DORY

Project results

CAPITALIZATION ACTIONS FOR ADRIATIC MARINE ENVIRONMENT PROTECTION AND ECOSYSTEM BASED MANAGEMENT

Interreg
Italy - Croatia
DORY

EUROPEAN UNION

Index

1 INTRODUCTION

The Adriatic Sea is characterized by an invaluable richness of natural marine and fish resources which is the basis for tourism, recreational activities and contributes to the cultural heritage of the Adriatic Regions. However, the increased human exploitation of marine and coastal space and resources, in particular for fishing and aquaculture activities, which are key economic sectors for Adriatic communities intensified pressures on coastal and marine ecosystems, threatening the vitality of the ecosystems and the environmental quality of the sea.

Furthermore, Adriatic fishery resources are shared by Italian and Croatian communities and most of the socks suffer of overfishing and severe exploitation. Thus, to ensure an efficient protection of marine biodiversity and to reduce the conflicts of use and guaranteeing a sustainable management of Adriatic marine resources, it is still necessary to improve the cross-border institutional dialogue and the implementation of shared actions and management measures for the adoption of lower impact fishing and aquaculture methods.

With the ECOSEA project, funded by the Adriatic IPA CBC 2007-

2013 programme and implemented from 2012 to 2016, Italian and Croatian Institutions with the support of a Scientific Advisory Board already worked on a governance level to propose solutions for a common vision in terms of sustainable management of fisheries resources and on operational level conducted several pilot actions oriented to revitalize the marine habitats.

DORY project - funded under the capitalization call of the Interreg Italy-Croatia Programme 2014-2020 and operating from January 2018 to September 2019 - built upon the potential of the ECOSEA cooperation network.

The Institutions involved continued to work closely with fishermen and under the best scientific guidance to test solutions developed in terms of common management models and tools, further implemented evidence-based spatial planning tools taking into account biological, economic and social complexities of marine resources.

2 DORY VISION AND PARTNERSHIP

DORY contributed to Adriatic Sea ecosystems protection and conservation acting for marine resources sustainable use under common and science-based approach. Project partners, capitalizing the ECOSEA project solutions, performed a set of regional and cross border activities to reduce fisheries and aquaculture activities pressure on marine areas, improve habitat and species protection and conservation and contextually promoted a fisheries resources science-based management as part of a coordinated development of Maritime Spatial Planning (MSP) process, addressing the EU objective of ecosystem based management.

Partnership is composed by Italian and Croatian regional authorities, development agencies and by the most relevant scientific institutions for marine environmental research in the area:

Marche Region, Fisheries Department (Italy) - Lead Partner

Veneto Region - Hunting & Fisheries Directorate (Italy)

Emilia Romagna Region (Italy) - Hunt and Fisheries Unit

Friuli Venezia Giulia Region - Hunting and Fish resources Unit (Italy)

IRBIM, Ancona (Italy) - Institute for Biological Resources and Marine Biotechnologies

Zadar County (Croatia)

PI RERA S.D - Regional Development Agency of Split - Dalmatia County (Croatia)

Institute of Oceanography and Fisheries (Croatia)

DORY acted **on two levels**, from a more institutional and governance level promoted **the adoption of common management measures** for the reduction of impacts deriving from economic activities on fishing stocks and **from a more operational level tested management strategies to improve biodiversity conservation (e.g. protection of spawning and nursery areas) and to reduce the ecological impact of aquaculture.**

3 COMMON MANAGEMENT MODELS FOR SUSTAINABLE GOVERNANCE OF ADRIATIC FISHERIES

The activity was aimed to test and further implement common cross-border model and co-management approaches for sustainable fisheries management capitalizing ECOSEA achievements and multi-level working group approach under the best scientific guidance.

The model for sustainable fisheries management has been applied on 2 shared stock of high commercial value and overfished (Solea solea, Sepia officinalis) selected by the Partnership for defining, **together with stakeholders' by means of a well coordinate engagement process**, a set of measures to manage and regulate catches.

The information collected **have been pooled to test an advanced MSP tool (DISPLACE) providing for scenario of alternative spatial management measures and fishing effort and catches redistribution.**

A specific attention has been given to the testing of a particular scenario for the setting up of a CB protected area within the so-called "Sole Sanctuary", the core spawning area for this species, located in international water between the two countries, not protected and managed so far.

3.1 – THE TARGET SPECIES: COMMON SOLE AND CUTTLEFISH

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

Spatial distribution

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. According to data collected during SoleMon surveys 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).

As a result of the different spatial distributions, juveniles are exploited exclusively by Italian vessels, especially by beam trawlers

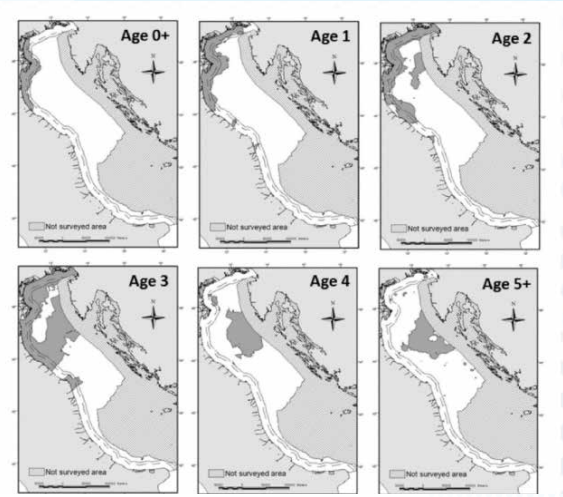

Figure 1 - Maps of spatial distribution by age classes of soles. The 6 and 9 nautcal miles from the Italian coast are shown respectively by broken and continuous black lines (Scarcella et al., 2014).

(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.

Fisheries and landings

In the North Adriatic common sole is targeted by bottom and beam 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 for this species is 20 cm, not corresponding with the length at first maturity estimated around 25 cm and 25.8 cm.

Based on the Length-at-age relation, exploitation could be predictable almost on all the age classes from 1 to 4+, but in relation to the STECF (2017) data, it is dominated by ages 0 and 1-year specimens.

