DORY - Capitalization actions for aDriatic marine envirOnment pRotection and ecosYstem

PA 3 – Environment and cultural heritage
Specific Objective 3.2 - Contribute to protect and restore biodiversity
Application ID – 10041641

Title of the deliverable	D3.2.2 Cross-border model for sustainable fisheries management of Adriatic Sea targeting the common sole Solea solea and the cuttlefish Sepia officinalis
Work Package:	WP3 - Implementation of sustainable fisheries management model
Activity	Activity 3.2 - Testing the Cross-Border Model for Sustainable Fisheries Management on shared stocks
Partner in charge (author)	P4 – CNR – IRBIM National Research Council - Institute for Biological Resources and Marine Biotechnologies
Contributor	IOF Institute of Oceanography and Fisheries
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Introduction on the DORY Project

The Adriatic Sea is characterized by an invaluable richness of natural marine and fish resources, which is the basis for tourism, recreational and fishing activities, and contribute to Adriatic cultural heritage. However, despite protections measures, the increased human use of marine and coastal space and resources in particular for fishing and aquaculture activities which are key sectors for Adriatic Regions, has intensified pressures on coastal and marine ecosystems threatening its vitality and the whole environmental quality of the sea. Moreover, MPAs in Adriatic-generally small and costal- suffer from inappropriate planning or management process and degradation of the unprotected surrounding ecosystem. Strengthened sustainable and science-based management of fisheries, improved sustainable practices and knowledge on technical solutions to reduce ecological impact of fisheries and aquaculture, improved integrated planning capabilities and ecosystem-based approach are common challenges for protection of marine habitat and species in Adriatic. In this sense, several attempts have been conducted also thanks to ETC projects. In particular, ECOSEA project (IPA CBC 2007-2013) contributed to introduce integrated and common management principles for long-term sustainability of marine resource based on: best available scientific advice, stakeholder involvement, sustainable practices and advanced MSP tool. On these bases, DORY project, promoted by 4 Regions (IT), 1 County and 1 Development Agency (HR) and 2 Research Centers (IT, HR) intends to capitalize ECOSEA results and its cooperation network, to strengthen Adriatic institutional dialogue and promote the adoption of common management models for sustainable fisheries to reduce economic activities threats on Adriatic marine stocks, and knowledge based tools to enhance biodiversity in terms of priority and essential fish habitats and to halt aquaculture ecological impact. Focusing on Italian and Croatian area, DORY will carry out pilot activities to test the cross-border management model on high commercial value and overexploited shared stock and DISPLACE tool to define, with stakeholders'

and under scientific evidences, measures to manage and regulate catches and provide for scenario of alternative spatial management measures and fishing effort/catches redistribution. DORY will moreover carry out pilot application of innovative techniques to reduce fishing activity impact on overexploited stock and reduce aquaculture activities ecological impact. DORY will also lays the foundation for the setting up of a CB protected area for overexploited species recovery and protection. Moreover, the project activities will improve strategic and operational competences of policy makers, technicians, MPAs managers, operators, researchers in project area, making available the stock of knowledge and tools also to whole EUSAIR coastal regions.

Implementation of sustainable fisheries management model

WP3 aims to test and further implement common CB models and co-management approaches for sustainable fisheries management, capitalizing ECOSEA achievements and multi-level working group approach under the best scientific guidance. The WP foresees a preparation phase (Act 3.1) to fine-tune, by means of recommendations tailored on CB Italy-Croatia area, the model for sustainable fisheries management applied on shared stock and the use of advanced MSP tools for adopting measures to mitigate threats to Adriatic marine biodiversity. Given the recommendations, partners will test the cross-border model on two additional shared stock of high commercial value and overexploited (*Solea solea*, *Sepia officinalis*)(Act 3.2) for defining, together with stakeholders', a set of measures to manage and regulate catches. Scientific partners (PP4, PP7) will coordinate the process, institutional partners will organize stakeholders meetings to ensure bottom-up approach in model preparation. Data collected in Act 3.2 and within ECOSEA will be pooled to test an advanced MSP tool (DISPLACE) providing for scenario of alternative spatial management measures and fishing effort/catches redistribution (Act 3.3). Simulations will support MSP approach evolution in the Adriatic Region, helping to achieve sustainable exploitation of shared stock by an ecosystem-based resource management. CNR-IRBIM, with IZOR cooperation, will be responsible to feed and run DISPLACE model, Institutional Partners (LP, PP1, PP2, PP3, PP5, PP6) will contribute with data provision and stakeholders feedback to management

measures definition. Furthermore, specific attention will be given to the testing of a particular scenario for the setting up of a CB protected area (Act 3.4) within the so-called “Sole Sanctuary”, the core spawning area for this species, located in international water between the two countries, not yet protected and managed so far. To this, a feasibility study will be drafted by IZOR with CNR-IRBIM cooperation.

Testing the Cross-Border Model for Sustainable Fisheries Management on shared stocks

The Activity deals with the testing of the model sustainable fisheries management developed within ECOSEA on two additional shared stocks,highly exploited and of high commercial value (common sole and cuttlefish).Guidelines (Act 3.1) have provided the roadmap to be followed,taking into account the pressure of fisheries on ecosystem,the marine environment status and market demands,with due respect for ecosystem balance.

The document is drafted by CNR-IRBIM and IZOR with the contribution of all PPs and details key elements and operative indications for a sustainable exploitation of the target species,taking into account their ecology, spatial distribution and the seasonal market demand. Measures for a sustainable exploitation of the stocks along with economic proficient catches are identified by means of a bottom-up approach, where the operators involvement played a crucial role.The model provides for methodological, technical and scientific recommendations to improve fisheries management and governance and spread to further common stock resources management plan based on an ecosystem approach.

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Target species

Common sole (*Solea solea*, Linnaeus, 1758)

Spatial distribution

Common sole occurs in the east Atlantic, southward from Trondheim Fjord (including North Sea and western Baltic) to Senegal, including Cape Verde and the Canary and Madeira Islands (FAO, 2018). It is also present in Bosphorus and the southwest Black Sea. In the Mediterranean Sea, it is present throughout the basin, including the Gulf of Lion, Ligurian Sea, Ionian Sea, Tyrrhenian Sea, Aegean Sea and Adriatic Sea (Tous et al., 2015). According to data collected during SoleMon surveys (Scarcella et al., 2014), age class 0+ aggregates inshore along the Italian coast, mostly in the area close to the Po river mouth. Age class 1+ gradually migrates offshore and adults concentrate in the deepest waters in at South West from Istria (Fig. 1).

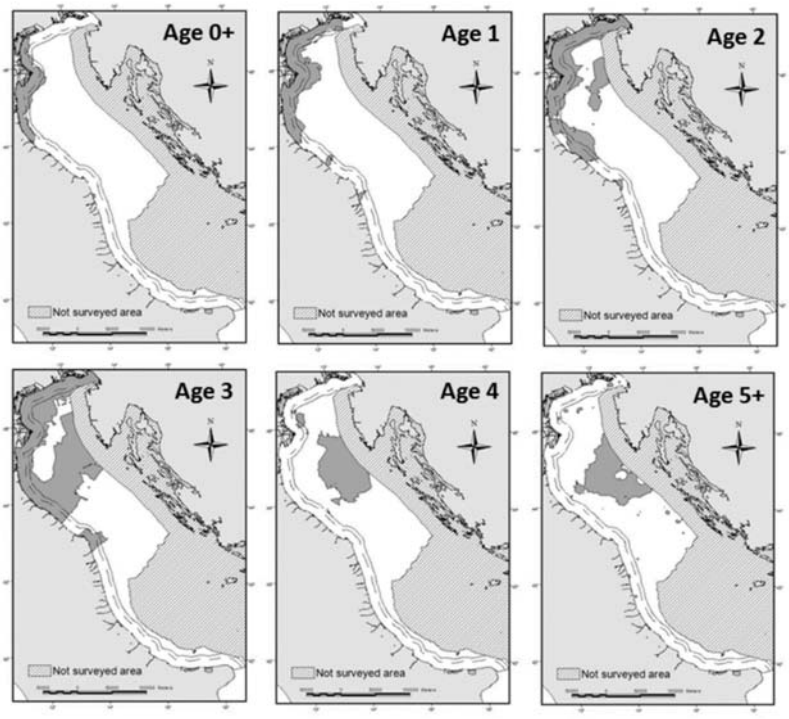


Figure 1. Maps of spatial distribution by age classes of soles. The 6 and 9 nautical miles from the Italian coast are shown respectively by broken and continuous black lines (Scarcella et al., 2014).

