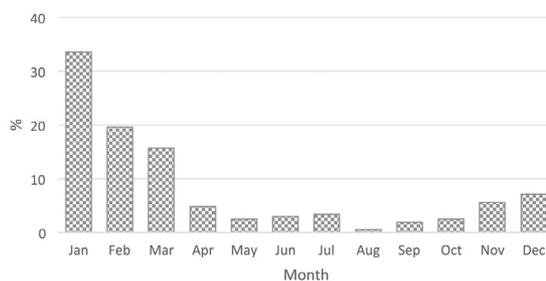


Fig. 2. Average monthly appearance of three predators – tuna (a), dolphins (b), swordfish (c) that accompany purse seine fishing activity in fishing zone G, Adriatic, 2013-2016

Monthly occurrence of dolphins and swordfish showed opposite pattern - dolphins were mostly noted during summer (August, 24 %; Fig. 2b) while the highest value of swordfish abundance was in winter (January, 34%; Fig. 2c). It can be argued that occurrence of the swordfish has also been affected by its spawning migrations pattern. Namely, adult specimens,

after spawning in Mediterranean - southern part of the Italian Peninsula and Sicily (NAKAMURA, 1985) during summer months, as opportunistic feeders, start trophic migrations within the Adriatic during January and February. This is in line with the fact that swordfish specimens were present in mention spawning grounds all year round, except January and February (NAKAMURA, *ibid.*).

By analysing inter annual trends of predators' occurrence, it was noted that the presence of tuna and dolphins increased and swordfish decreased over the years (Fig. 3). Decrease of swordfish appearance coincided with the ban that was established from 2014 onwards in winter months (December - January and recently February). Slight increase of other two mentioned species that interact with purse seine fishery within the investigated period were not statistically significant ($r^2 < 0.36$). Observed increase of tunas and dolphins, although not significant, indicated the obvious positive effects of the protection measures taken for both species. Namely, following the ICCAT recommendations, the Recovery Plan for Bluefin tuna inhabiting eastern Atlantic and Mediterranean is in force until 2022, while bottlenose dolphins are protected under Croatian law and are placed in the National Red List, categorised as "Endangered".

PCA analysis of the whole data set (amount of small pelagic catch and number of each observed predator occurred near purse seine fishing operation) revealed that higher values of purse seine catches (sardine and anchovy) were realised when no predators or only dolphins

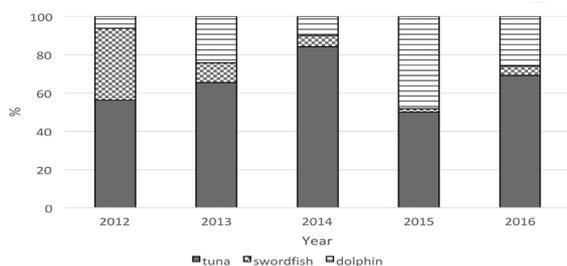


Fig. 3. Inter annual occurrence of tuna, dolphin and swordfish near purse seine fishing operation obtained in fishing zone G, Adriatic, 2013 – 2016

appeared (Fig. 4). On the other hand, somewhat lower catches were observed in presence of tuna specimens. Dolphins, mostly bottlenose dolphins, as they are most abundant and widespread dolphins in Adriatic (HOLCER, 2012), are known as fisherman companions in general. Their interaction with fisheries might be positive or negative. In this case, it seems that these dolphins accompanied purse seine "Srdelara" fishing operation and help rounding up the school of small pelagic fish as no decrease in catches due to its appearance were noted, actually higher catches were realised in their presence. Conversely, presence of tuna specimens resulted in lower small pelagic catches obtained by purse seine "Srdelara" due to dispersion of small pelagic fish schools or by avoiding the net setting in order to eliminate the risk of tuna capture.

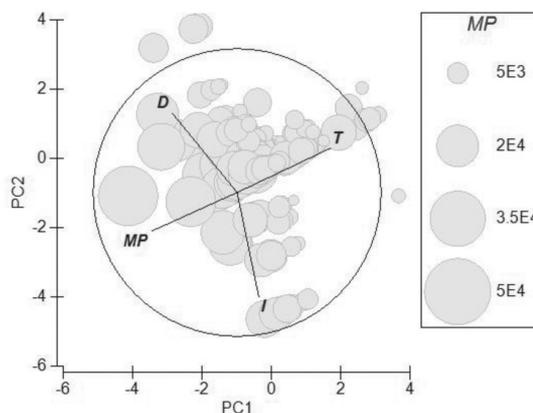


Fig. 4. PCA plot of data sets (MP- small pelagic catches, T- tuna, D-dolphin, I- swordfish) collected during the fishing operation with purse seine "Srdelara" in fishing zone G from 2013 to 2016

CONCLUSIONS

Nevertheless, this preliminary obtained results pointed once again that collaboration among fisherman and scientists is possible and more than welcome. Purse seiners or any other fishing vessels might serve as useful scientific platform which could offer large amounts of data with generally good spatial and temporal coverage. Integration of experience and scientific knowledge should bring us closer to an ecosystem-based management which should mitigate the problems of exploited stocks (weather they

were target or by-catch specimens), fisherman/fishery and policy makers.

ACKNOWLEDGEMENTS

This research was funded by the Ministry of Agriculture of the Republic of Croatia, as a part

of the research project “Studies on pelagic fish stocks of the Republic of Croatia”. A special thanks to Captain D. ŠKROBICA and his crew for their skill and cooperation at sea.

The referees’ comments and suggestions are greatly appreciated.