Fishing effort

Among the three countries fishing in the GSA 17, Italy has the biggest Fishing effort value, followed by Croatia and then Slovenia (Fig. 2). By referring to the landing economic and weight values for the three countries, it is clear that, as recorded for the landed, it is perfectly reflected on the revenue obtained. Common sole is a very important commercial species in the central and northern Adriatic repre-

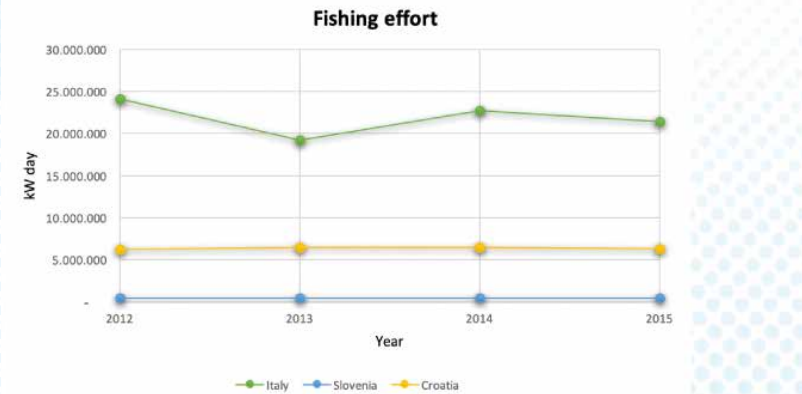

Figure 2 – Fishing effort (kW day) of Italian, Slovenian and Croatian fleet targeting common sole.

senting more than 25 million of euros in term of economic landing value, only for Italy.

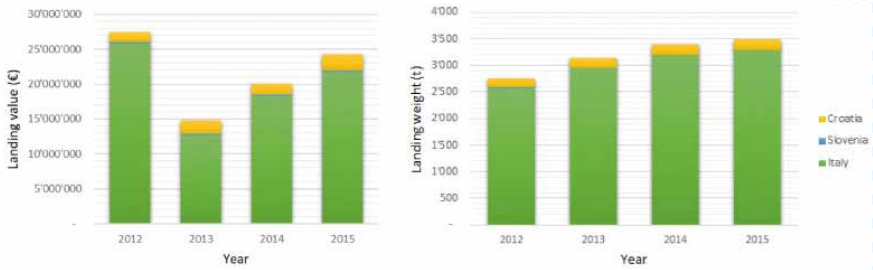

Figure 3 – (A) Economic landing values, (B) Weight landing values (STECF, 2017).

Stock assessment

The existence of a single stock of common sole within the GSA 17 has been demonstrated by tag-and-recapture and DNA sequencing experiments. Thanks to these evidences it was possible to analyse the GSA 17's sole stock as single unit. Results suggest an overfishing situation for the S. solea stock. Also, multiple assessment approaches used to analyse the health of the sole stock indicated overexploitation with extremely high fishing mortality.

Fisheries independent information: SoleMon survey

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

Trend of market prices

The three nations 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. In general, a variable increase of prices can be observed during summer months (Fig. 4)

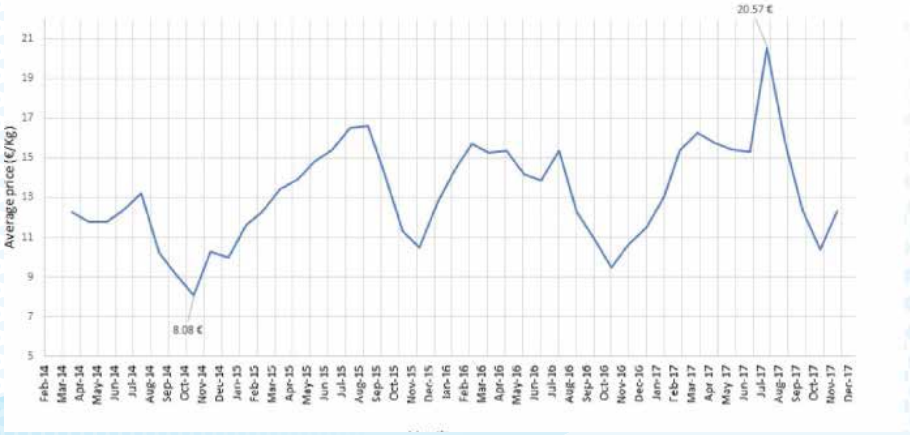

Figure 4 - Monthly mean price (€/kg) of common sole in the fish markets of Ancona, Cesenatico, Civitanova Marche, Goro e San Benedetto del Tronto (February 2014 – December 2017 ; from ISMEA 2018a).

Proposed management measures for common sole

Currently, the catch composition of sole in the northern and central Adriatic Sea is dominated by ages 0 and 1-year specimens, with a low occurrence of large individuals because the minimum landing size is 20 cm. Length at first maturity is 25 cm, this value currently has been estimated at 25.8. Demographic erosion affects not only the spawning capacity of the stock but also the average market price and revenues from fishing activities.

- One of the first management measures proposed has been the increase in the minimum landing size to 25 cm TL, shifting the target towards the adult portion of sole population. To avoid the impoverishment of the stock, protecting juveniles that, as said before, tend to aggregate inshore, it would also be useful to make changes in the mesh size of the small-scale fishery.

- A gillnet having a minimum mesh size of 72 mm (stretched) would help to avoid the common sole target by catch (undersized), and then all the juveniles.

- Furthermore, the institution of a "sole sanctuary" (Fig. 5) would lead to protection of part of the sole spawning aggregation. Whereas it is an area where trawling is yet not B common, the proposal would be to exclude fishing with gill nets during the reproductive season (December – February).