As a result of the different spatial distributions, juveniles are exploited exclusively by Italian vessels, especially by beam trawlers (i.e. rapido trawl), while adults are caught by Croatian and Slovenian fishing fleets in their respective national waters and by the Italian fleet operating in international waters (Grati et al., 2013).

Fisheries and landings information

In the Central and Northern Adriatic Sea, GSA 17, the common sole is targeted by bottom and rapido trawlers, set gillnets and trammel nets, belonging to Italy, Croatia and Slovenia. The fishery is carried out all year round, with a closure period (at least 30 consecutive days) for Italian trawlers, between July and October, depending on the maritime district. The minimum landing size (MLS) for this species is 20 cm TL, which does not correspond with the length at first sexual maturity, which is estimated around 25 cm TL (Vallisneri *et al.*, 2000) and 25.8 cm TL (Fabi et al., 2009). Based on the Length-at-age relationship, exploitation could be predictable almost on all the age classes from 1 to 4+, but in relation to the STECF (2017) datas, catches in GSA17 are dominated by ages 0 and 1-year specimens.

Among the three countries exploiting the GSA 17, Italy shows the highest Fishing effort value, which is followed by Croatia and Slovenia (Fig. 2).

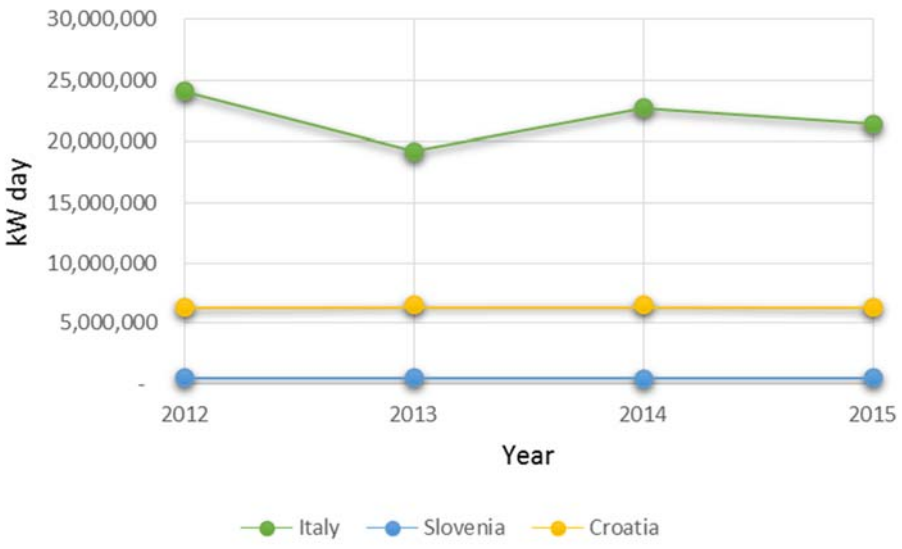


Figure 2. Fishing effort (engine power in kW per day) of Italian, Slovenian and Croatian fleets targeting the common sole.

Taking into account the landings of the three countries in economic and weight terms, it is clear that the common sole is a very important commercial species in the central and northern Adriatic Sea (Fabi et al., 2009), representing from €13M to more than €25M in Italy, corresponding to a range of 1000-2000 tons (Fig. 3). In Croatia the biomass and the value of landings for this species are always much lower than in Italy, especially in terms of value per weight unit.

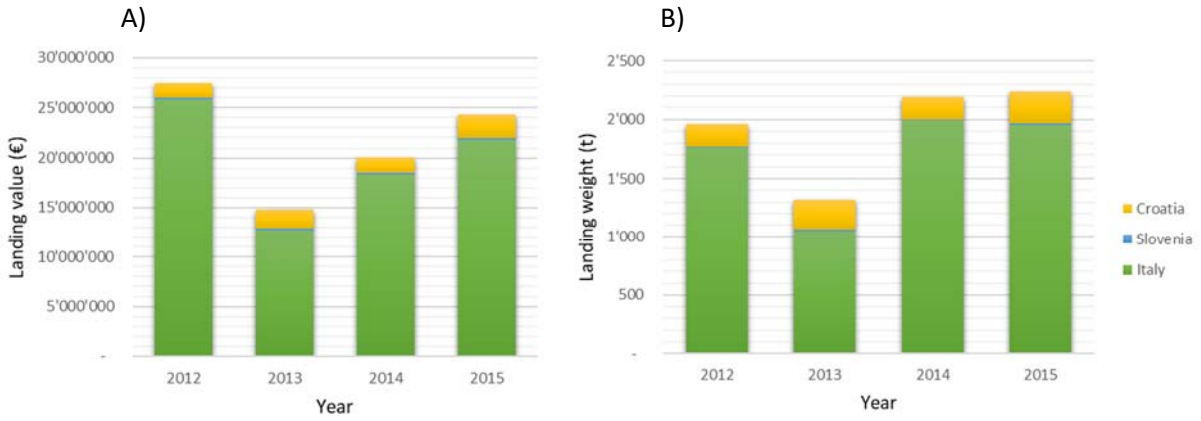


Figure 3. (A) Landing value (€); (B) Weight of landings (STECF, 2017).

Stock assessment

The existence of a single stock of common sole within the GSA 17 has been demonstrated by tag-and-recapture (Pagotto et al., 1979) and DNA sequencing experiments (Guarniero et al., 2002). Also a study supported by Sabatini et al. (2018) about the population structure of common sole in the Adriatic Sea, confirmed the previous evidences about the genetic differentiation between the stocks in GSA 17 and GSA 18. Thanks to these evidences it was possible to analize the GSA 17's sole stock as single unit. XSA and statistical catch at age (SCAA) using SS3 model were performed

by GFCM (2015). Considering the longer data series employed and the possibility to model the selectivity of fleets and survey, it has been decided that the SCAA using SS3 provides more precise and accurate results on the status of the stock, thus such analysis have been here illustrated (Fig. 4). Results suggest an overfishing situation for the *S. solea* stock for the SS3 model. Multiple assessment approaches used to analyse the health of the sole stock indicated clear overexploitation with extremely high fishing mortality (Scarcella et al., 2012) already a few years ago.