REFERENCES

- CERTAIN, G., J. MASSE, O. VAN CANNEYT, P. PETIT-GAS, G. DOREMUS, M.B. SANTOS & V. RIDOUX. 2011. Investigating the coupling between small pelagic fish and marine top predators using data collected from ecosystem-based surveys. *Mar Ecol Prog Ser*, 422:23-39.
- CLARKE, K.R.. 1993. Non-parametric multivariate analyses of changes in community structure. *Australian J Ecol*, 18:117–143.
- CLARKE, K.R. & R.M. WARWICK. 2001. Changes in marine communities: an approach to statistical analysis and interpretation, 2nd edition. PRIMER-E Ltd, Plymouth, 175 pp.
- CURY, P., A. BAKUN, R.J.M. CRAWFORD, A. JARRE, R.A. QUIÑONES, L.J. SHANNON & H.M. VERHEYE. 2000. Small pelagics in upwelling systems: patterns of interaction and structural changes in “wasp-waist” ecosystems. *ICES J Mar Sci*, 57:603–618.
- DŽOIĆ, T., G. BEG PAKLAR, B. GRBEC, S. IVATEK-ŠAHDAN, B. ZORICA, T. ŠEGVIĆ-BUBIĆ, V. ČIKEŠ KEČ, I. LEPEN PLEIĆ, I. MLADINEO, L. GRUBIŠIĆ & P. VERLEY. 2017. Spillover of the Atlantic bluefin tuna offspring from cages in the Adriatic Sea: A multidisciplinary approach and assessment. *PLoS ONE* 12(11): e0188956. <https://doi.org/10.1371/journal.pone.0188956>
- FAO. 2005-2014. Fisheries and aquaculture software. FishStat Plus - Universal software for fishery statistical time series. In: FAO Fisheries and Aquaculture Department, Rome.
- HOLCER, D. 2012. Ecology of the common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821) in the Central Adriatic Sea. Zagreb: University of Zagreb, p. 208.
- JARDAS, I., 1996. The Adriatic ichthyofauna. Školska knjiga d. d., Zagreb (in Croatian), 533 pp.
- KRALJEVIĆ, V., V. ČIKEŠ KEČ & B. ZORICA. 2014. Analiza ulova ostvarenih plivaricom srdelarom u Jadranu. *Ribarstvo: znanstveno-stručni časopis za ribarstvo*, 72: 142-149.
- MARÇALO, A., I. KATARA, D. FEIJÓ, H. ARAÚJO, I. OLIVEIRA, J. SANTOS, M. FERREIRA, S. MONTEIRO, G.J. PIERCE, A. SILVA & J. VINGADA. 2015. Quantification of interactions between the Portuguese sardine purse-seine fishery and cetaceans. *ICES J Mar Sci*, 72(8): 2438–2449.
- NAKAMURA, I. 1985. FAO species catalogue. Vol. 5. Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. *FAO Fish. Synop.* 125: (5) 65.p.
- NN. 2005. Croatian Official Gazette no. 144/2005.
- SILVA, M.A., R. FEIO, R. PRIETO, J.M. GONÇALVES & R.S. SANTOS. 2002. Interactions between cetaceans and the tuna fishery in the Azores. *Mar Mam Sci*, 18: 893–901.
- SINOVIĆ, G., B. ZORICA, V. ČIKEŠ KEČ & B. MUSTAĆ. 2009. Inter-annual fluctuations of the population structure, condition, length-weight relationship and abundance of sardine, *Sardina pilchardus* (Walb., 1792), in the nursery and spawning ground (coastal and open sea waters) of the eastern Adriatic Sea (Croatia). *Acta Adriat.*, 50 (1): 11-21.
- ŠKRIVANIĆ, A. & D. ZAVODNIK. 1973. Migrations of the sardine (*Sardina pilchardus*) in relation to hydrographical conditions of the Adriatic Sea. *Neth J Sea Res*, 7: 7-18.

Received: 3 May 2018

Accepted: 5 October 2018

Interakcija plivarice za ulov sitne plave ribe i njenih grabežljivaca – preliminarno istraživanje u istočnom Jadranu

Barbara ZORICA, Vanja ČIKEŠ KEČ, Kristijan ZANKI,
Leon GRUBIŠIĆ i Tanja ŠEGVIĆ-BUBIĆ

**Kontakt e-pošta: cikes@izor.hr*

SAŽETAK

Zahvaljujući vrlo dobroj suradnji s ribarskim sektorom, točnije jednom komercijalnom plivaricom koja koristi plivaricu "Srdelaru" u ribolovnoj zoni G, su prikupljeni preliminarni podaci vezani uz interakciju ovog tipa ribolova i njegovih predatora. U razdoblju od 2013. do 2016. godine, prema podacima prikupljenim od strane iskusnog promatrača na palubi ove komercijalne plivarice, je utvrđeno da su tune, dupini i igluni najvjerniji pratioci ovog tipa ribolova te da je njihova abundancija redom bila 68,6%, 22,0% i 9,4%.

Premda je uočeno da su navedeni grabežljivci prisutni tijekom cijele godine ipak je njihova pojavnost kolebala od mjeseca do mjeseca – najmanje tuna je zabilježeno u razdoblju od svibnja do lipnja, nešto više dupina je uočeno od srpnja do listopada, dok su igluni bili najbrojniji od siječnja do ožujka.

Tijekom istraživanog razdoblja je utvrđeno blago povećanje broja tuna i dupina premda to povećanje nije bilo statistički značajno. Korelirajući ulove ostvarene istraživanom komercijalnom plivaricom i broja uočenih grabežljivaca, čini se da će u slučaju pojave tune ostvareni ulov biti manji s obzirom da ona rasprši ciljanu plovu sitne plave ribe, dok će relativno dobar ulov ista plivarica ostvariti u prisutnosti dupina koji će uočenu plovu još više zbiti.

Ključne riječi: srdela, brgljun, tuna, dupin, istočno Sredozemlje