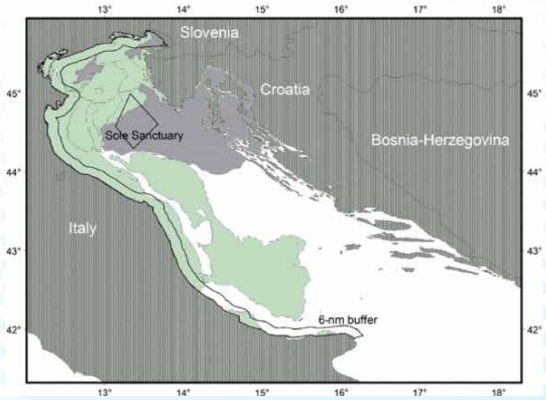

Figure 5 – "Sole sanctuary", modified from Bastardie et al., 2017

Considering the overfishing and low biomass situation of the sole stock in GSA 17 a reduction of fishing effort and an improvement in exploitation pattern would be necessary, especially of Italian rapido trawlers and gillnetters, which mainly exploit juveniles.

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

Spatial distribution

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 returning to shallow water in spring and summer. 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, thereby stimulating egg deposition on traps. 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.

Fisheries and landings information

In the GSA 17 cuttlefish is targeted by fisheries belonging to Italy, Croatia and Slovenia. 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.

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. 6).

Figure 6 – (A) Fishing effort (Kw day) of Italian, Slovenian and Croatian vessels targeting cuttlefish in the GSA 17, from 2012 to 2015 (STECF, 2017). (B) Economic landing values, (C) Weight landing values.

Fisheries independent information: SoleMon

Fishery independent information regarding the state of the common cuttlefish in GSA17 was derived from SoleMon surevy, using datas from 2005 to 2016.

Trend of market prices

The three nations 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. 10) (STECF, 2017).

Market prices of cuttlefish in the main Italian fish markets of the Adriatic Sea showed a clear seasonal trend (Fig. 7) with a general increase in summer and decrease in winter, probably related to the availability of the species. An increasing trend of prices can be observed-

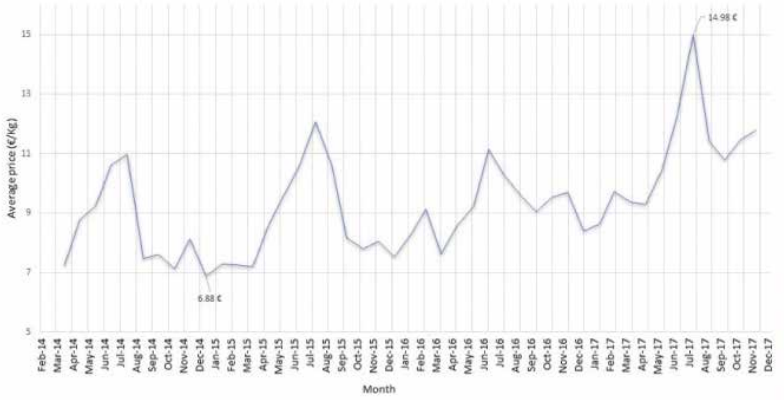

Figure 7 – Monthly mean price (€/Kg) of cuttlefish in the fish markets of Ancona, Cesenatico, Civitanova Marche, Goro e San Benedetto del Tronto (February 2014 – December 2017 ; from ISMEA 2018b).

Possible management measures for cuttlefish

Considering the common cuttlefish habits, with reference to the coast-wide migration of juveniles, one of the possible management measures will be:

- to maintain the closure of the fishing period, until 31th October, up to 6 miles from the Italian coast.

Moreover, to increase the reproductive success of this species, there would be some good practices to apply, since artificial hard substrate are the new excellence sites for the deposition of eggs because of the natural one decline (seagrasses).

For example:

- to avoid cleaning traps for small-scale fishery (Fig. 8)

- the installation of hard structures between the rows of mussel aquaculture.

Figure 8 - Traps with cuttlefish and eggs, modified from Melli et al., 2014.

3.2 - The DISPLACE model and the alternative management scenarios tested

Scientific Institutions (CNR-IRBIM and IOF), after having shared and discussed the proposed measures with the stakeholders, tested by means of the advanced MSP (DISPLACE –https://displace-project.org/blog/) tool the spatial management scenarios supposed to help the sustainable exploitation of shared stock and supporting MSP approach evolution in the Adriatic Region, by an ecosystem-based resource management.

The DISPLACE model framework is developing a research and advisory-based platform to transform fishermen's detailed knowledge and micro-decision-making behaviour into simulation and management evaluation tools.

This involves advanced methods to assess and provide advice on the bio-economic consequences for the fisheries and fish stocks of different fishermen decisions and management options.

DISPLACE is an agent-based simulation model developed to fisheries, habitat conservation, maritime spatial planning and management issues, especially from the perspective of the fisheries. Agent-based models aim to consider the socio-economic and ecological processes at the individual scale (e.g., the fishing vessels) to capture the effects of human decisions at that level and then go through the individual processes up to the aggregated dynamics (e.g., the fisheries as a whole, or other marine ecosystem components).

DISPLACE have already been applied to the north Adriatic (GSA 17) to the Italian demersal fisheries. In the framework of DORY, the 2017 Adriatic Sea application has been recently updated with most recent fish stock assessment data, extended to include the Croatian fisheries.

The effects of the following spatial management scenarios have been tested:

1. Baseline – it is the baseline scenario (status quo), considering recent fisheries regulation rules in Italy, Croatia and Slovenia.

2. The 6-nm trawling ban along the Italian coasts (GSA17), which is supposed to reduce fishing pressure on this vulnerable area (Figure 10); it represents one of the most relevant nursery areas for many species, especially for common sole and cuttlefish. This scenario excludes Croatia and Slovenia's waters due to existing strict fisheries regulations and complex geomorphological characteristics of eastern Adriatic coast, as well as the Maritime Departments of Monfalcone and Trieste. Scientists have demonstrated that the only nurseries consistently protected in European Mediterranean waters are those of coastal species, such as red mullet, common Pandora and common sole with 66.8%, 54.1% and 46.1% respectively of persistent nursery areas under protection. This is mostly due to the trawling ban within 3 nautical miles of the shoreline or 50 m depth, applied through current management measures as defined by Article 13 of EU Council Regulation 1967/2006. This situation is particularly evident for the Northern Adriatic Sea. Based on this evidence, the implementation of the spatial management measure currently in force (3 nautical miles) with an extension to the 6 nautical miles would have the potential to substantially improve current fisheries exploitation patterns.