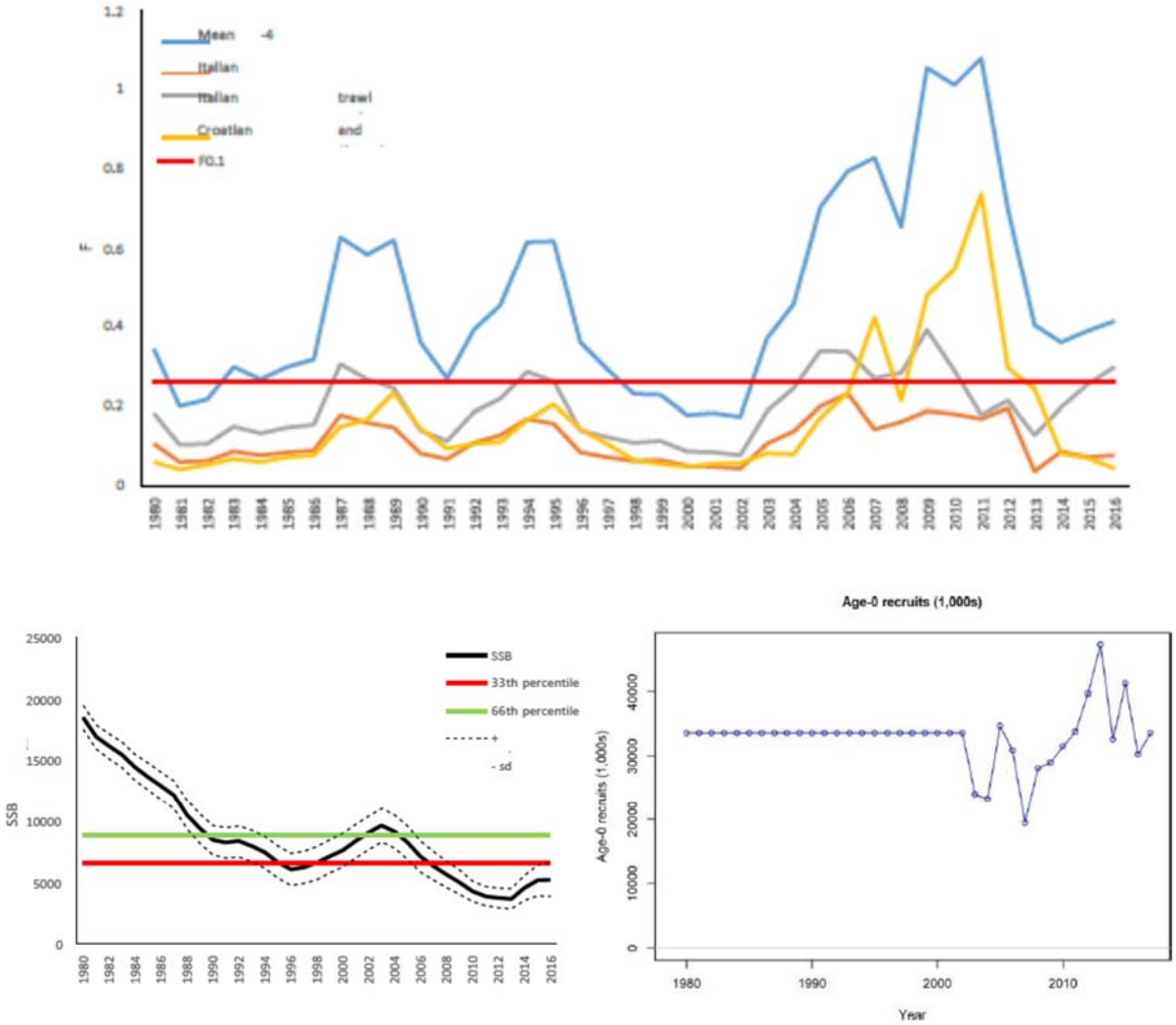


Figure 4. Final assessment results SCAA run (FAO-GFCM, 2017).

Fisheries independent information: SoleMon survey

The SoleMon trawl surveys provided data either on common sole total abundance and biomass as well as on important biological events (recruitment, spawning). Figure 5 (A) shows the biomass indices of sole obtained from 2005 to 2015; slightly increasing trends occurred till fall 2007, followed by a decrease in fall 2008-2009, and an increase in 2010-2016 (FAO-GFCM, 2016).

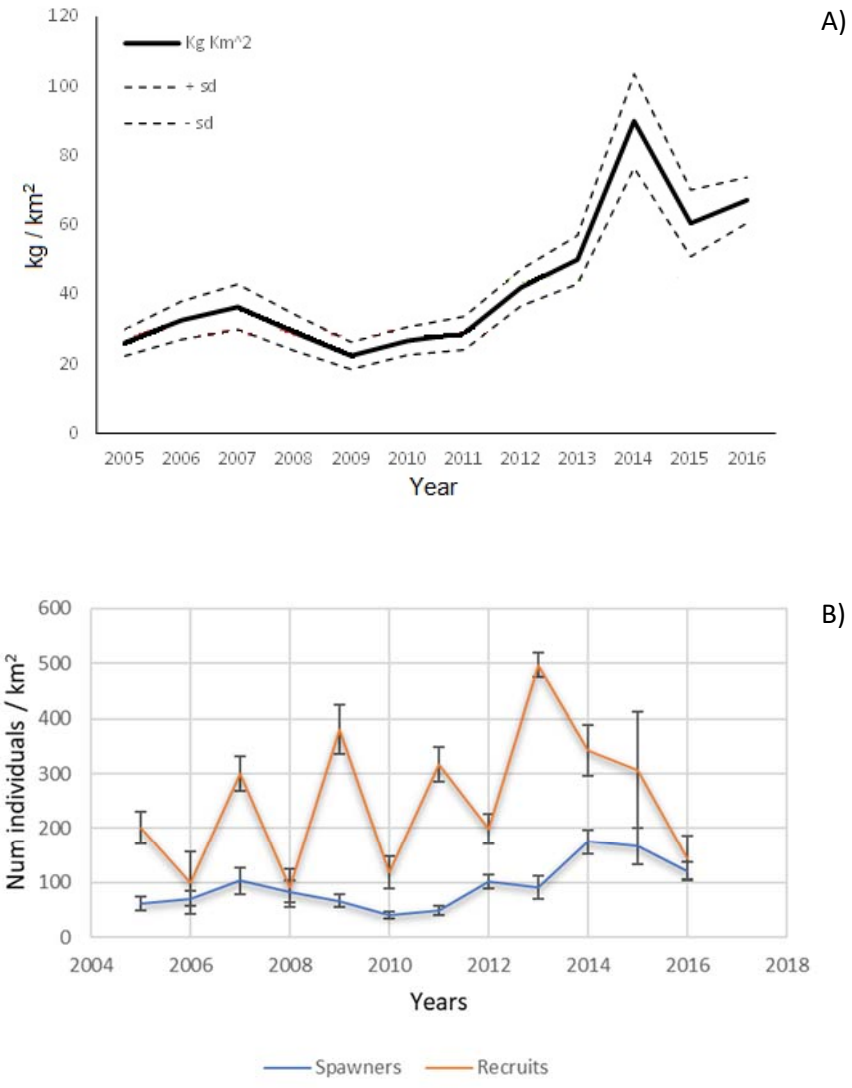


Figure 5. A) Biomass indices (± s.d.) of common sole (data by FAO-GFCM, 2017), B) Abundance indices (± s.d.) of common sole adults and recruits obtained from SoleMon surveys.

Trend of market prices

The three countries show different prices for the common sole in the years from 2012 to 2015 (Italy: 9.25-14.70 €, Croatia: 8 €, Slovenia: 13-16 €) (STECF, 2017). Making a zoom, market prices of common sole in the main Italian fish markets of the GSA 17 did not show a clear monthly trend (Fig. 6). In general, a variable increase of prices can be observed during summer months (data from ISMEA 2018a; Fig. 7).

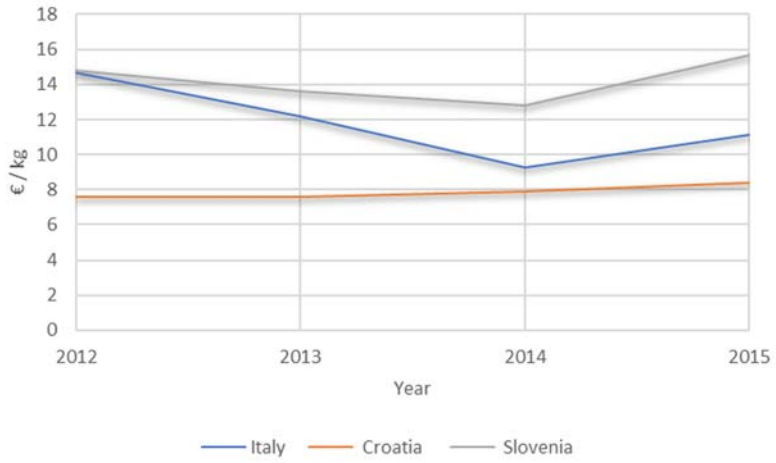


Figure 6. Annual mean prices (€/kg) of common sole in the three countries bordering GSA17 (2012-2015).