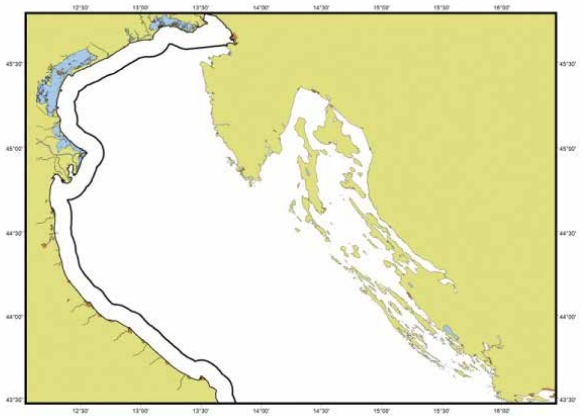

Fig. 10 – Map showing the 6-nm buffer along the Italian coast.

3. Sole Sanctuary - a permanent closure of the "sole sanctuary" area (Figure 11) for bottom otter and rapido/rampon trawlers (both Italian and Croatian fleets). Again, the closure of this area highlights the importance of reducing the fishing pressure on vulnerable areas (e.g., spawning areas) that are considered of biological interests for commercial species.

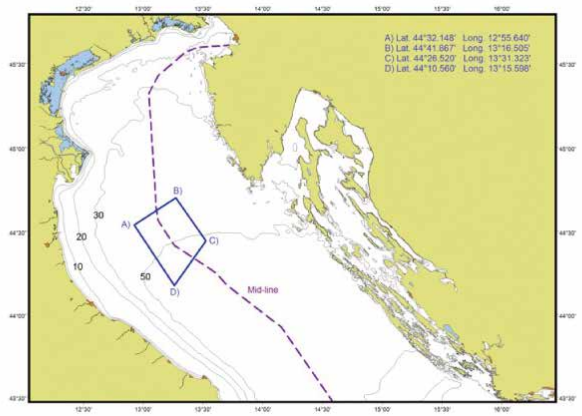

Fig. 11 – Map of the "sole sanctuary".

4. Sole Selectivity - Increase the selectivity of gillnet through the adoption of a 72mm stretched mesh size and increase of the common sole minimum landing size to 25 cm TL (the current one is 20 cm TL);

Through the software, it was possible to obtain a quantification of the changes provoked by the implementation of alternative plans comparing them against the baseline situation where the current management was applied.

SUMMARY OF THE MOST RELEVANT TESTED SCENARIOS AND RESULTS

3.2.1 - The recommendations for policy makers

Based on the results of the scenario projected over a period of six years, the scientific institutions provided the following recommendations to the policy makers

3.2.1.1 - The Sole Sanctuary

The spatial management measure concerning the Sole Sanctuary is strongly recommended. These results and recommendation obtained through the DORY project have been already presented to policy makers at the "STECF EWG 19-02: Multi-Annual Plans for the fisheries exploiting demersal stocks in the Adriatic Sea" and published on the associated report (STECF, 2019).

To date, the closure should avoid many conflicts, because the fishing effort exerted in this area, especially the trawling fishery one, is very low if compared to the rest of the GSA 17, due to the distance from the ports and the type of seabed habitat, which is characterized by species that may obstruct the net meshes (e.g. bryozoans) and others (e.g. holothurians) that can affect the catches making these less suitable for market (see deliverable 3.3.2 and 3.4.1).

Moreover

- the closure to the fisheries in the area could also be seen as a precautionary approach.

In fact, if with the progress in technology were possible to have gears avoiding what is compromising the efficiency of trawling activity, the area would be targeted as much as the others. Since Asiatic markets demand regarding sea-cucumbers is increasing, it would also help to safeguard Holothuroidea species, in this case *Holothuria (Panningothuria) forskali*, followed by *Amathia semiconvoluta, Parastichopus regalis, Phallusia mammillata*, and *Holothuria tubulosa.*

In particular, based on the results of DISPLACE the exclusion of rapido trawlers (TBB) from the Sole Sanctuary would decrease the total fishing effort, the CPUE (catch per unit effort) and landings of common sole, and the discard rates of this species.

On the other hand, this scenario would increase the total CPUE in the medium term. The common sole is the main target species for TBB. The **exclusion of bottom otter trawlers (OTB) from the Sole Sanctuary** would decrease the total fishing effort, the total number of trips, CPUE and landings of common sole, and total landings. On the other hand, the trip duration and the common sole discard would increase. It should be mentioned that the common sole is not a target species for OTB, as it contributes for a very small fraction of the total landings of this fleet segment.

Based on the results, the exclusion of gillnetters from the Sole Sanctuary would increase the CPUE and the landings of the common sole in the medium term.

In addition, a reduction of common sole discard would be also expected. From the outputs of DISPLACE model and based on scientific knowledge, it would be advisable to close the "Sole sanctuary" to gillnets activity, at least from December to February, during the reproductive season of common sole.

It would allow to the larger individuals, that constitutes the Spaw-

ning Stock Biomass, to have more chance to reproduce successfully

3.2.1.2 - Minimum landing size

The minimum landing size (MLS) for this species is 20 cm, not corresponding with the length at first maturity estimated around 25 cm and 25.8 cm.

Demographic erosion affects not only the spawning capacity of the stock but also the average market price and revenues from fishing activities.

One of the first management measures to be applied could also be the

- increase in the minimum landing size to 25 cm TL, shifting the target towards the adult portion of sole population. To avoid the impoverishment of the stock, protecting juveniles that, as said before, tend to aggregate inshore, it would also be useful to make changes in the mesh size of the small-scale fishery.

- A 72 mm mesh size (stretched) would help to avoid the common sole target by catch (undersized), and then all the juveniles.

From the results of DISPLACE model, the estimated income at medium-term should grow, due to the increase in the medium size of landings of common sole specimens.

3.2.1.3 - Protection of 6nm

Scientists demonstrated that the only nurseries consistently protected in European Mediterranean waters are those of coastal species, such as red mullet, common Pandora and common sole with 66.8%, 54.1% and 46.1% respectively of persistent nursery areas under protection. This is mostly **due to the trawling ban within 3 nautical miles of the shoreline or 50 m depth, applied through current management measures as defined by Article 13 of EU Council Regulation 1967/2006.**

This situation is particularly evident for the Adriatic Sea.

Based on this evidence

- the implementation of the spatial management measure currently in force (3 nautical miles) with an extension to the 6 nautical miles would have the potential to substantially improve current fisheries exploitation patterns.

The Italian Ministry of Agricultural, Food, Forestry and Tourism Policies (MIPAAFT) regulates the temporary closure of fishing activities for bottom (OTB and TBB) and pelagic trawlers in the Adriatic Sea (August-July). Since 2012 such Regulation also includes temporary spatial restrictions: 1) vessels enabled to coastal fishery (<6 nm from the coast) or having LOA <15 m cannot operate inside the 4 nm from the beginning of the temporary closure until 31th October; 2) vessels having LOA >15 m cannot operate inside the 6 nm from the beginning of the temporary closure until 31th October. These regulations exclude the Maritime Departments of Monfalcone and Trieste because, due to the peculiar geo-morphology of the northern Adriatic, the fishing grounds of such Maritime Departments have a limited spatial extension.

Currently, Italian small-scale trawlers (e.g. IV category fishing license “coastal fishery”) operates between the 3 and 6 nautical miles. Large-scale OTB generally exploit offshore fishing grounds, with the exception of large-scale TBB, which usually operate in shallow water fishing grounds (depth < 50 m). The exclusion of small-scale trawlers from the 6 nautical miles would generate spatial conflicts along with potential socio-economic issues for this fleet segment.

From the DISPLACE results it is possible to notice that gillnet fishery will benefit from the 6nm closure to OTB and TBB in terms of higher sole CPUE and sole landings. Rapido trawlers (TBB) will suffer a decrease of the fishing effort, as well as the total landings and sole landings. Discard rates for common sole will decrease and a general increase of the total CPUE would occur. For bottom otter trawlers (OTB) this scenario would produce a general increase in the CPUE of the total catch and the sole, total landings, as well as of sole landings.

Based on the outputs of DISPACE model and scientific knowledge, this measure would consist in the ban for the trawlers activity (TBB and OTB) up to 6nm form the coast. Due to peculiar geomorphology of the basin, this measure applies only to Italian fleet, and not to the Croatian and Slovenian ones. The measure is recommended in order to protect not only the common sole, but also all the species

that have their Essential Fish Habitat in the coastal zone, especially the common cuttlefish. During autumn and winter individuals of common cuttlefish migrate to deeper water; returning to shallow water in spring and summer. In fact, spawning occurs in shallow, inshore waters in April to July in the Adriatic. Young specimens are restricted to shallow water until their cuttlebones are fully formed.

- With this measure part of the cycle could be preserved ensuring at the same time a better recruitment. Actually, it does not exist a minimum landing size for cuttlefish.

Moreover, to increase the reproductive success of common cuttlefish species, there would be **some good practices** to apply, since artificial hard substrate are the new excellence sites for the deposition of eggs because of the natural one decline (seagrasses). For example: **to avoid cleaning traps for small-scale fishery and the installation of hard structures between the rows of mussel aquaculture.**

4 DORY PILOT PROJECTS: SUSTAINABLE PRACTICES FOR BIODIVERSITY RESTORATION AND AQUACULTURE ECOLOGICAL IMPACT REDUCTION

As mentioned before the Institutional partners, under the scientific guidance of the Research Bodies, carried out within the project pilot application of innovative techniques to enhance biodiversity in terms of priority and essential fish habitats and to halt aquaculture ecological impact.

Building upon the previous ECOSEA pilot activities in different Adriatic areas, the project partners consolidated the best practices experienced and spread their application in different high value and protected habitats.

The pilot projects were aimed to:

- Protect commercial species nursery areas and improve biodiversity through the testing and adoption fish stock restoration measures (Friuli Venezia Giulia and Emilia Romagna Region);

- Reduce the ecological impact of mussel aquaculture through the testing and adoption of ecologically sustainable farming materials and methods (Veneto Region, Zadar County and Marche Region).

As a first step common guidelines have been developed, based on a review and fine-tuning of the ECOSEA achievements, to easier the transfer process in other regions, organizations and areas of application.

4.1 – FRIULI VENEZIA GIULIA PILOT ACTIVITY

Introduction and objective

In Friuli Venezia Giulia the main objective of the project DORY was to carry out a pilot action with the support of the local cooperative for small-scale fishery (CO.GE.PA.), aimed to protect and increase the cuttlefish (Sepia officinalis) stock. This activity represents a capitalisation of a pilot action carried out within the project ECOSEA as the cuttlefish is a very important fish resource for both the small-scale fishery and fishing trawls in the marine area of Friuli Venezia Giulia region. The general goal has been declined in specific objects as i) to collect and preserve the cuttlefish eggs, ii) to protect the eggs in a nursery area, iii) the control and the evaluation of egg development and hatching success.

Project implementation

Methods of cuttlefish egg collection involved both **fish traps (fyke nets)** commonly used by small-scale fishermen and **specific experimental devices hand-made by fishermen**, consisting in longlines of different lengths (250-500 meters) carrying floating ropes (about 1 rope/meter) acting as a sea grass bed. Given the generally flat and sandy bottom of Friuli Venezia Giulia marine area, both devices represent important substrates for cuttlefish egg laying. During the 2018 and 2019 fishing seasons, from April to June, 10 fishermen collected all the available eggs, which have been subsequently moved to a dedicated nursery area. Eggs were collected in 4 different fishing grounds of Friuli Venezia Giulia marine study area, within a depth range of 3 to 7 meters, while the nursery area was localised in the **Marano lagoon**, near a mouth connecting the lagoon with the sea.

The nursery area hosted the **eggs inside specific hand-made hatcheries** until the hatching, 20 easy-to-use floating hatcheries were built (cm 30x42x57) and positioned in the nursery area.