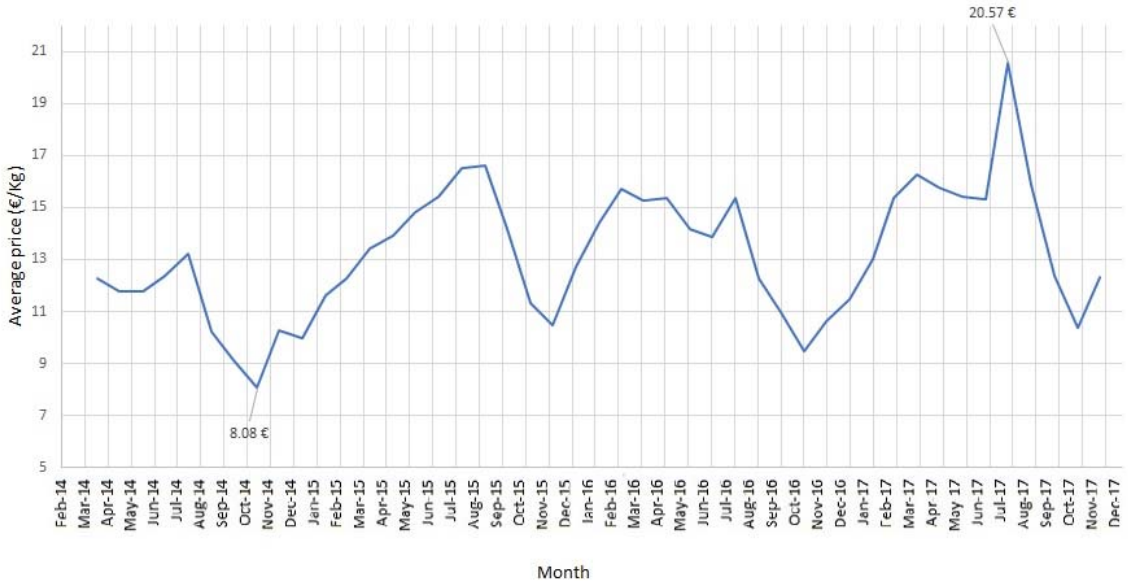


Figure 7. Monthly mean price (€/kg) of common sole in the fish markets of Ancona, Cesenatico, Civitanova Marche, Goro e San Benedetto del Tronto (February 2014 – December 2017 ; from ISMEA 2018a).

Common cuttlefish (*Sepia officinalis*, Linnaeus, 1758)

Spatial distribution

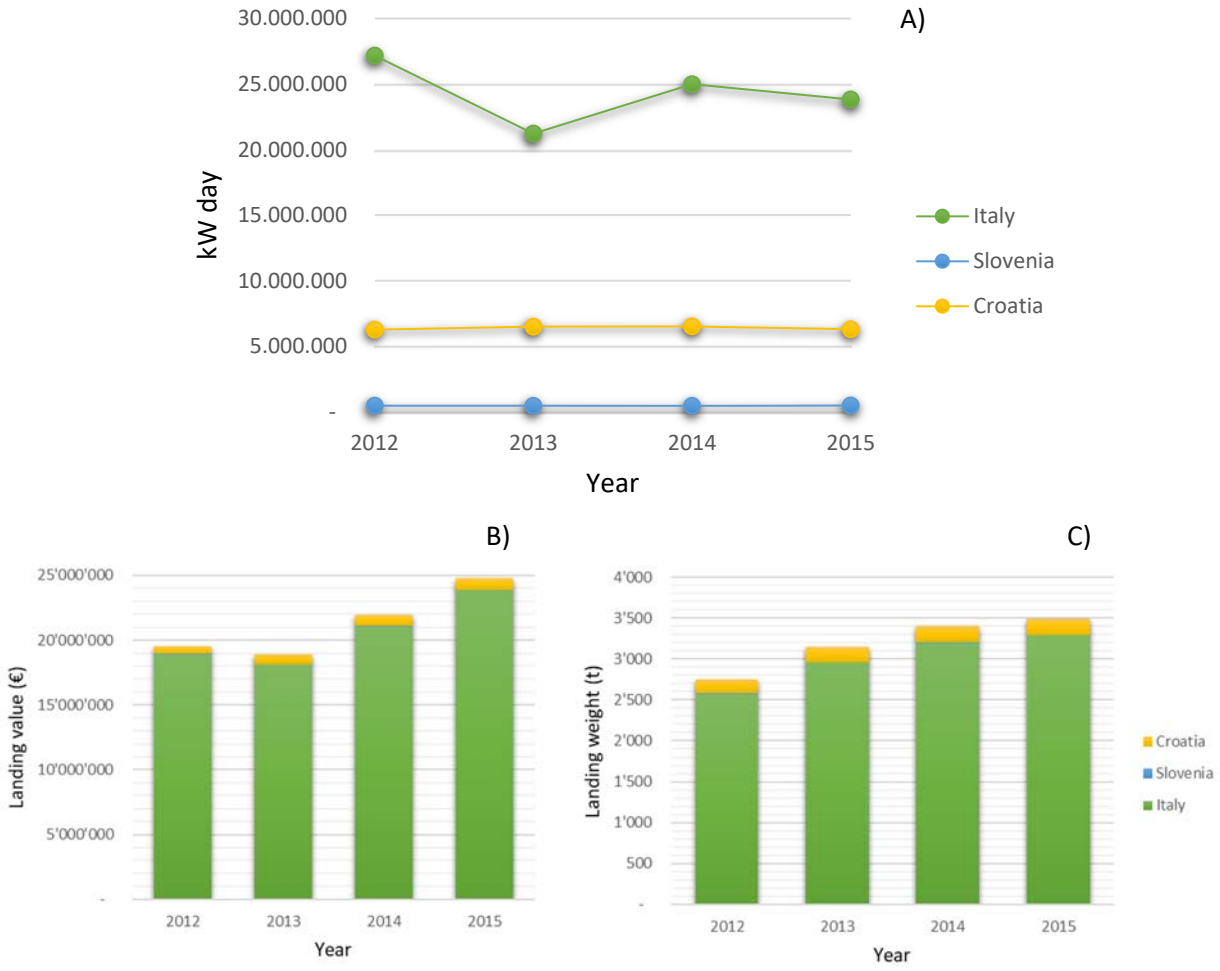
This species has a wide geographic distribution. It occurs in the northeast and east Atlantic Ocean and Mediterranean Sea extending from the Shetland Islands and Norway in the north, through the Mediterranean Sea to northwest Africa (i.e. to Senegal) in the south. It is not present in the Baltic Sea (Barratt & Allocock, 2012). According to data collected during SoleMon surveys (ADRIAMED, 2011), cuttlefish aggregates in the northern sector of GSA 17. During autumn and winter individuals migrate to deeper water (approximately 100m); returning to shallow water in spring and summer. In the Mediterranean large males return to shallow waters ahead of females with females and smaller individuals joining them throughout the spring and summer. Spawning occurs in shallow, inshore waters in April to July in the western Mediterranean. Cuttlefish are generally known to lay eggs on seagrass, but in the GSA 17, seagrass is present only inside the Venetian lagoon, where the seagrass meadows have experienced a marked reduction caused by human activities, including fishing with hydraulic dredges, extensive aquaculture of clams and possibly pollution. The scarcity of natural substrates encourages the deposition of eggs on artificial

substrates, including traps. Indeed, eggs are laid not only on the inner surfaces of traps, but often on the outer ones as well. Moreover, the presence of eggs has been demonstrated to attract mature cuttlefish [38], thereby stimulating egg deposition on traps (Melli et al., 2014). Those young that hatch in spring usually spawn in the autumn of the following year; those that hatch in autumn usually spawn in the spring of their second year. Young are restricted to shallow water until their cuttlebones are fully formed (Reid et al. 2005).

Fisheries and landings information

In the GSA 17 cuttlefish is targeted by fisheries belonging to Italy, Croatia and Slovenia fleets. *S. officinalis* is primarily trawled, either as a target species, or as bycatch to demersal finfishes. This kind of fishery is carried out all year round, with a closure period (at least 30 consecutive days) for Italian trawlers, between July and October, depending on the maritime district. Cuttlefish is also target of set gillnet, trammel net, stationary uncovered pounds net, fyke net and pot fisheries. The artisanal fisheries, however, utilize a variety of selective gear, often combined with the use of light. Exploitation is based on all the age classes. Actually, it does not exist a minimum landing size for this species.