Fig. 12 - Friuli Venezia Giulia study area. Yellow symbols represent longlines devices located at sea, while nursery area was positioned inside the lagoon area.

Fig. 12B - Nursery area

Chemical-physical parameters of the water were recorded as well as the different phases of egg development and the hatching success. Chemical- Physical monitoring was carried out by measurement of temperature, salinity and dissolved oxygen with multi-parameter probe (on site 2 monthly checks) in the nursery area (1,5m depth) and in the eggs collection areas (1m, 3m, 6-7m depth).

Biological monitoring was carried out by evaluation of egg development, hatching success and evaluation of egg collection by artificial long line (on site 2 monthly checks by scientific expert – weekly check by fishermen).

Moreover, in the surroundings of the nursery area it was investigated the efficacy of the pilot action in terms of presence of cuttlefish juveniles and possible pressures as predatory fish abundance.

Timetable

Phase A) preparation of the equipment of the experimental nursery, and operating protocols (April-May 2018)

Phase B) installation of the equipment in the sea, collection of the eggs and incubation, biological monitoring and evaluation of the preliminary results (season 2018, 1 June-15 November 2018);

Phase C) installation of the equipment in the sea, collection of the eggs and incubation, biological monitoring and verification of the results (season 2019, 1 April-30 August 2019).

Results

A huge number of cuttlefish eggs have been collected by fishermen in both years, despite the delay in cuttlefish arrival within the coastal waters during spring 2018 and the adverse sea weather conditions that occurred in May 2019. In 2018 about the 96% of eggs collected successfully hatched. Very interestingly, it was found that higher the depth, higher the number of cuttlefish eggs deposed in the longlines. Unlike project ECOSEA pilot activity results, demersal mollusc predators (Murex spp.) were found on the longlines.

The monitoring activity confirmed the spill over of young cuttlefishes from the nursery area in 2018. Grass gobies (*Zosterisessor*

Fig. 13 - Floating ropes with cuttlefish eggs

ophiocephalus) have been recognised as the possible main predator of young cuttlefishes: however, no unusual presence of this fish as well as other predatory species have been recorded in the surroundings of the nursery area in 2018. In 2019, about the 91% of eggs collected successfully hatched. Unfortunately, we recorded unusual high-water temperature and huge fouling processes in the second half of June 2019, probably affecting the vitality of the eggs both on the longlines and in the nursery area. The monitoring activity confirmed the spill over of young cuttlefishes from the nursery area also in 2019: 50 specimens have been captured around the area with small-meshed traps (2-4 mm). Some specimens of grass gobies, sea bass (*Dicentrarchus labrax*) and European flounder (*Platichthys flesus*) have been captured around the area in 2019 with large-meshed traps (20 mm). These species represent potential predators of young cuttlefishes.

Final considerations

Beyond the good results for the cuttlefish stock in terms of a huge amount of hatched eggs (always more than 90%), we can conclude that one of the most important results from both ECOSEA and DORY projects is that the local consortium of small-scale fishery adopted the collection of the eggs and the relocating to the nursery area as a usual fishery practice, steadily recognised as a sustainable

scheme to enhance and possibly increase the cuttlefish stock.

4.2 - EMILIA ROMAGNA PILOT ACTIVITY

Introduction and objective

Emilia Romagna Region tested specific and improved devices to safeguard cuttlefish eggs development within marine areas affected by the shellfish farms presence.

Project implementation

The two areas identified were located, respectively, within a shellfish farming plant located off the coast of Cervia, referring to the "La Fenice" Cooperative Society, and in a second shellfish farming facility located off the coast of Cattolica, managed by the "Allevamenti in Acque Marine" Cooperative Society. Both areas hosted similar equipment in the framework of the ECOSEA project. For each of these, **two long-lines of about 1,000 m each were positioned,** each one armed with 300 collectors, for a total number of 600 collectors.

In total, four long-lines were built and positioned, two for each chosen area, for a total length of 4,000 m and a total number of 1,200 collectors.

Two different type of collectors were positioned at a distance of about 3 meters from each other, trying to alternate as much as possible the two different kinds.

The first type of egg collector (figure 15 A, first type of collector), 150 in number for each long line, is constituted by a net tube made of biodegradable material of total length of 50 cm, with a 9 mm mesh on the side. The net is produced by the Intermas Group and made of 100% natural materials, composed of starch mixtures, certified as EN 13432 and EN 14995.

Fig.14 - (location of the pilot actions)

The second type of collector, 150 in number for each long line, consists of a rope of approximately 0.5 m of natural fiber (sisal) 100% biodegradable with a diameter of 8 mm, in the upper part of which there is a float, made with a cork microagglomerate for food use perforated to allow the anchorage to the rope. The rope in use for the long line, bearing the eggs collectors, has a diameter of 12 mm is weighed down by 300 lead sinkers weighing about 100 g each. The longlines were anchored to the bottom thanks to dead bodies weighing about 16 kg each. To avoid contributing to the increase in plastic pollution, all the materials used are biodegradable, in metal or inert.

Fig.15 A
type of net egg collector

Fig.15 B
type of Rope collector

Timetable

- On-board observations by a qualified scientific expert during each main phase:
  - Deployment of long-line (spring 2019)
  - Monitoring (spring-summer 2019)
  - Final harvest (summer 2019)
- Underwater inspections by qualified divers performed during the monitoring.

Results

The evaluation method was limited to visual observations on the degree of rooting of the eggs on the collectors and on the performance of the materials used for the realization of the long line and the collectors. About a month after the deployment of the first group of collectors, monitoring operations started to verify both the effectiveness of the collectors in favoring the attachment of cuttlefish eggs and the resistance over time of the biodegradable material.

The behavior of the collectors resulted to be quite different between the two selected sites.