By analysing the total annual landings of this species in the Adriatic in the period from 1972 to 1997, Mannini and Massa (2000) observed distinct fluctuations in the catch. Among the three



countries fishing in the GSA 17, Italy has the biggest Fishing effort value, followed by Croatia and then Slovenia. This is even reflected on the economic and weight values of the cuttlefish's landings (Fig. 9).

Figure 9. A) Fishing effort (Kw/day) of Italian, Slovenian and Croatian vessels targeting cuttlefish in the GSA17 from 2012 to 2015 (STECF, 2017). B) Landing value (€), C) Weight of landings (t).

Stock assessment

The assessment of this species were carried out using the CMSY production model that estimates fisheries reference points (MSY, Fmsy, Bmsy) as well as relative stock size (B/Bmsy) and

exploitation (F/Fmsy) from catch data and broad priors for resilience or productivity (r) and for stock status (B/k) at the beginning and the end of the time series. The results of CMSY model and estimates from Length-Frequency data from the Italian commercial fleets using Beverton and Holt 1996 formula, showed that the exploitation slightly below FMSY in CMSY model and above the M in the second model. In both cases, the biomass is below safe biological limits (BMSY or proxies). The harvest rate (catches/biomass a proxy of F) using the SoleMon survey as biomass index has been estimated and an empirical reference point was also used.

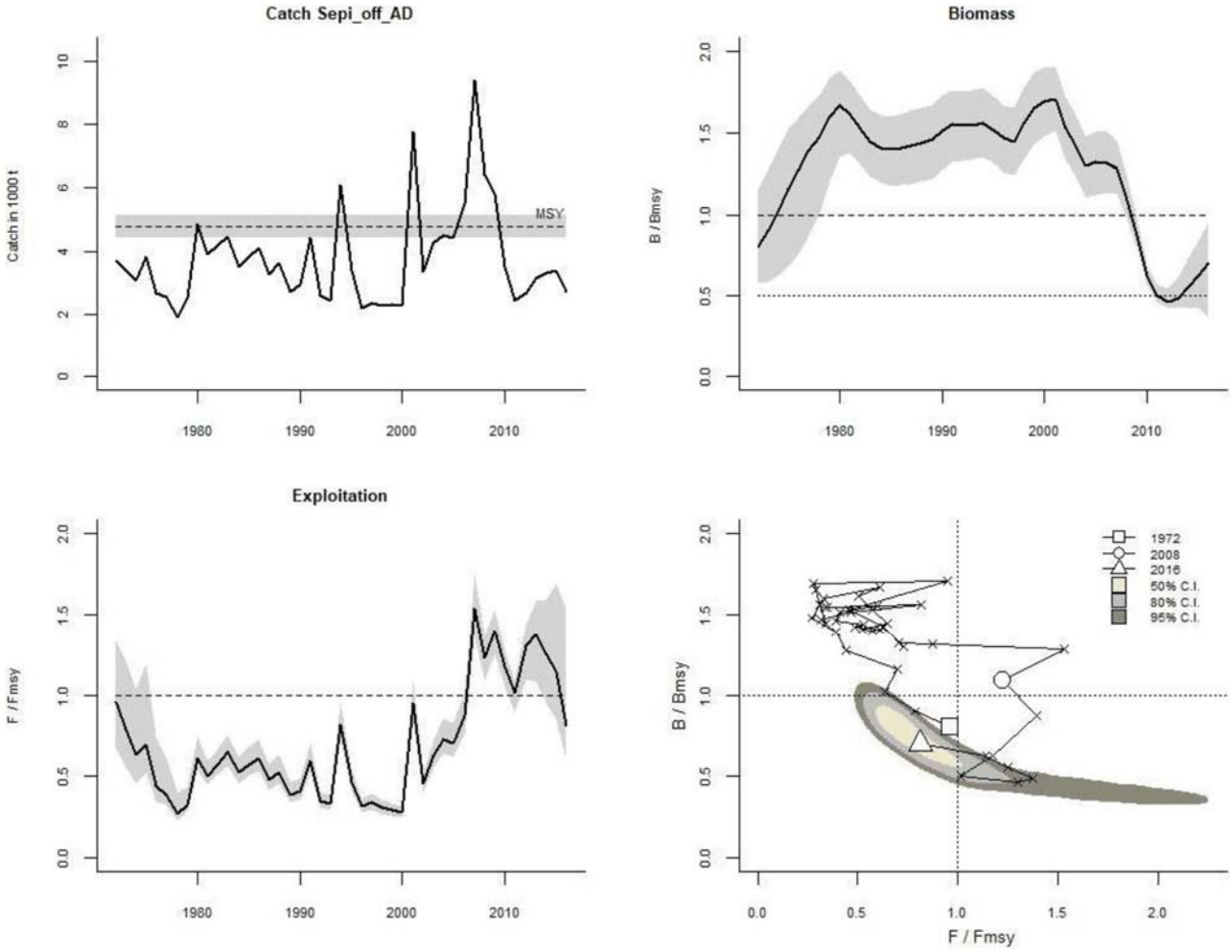
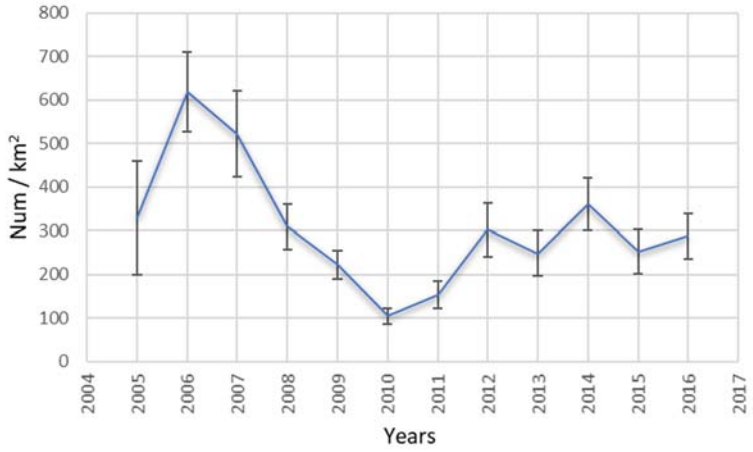


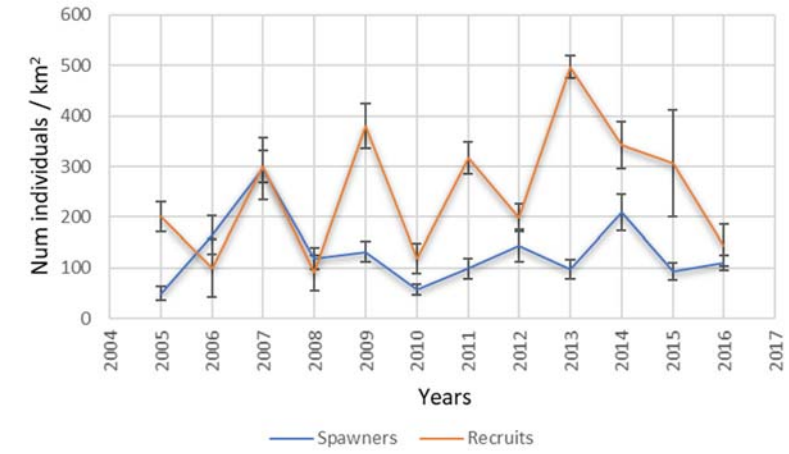
Figure 10. Results of final C-MSY run.

Fisheries independent information: SoleMon

Fishery independent information regarding the state of the common cuttlefish in GSA17 was derived from the international survey SoleMon, using datas from 2005 to 2016. Figure 11 shows the estimated trends for total (A), spawners and recruits abundance (B) and biomass (C). Fishery independent data collected in the framework of SoleMon survey show a decrease of relative abundance and biomass from 2006 to 2010 followed by slightly higher values in the remaining period and fluctuating between the empirical thresholds of the 66th and 33rd percentiles.



A)



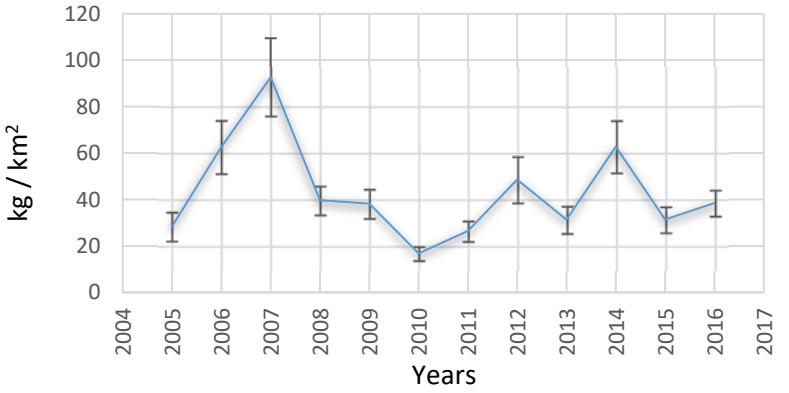


Figure 11. Trends for A) total abundance, B) abundance of spawners and recruits; C) total biomass.

Trend of market prices

The three countries show different prices for the common cuttlefish in the years from 2012 to 2015 (Italy: 6.15-7.35 €, Croatia: 3.45-4.60 €, Slovenia: 6.25-6.95 €; Fig. 12) (STECF, 2017).

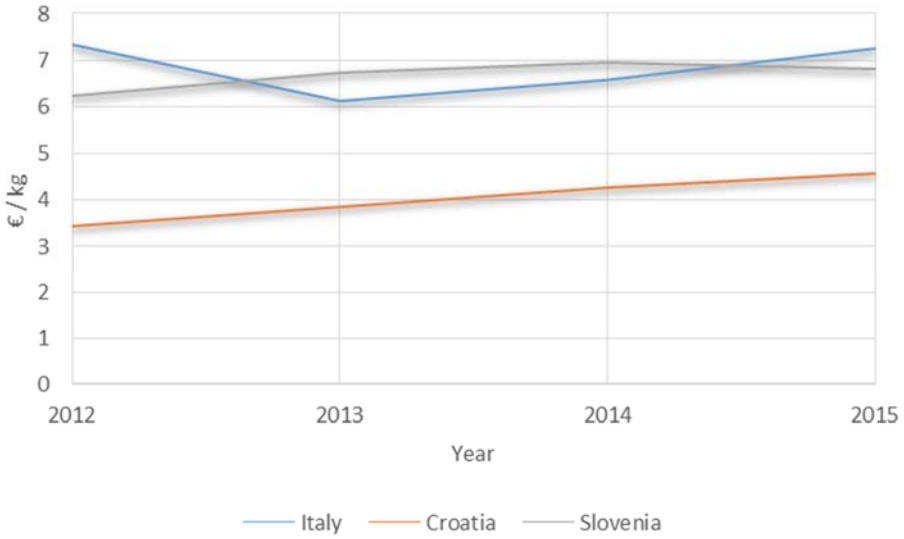


Figure 12. Annual mean prices (€/kg) of common cuttlefish in the three countries (2012-2015).

Making a zoom, market prices of cuttlefish in the main Italian fish markets of the Adriatic Sea showed a clear seasonal trend (Fig. 13), with a general increase in summer and decrease in winter, probably related to the availability of the species. In general, an increasing trend of prices can be observed during the last four years (data from ISMEA 2018b).

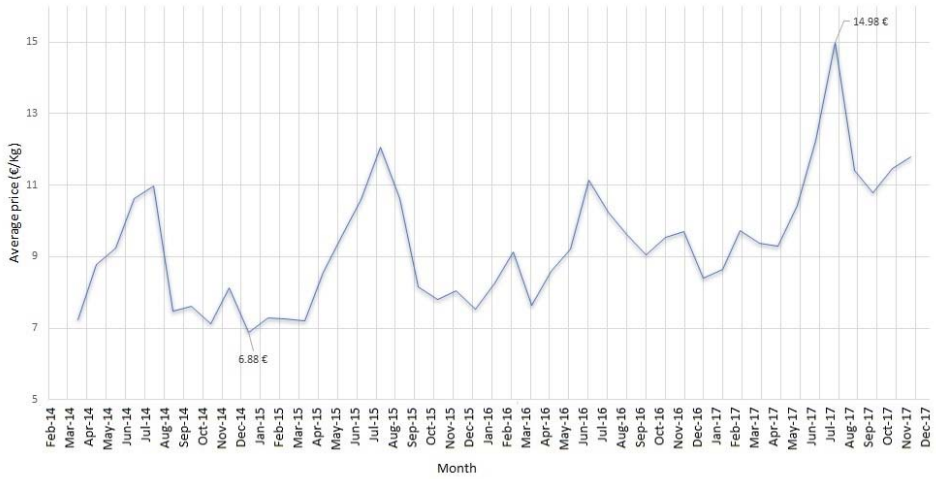


Figure 13. Monthly mean price (€/Kg) of cuttlefish in the fish markets of Ancona, Cesenatico, Civitanova Marche, Goro e San Benedetto del Tronto (February 2014 – December 2017; from ISMEA 2018b).

Stakeholder involvement for identifying possible management measures intended to reach a sustainable exploitation of shared stocks (common sole and cuttlefish)

The Advisory Board of DORY identified a number of management measures/best practices that have been proposed to the stakeholders during *ad hoc* meetings carried out in Italy and Croatia by means of a bottom-up approach.

The methodology followed during such seminars/workshops started with a brief introduction of the state-of-the-art of the two target species (i.e., abundance, trend, state of exploited stock, socio-economic relevance, etc.) made by the fishery scientists involved in the project.

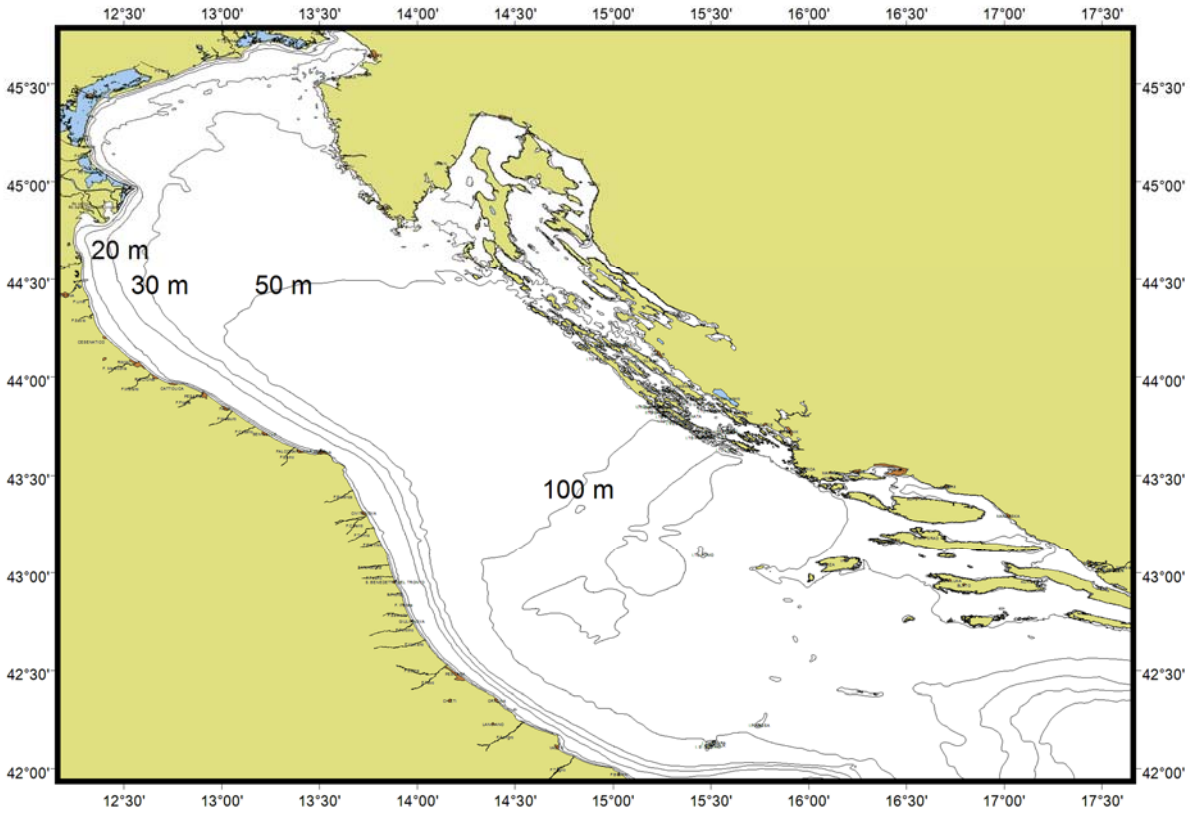
The second step was an explanation of each management measure/best practice identified by the Advisory Board, promoting a discussion regarding the management issue and the needs for a healthy fish stock conservation. At the same time, a paper questionnaire was submitted to the audience in order to collect individual stakeholders' point of view.