1. Regarding the Cattolica area, after just over a month after the deployment of the collectors, there was only one biodegradable net piece, while those consisting of the rope equipped with an apical float were all present. During the various inspections, the latter showed non-homogeneous behavior, alternating collectors with bunches of eggs, especially in the most apical part, to others without eggs. In addition to the structure of the collectors, numerous and abundant depositions have been observed near the anchorage points, connecting chains and dead bodies included, and on numerous sections of the long line rope. In some cases during the underwater observations cuttlefish were observed intent on the deposition, both on the structures of the long line and on other rigid substrates located nearby: branches or nets for mussel farming.The eggs present were of different sizes, indicating the various stages of egg development. The seabed was covered by a more mobile layer of silt about 2-3 cm thick.
2. Regarding the off shore area in Cervia, the bottom appeared more compact and both the rope and the collectors were not covered by silt. In this case the biodegradable nets were present, although in some cases they appeared deteriorated in the part in contact with the top of the long line.

The collectors, as well as the top of the long line and the anchor points, although free of sediment, had a number of eggs significantly lower than those found at the site off the coast of Cattolica and no cuttlefish individuals were observed.

In general, over time, a gradual loss of buoyancy has been observed in collectors equipped with floats, probably due to the gradual development of fouling and absorption of water by the natural fibers and cork microagglomerate.

Fig.16A
Eggs on the collectors

Fig.16B
Eggs and cuttlefish intent on the deposition

Final Considerations

Even with some limitations, it can be considered that the experimentation conducted provided a good result, both in relation to the functionality of one of the two types of collectors, which carried

out their aim, as well as the very structures of the long line, especially regarding the information acquired on the use of this material never previously used for this purpose.

The adoption of biodegradable materials for the construction of the collectors and of the load-bearing rope as foreseen by the project did not allow the best use of the knowledge acquired during previous experiments, such as ECOSEA, as there was not enough experience in the use of these materials and adequate knowledge of their behavior in those conditions of use. Neither direct nor verifiable on the basis of bibliographic information.

The behavior of biodegradable nets in the two survey areas was unusual, probably due to the different nature of the sediment present on the sea bottom, siltier in the case of the Cattolica site, more compact in the case of the Cervia site. This situation could have caused an acceleration of the degradation process of the organic component once covered by the light layer of sediment, leading to the detachment of the net sections from the biodegradable rope. The rope in Sisal itself showed clear signs of reductive phenomena in the most superficial part. On the other hand the choice on that type of material for the nets, produced by a Spanish company, was determined by the fact that it is usually used to protect young plants from rodents and, therefore, subjected to moisture and in contact with the ground. In addition to being the only one identified during a thorough investigation carried out by consulting the main websites of the manufacturing sector. It is appropriate to believe that it would have been better to equip the rope collectors with a greater floatability, evaluating that over time this would be reduced due to the absorption of water and the fouling weight. The choice to limit the buoyancy, as well as that of weighing down the top of the long line with small lead barrels, is derived however from the need to avoid, as far as possible, the ascent to the surface of the long line due to the effect of the wave motion. In fact, in previous experiences the occurrence of these phenomena has caused some damage to the farmers who hosted the experiments, due to the loss of the product and the amount of work necessary to free the mussel nets and floating long-lines structures from the egg collector main rope wrapped. The repetition of this type of accident could strongly condition the willingness of the farmers to accept similar structures within their own farm.

4.3 VENETO REGION PILOT ACTIVITY

Introduction and objective

Within EcoSea project Veneto Region tried to lower the environmental impact of mussel farms in the Northern Adriatic by experimenting the use of a new, highly automated and environment-friendly technology, and using biodegradable cotton mesh bags instead of plastic ones (the so-called “New Zealand-type” mussel farms). However, the conversion to the New Zealand method would require large investments for the acquisition of new gear, fitting of the existing vessels would be difficult and the farm operators would require extensive training. On the other hand, continuous-rope mussel farms are best suited to sheltered conditions such as those found in enclosed bays, while the open sea conditions of the Italian Northern Adriatic Sea pose a threat of damage and production loss. Thus, Veneto Region’s pilot action in Project Dory was aimed to look for a simpler method for reducing the environmental impact of the plastic waste produced by mussel farms: the goal was to identify an alternative material for the mesh bags totally biodegradable while ensuring the same performance of plastic mesh and requiring no change in the production process, expertise required and gear employed.

Project implementation

The pilot action was so designed:

OBJECTIVE: to carry out a complete mussel-farming production cycle, using at least two different types of biodegradable mesh “socks”, with regular on-board and underwater monitoring to assess the performance of the experimental materials as opposed to the traditional polyethylene “socks”.

A complete mussel-farming production cycle consists of the following phases:

- “Socking” of the mussel seed (autumn)
- First harvest and re-socking (late spring)

- Final harvest (late summer)

LOCALISATION: a longline mussel-farming plant in the Po River delta area

EXTENSION OF THE PILOT ACTION AREA: at least 1 km

MATERIALS TO BE TESTED: 2 certified as biodegradable or compostable, and compliant with EU regulations on materials suitable for food contact.

MONITORING ACTIVITIES: on-board observations during the three production phases and underwater surveys - In addition, exposure tests had to be carried out to test the behaviour of the experimental materials in the most likely scenario, i.e, fragments of net washed ashore and buried by the sand. The awarded contractor was Cooperativa fra pescatori dell'Adriatico, based in Scardovari

Fig.17 - Location of the pilot activity

The tested materials were:

- *Bio-net*, by ROM Plastica of Chioggia, and certified compostable according to EN 13432"
- *Green-net*, by APM / BioPro of Ravenna, a natural bioplastic based on PHA, already used for biodegradable food packaging and possessing a high breaking load.

Timetable of the pilot action:

- 12-18 November 2018: Socking of the mussel seed. All socks deployed were "ROM Plastica "Bio-Net". Samples were taken and buried at a beach for the exposure tests described before.
- 9 February 2019: underwater monitoring
- 17 May 3019: underwater monitoring
- 3-7 June 2019: harvest and re-socking. Socks used were 50% Bio-Net and 50% Green Net. Samples were taken and buried at a beach for the exposure tests described before.
- 22 July 2019: underwater monitoring
- 28 august 2019: underwater monitoring

The fifth underwater monitoring and final harvest phase weren't performed, because by August 28th all the experimental socks were lost at sea.