Annex I is a copy translated in english of the questionnaire. During the meeting with stakeholders the questionnaire was translated in the respective native languages (Italian and Croatian).

Annex I

Which kind of fishery do you belong to?

- Bottom otter trawling
- Rapido trawling
- Set gillnets
- Fyke nets
- Trammel nets
- Pots
- Stationary uncovered pound nets



1- In which area of the GSA 17 do you mainly fish?

Questions about the common sole:

2- How would you define the amount of landing in terms of abundance (number/kg) for this species over time?

- o Very decreasing
- o Decreasing
- o Constant
- o Increasing
- o Very increasing

3- How would you define the economic relevance of this species?

- o Very relevant
- o Relevant
- o Neither relevant nor irrelevant
- o Irrelevant
- o Very irrelevant

4- Do you believe that management measures are necessary for this species?

- o Absolutely not
- o No
- o Yes
- o Absolutly yes

5- Express an opinion on the following proposed management measures for the common sole:

A. "Sole sanctuary"

- o Strongly agree
- o Somewhat agree
- o Neither agree nor disagree
- o Somewhat disagree

- o Strongly disagree

B. Increase the gillnet mesh to 72 mm (Italy) and 84 mm (Croatia)

- o Strongly agree
- o Somewhat agree
- o Neither agree nor disagree
- o Somewhat disagree
- o Strongly disagree

C. Increase the minimum landing size to 25 cm TL

- o Strongly agree
- o Somewhat agree
- o Neither agree nor disagree
- o Somewhat disagree
- o Strongly disagree

6- Do you have any suggestions on the management measures that can be applied for the common sole?

_____

_____

_____

_____

_____

Questions about the common cuttlefish:

7- How would you define the amount of landing in terms of abundance (number/kg) for this species over time?

- o Very decreasing
- o Decreasing
- o Constant
- o Increasing
- o Very increasing

8- How would you define the economic relevance of this species?

- o Very relevant
- o Relevant
- o Neither relevant nor irrelevant
- o Irrelevant
- o Very irrelevant

9- Do you believe that management measures are necessary for this species?

- o Absolutely not
- o No
- o Yes
- o Absolutly yes

10- express an opinion of approval for the following proposed management measures for the common cuttlefish:

A. Trawling ban inside the 6 nm until the 31th October

- o Strongly agree
- o Somewhat agree
- o Neither agree nor disagree
- o Somewhat disagree

- Strongly disagree

B. To avoid cleaning traps from cuttlefish eggs

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

C. Adoption of active restoking initiatives (referring to EcoSea Pilot Project experiences)

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

11- Do you have any suggestions on the management measures that can be applied for common cuttlefish?

_____

_____

_____

_____

_____

Questionnaires results

Results concerning the general questions about the perception on the state of the resources will be presented combined for Italy and Croatia, while the ones regarding the possible management measures will be showed separately by country. It is important to underline that in Croatia the rapido trawl fishing activity is really lower than the Italian one.

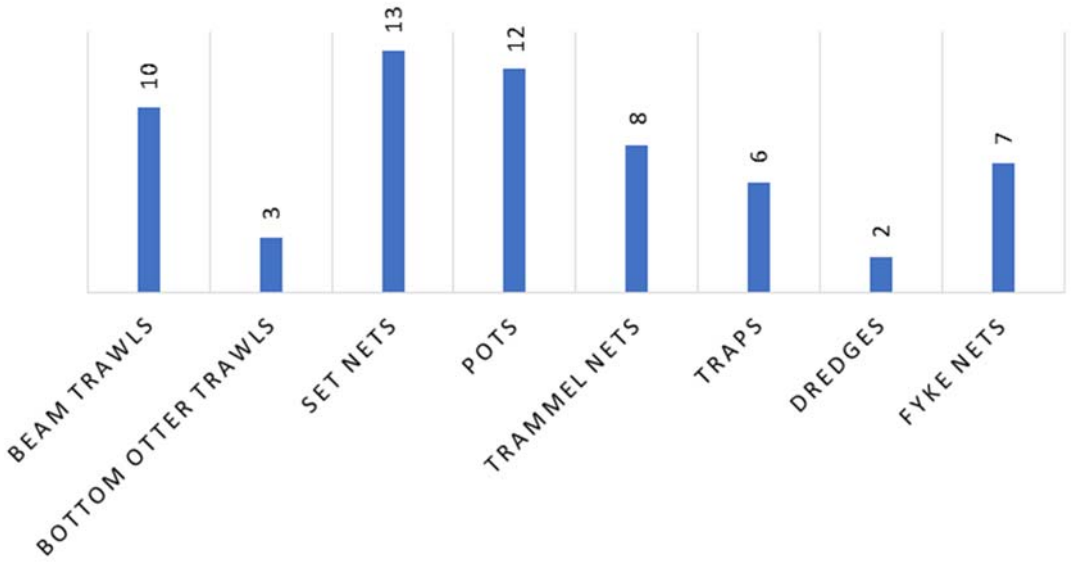


Figure 15. Number of interviewed fishermen subdivided by fishing gear.

Figure 15 shows that most of the respondents use set nets (13). It is important to remind that nets in general are often used combined with other set gears, such as traps, pots and fyke nets, depending on the season. All these gears are used by small-scale fisheries and it can be noticed that they were well represented during the meetings. Active gears, such as beam/rapido trawl, otter bottom trawl and dredges were also well represented, even if in lower number.

More than the 50% of the fishermen interviewed expressed the perception of a decline of the catches of common sole, and even worst when cuttlefish was the subject (Figure 16). Infact, in this case the percentage of the fishermen declaring an apparent decrease in the abundance of this target species are the 83%.

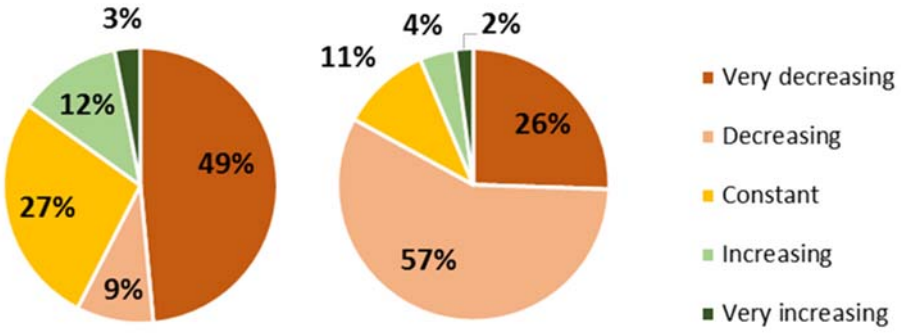


Figure 16. Stakeholders' perception of the catching trends for common sole (left) and cuttlefish (right).

These two species, apparently, have an high economic value for the interviewed fishermen (Fig. 17). In particular, cuttlefish shows an higher economic value, mainly due to the Croatian respondents, for which it represents an important resource in several areas.

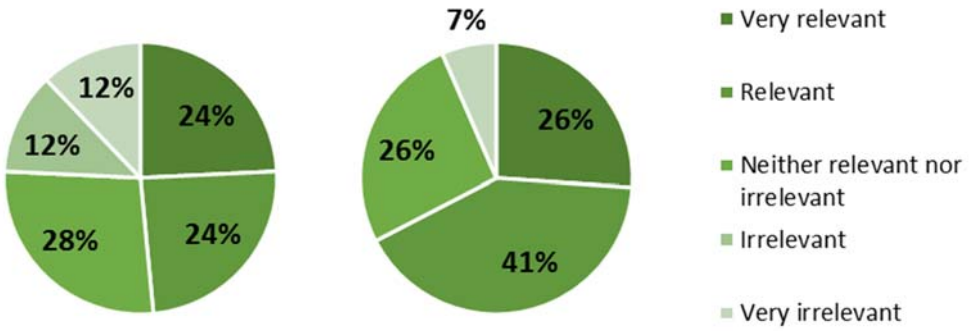


Figure 17. Stakeholders' perception of the landing value for common sole (left) and cuttlefish (right).

Concerning the managemant measure, most of the respondents believe that they are necessary for both species (91% for common sole, 81% for cuttlefish) (Fig. 18).

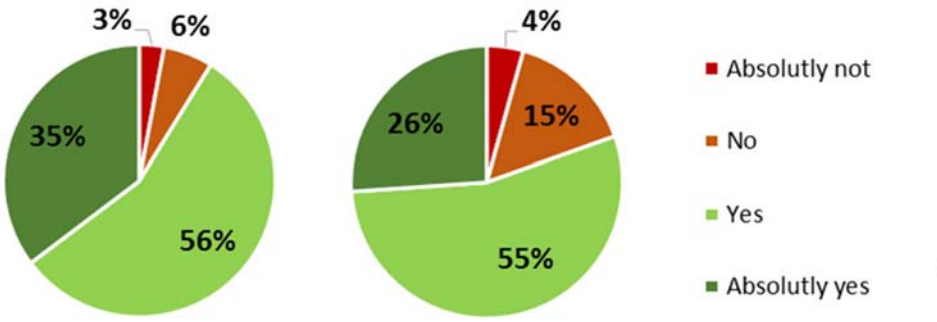


Figure 18. Stakeholders' perception of the necessity for management measures for common sole (left) and cuttlefish (right).

Focusing on the fishermen's opinion on the menagement measures proposed by the DORY Advisory Group, Figure 19 shows quite strong differences between countries.

In the case of the common sole, Italian fishermen generally disagree with the "sole sanctuary" and the increase of the minimum landing size from 20 cm TL to 25 cm TL. Croatian fishermen support the "sole sanctuary" and the increase of gillnet mesh size, while the increase of the minimum landing size to 25 cm TL shows a balanced number of opinions. The opposite opinions between Italian and Croatian fishermen on sole management measures could be explained by differences in the exploitation patterns. In fact, Italian fleets mainly exploit young soles using gillnets and rapido trawl, while Croatian fleets mainly catch large individuals using trammel nets along the Istria Peninsula coasts.

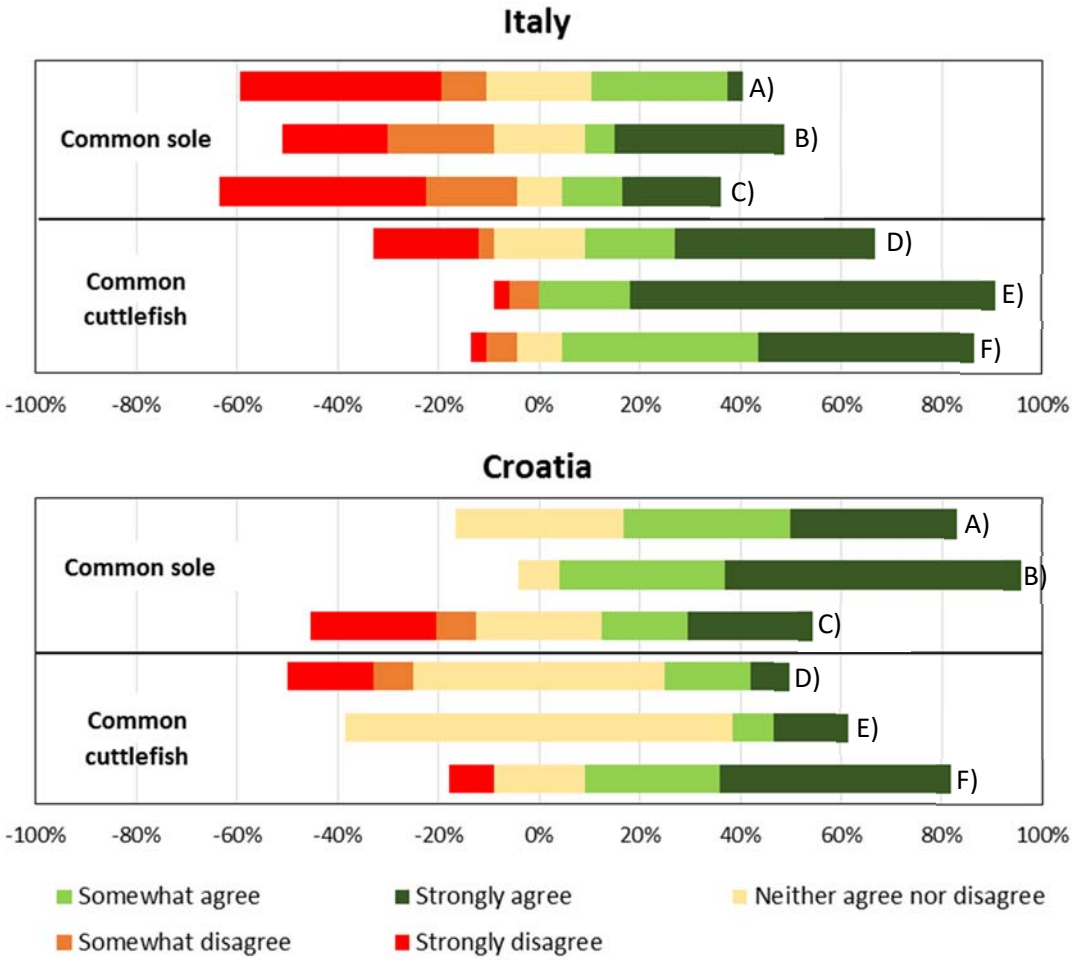


Figure 19. Stakeholders' perception of the necessity for specific management measures. A) sole sanctuary; B) increase of gillnets mesh size; C) increase of MLS to 25 cm TL; D) trawling ban inside 6 nm from the beginning of the seasonal ban until 31th October; E) avoid cleaning traps from eggs; F) adoption of restocking initiatives

The management measures proposed for the cuttlefish received a more positive overall feedback compared to the previous species. The only measure that received a number of disagreements is the banning of trawling inside the 6 nm from the beginning of the seasonal ban until the 31th October, but only along the Italian coasts of GSA17.

Measures that will be tested in DISPLACE Model

The results of the above mentioned stakeholders consultation highlighted in one side a disomogenity, specially related to geography of the answers origin, in the other side a general agreement, specially related to the adoption of good practices addressed to improve the status of the biological resource. The first one is attributable to how a specific measure could influence the regional fishing behaviour, underlining the multicultural composition of population that overlook the Adriatic Sea basin, each one followin a specific pattern of biological resource exploitation (see Grati et al., 2018).

Therefore, the scenarios that will be tested throught the DISPLACE bio-economic model will be related to the best scientific knowledge and specific perception of local communities, in order to filling the gap between them.

Seven scenarios will be tested:

1. trawling ban inside the 4 nm from the coast along the Italian side of GSA17;
2. trawling ban inside the 6 nm from the coast along the Italian side of GSA17;
3. Pomo Pit fisheries restrictions (A, B, C zones);
4. Sole Sanctuary fisheries restrictions;
5. Yearly decrease of the fishing effort by a 10%;
6. Sole selectivity (increase gillnet mesh size to 72mm and increase MLS to 25 cm TL);
7. All the above scenarios together.

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