ON BOARD OBSERVATIONS – CRITICALITIES EMERGEDUNDERWATER OBSERVATIONS

Bio-Net	Green-Net
Breaking load of biodegradable nets is less than the plastic version (the net can be torn by hands) → Doubts about the ability of the material to sustain an increasing load during a long exposure to the marine environment	Although the technical specs of the material report a breaking load of 1150 N (about 117 kg), the net can still be torn by hand. Same considerations of "Bio-net" apply.
Greater friction on the tubes used in the loading operations → increase in production times of at least 50%.	Green-net behave exactly like plastic nets in the loading operations – no difference in production times.
On harvest, the socks that weren't damaged during the growth phase, snapped under their own weight when pulled out of the water	Green-Net socks didn't make it to the harvest phase. They all broke during the storm events.

Results

9 February 2019

At this stage the experimental socks showed no signs of wear. They were actually in better conditions than the plastic ones.

Figure 18: Bio-net mussel socks after ca. 3 months underwater

17 May 2019

After 3 more months, the experimental site had been subjected to several storms, which delayed the harvest and re-socking phase a lot (normally, it would have been carried out by mid-April). This resulted in the mussels growing more than expected and applying an excessive weight on the socks. This in turn caused the major part (around 70%) of the experimental socks either to snap, or to lose the product. On the other hand, the polyethylene socks, while subjected to the same conditions, weren't damaged to the same extent.

22 July 2019

With warm climate mussels grow faster, and the load on the socks increase accordingly. After only 1 and ½ months from deployment, and some storm events Bio-net showed the same behaviour observed in the first period; Green-net socks resisted better but showed signs of premature degradation.

28 August 2019

By this time, all experimental socks were lost at sea.

Figure 19: Green-net (left) and Bio-Net (right) after around 1.5 months from re-socking

EXPOSURE TESTS

The net samples buried in the sand were taken and examined after 2 months. The samples were examined at the stereomicroscope, looking for signs of degradation, as filaments separating from the main fibres. Globally, Green-net samples show signs of quicker degradation than Bio-net samples under test conditions.

Figure 20: exposure tests setup

Final Considerations

There is no doubt that the trial as a whole represented a failure, with respect to the objective of identifying a biodegradable material suitable for replacing polypropylene in socks for mussel farming.

Anyway, some lessons can be learned to fine tune future experimentation, since the need to find a substitute for plastics in mussel farming remains, and there are several materials available that may have favourable characteristics, but couldn't be tested in this pilot action for cost and time reasons:

3. Focus on biodegradable materials: Compostable bioplastics can be easily disposed of when collected properly, but like Bio-Net, they don't necessarily degrade quickly in the environment.

d. Involve the raw material producers more: Generally, biodegradable plastics are engineered to degrade quickly, for example to be employed in shoppers and food packaging. This can well be why all Green-net socks broke, despite their initial break load which is comparable to that of traditional plastics. Therefore, producers must be involved more in the designing of the material to be tested, so to try engineer it to be more durable during the production phase and degrade only after, instead of just looking for what is already present in the market.

5. Test more materials in smaller samples: During the first phase of the pilot action, 1000 socks of the same material were deployed. In the second phase, they were 500 of Bio-net, and 500 of Green-net. Representative results could have been obtained with smaller numbers, allowing either to save funds, or to test more materials.

6. Test different sock lengths: In Dory, the experimental socks were made all the same length of the traditional plastics socks. By experimenting with shorter lengths, it could be possible to find that some material can resist through the production cycle, at the expense of a part of the product.

Finally, the cost of the new material must be taken into consideration. Both materials used in Dory were 4 times more expensive than plastics, for a given length. When selecting new materials to test, there must be an indication that the price of the nets, when produced on large-scale, will be affordable for mussel-farmers, or otherwise that incentives for their use can be put into force.

4.4 ZADAR COUNTY PILOT ACTIVITY

Introduction and objective

Zadar County implemented a project in an area where mussels are already cultivated with the "classic technology" of floating parks, in tubular nets. Production growth in this area is not sufficient and the available agricultural capacities have not been utilized. Zadar County is undertaking a series of activities to improve, such as conducting development studies, how to reduce environmental impact and how to use degradable, environmentally friendly materials for economic use. One of the key steps in the implementation of this pilot project is the transfer of acquired knowledge, from the Veneto region acquired within ECOSEA project in the testing of the New Zealand method to Zadar County.

Project implementation

A part of the line is selected to compare the classical method and New Zealand method of shellfish farming. Seed collection equipment was purchased and set up. An expert on the New Zealand method, who conducted the method in the Veneto region on the ECOSEA project, submitted a farm status report and provided instructions on how to implement the method. Transport and installation of equipment required for the implementation of the project that have been transferred from the ECOSEA project have been initiated (Figure 21).

Figure 21: The boat set for the mussel farm

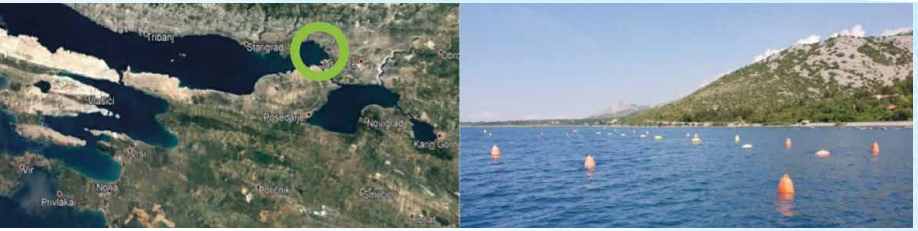

Figure 22: The location on of selected mussel farm in the Zadar County

Figure 23: finismachine calibration is complete

The problem with machine calibrations was that the speed and amount of seed filling on the continuous rope that had to be wrapped with a cotton net that often broke and tension needed to be reduced. After this first step, assisted by University of Zadar (Department of Ecology, Agronomy and Aquaculture), on the mussel farm some different situations were tested:

- Common technology with plastic pergolari at 2m and 6m of depth with density of 3, 5 and 7 kg for 1 meter of pergolari (Figure 24).

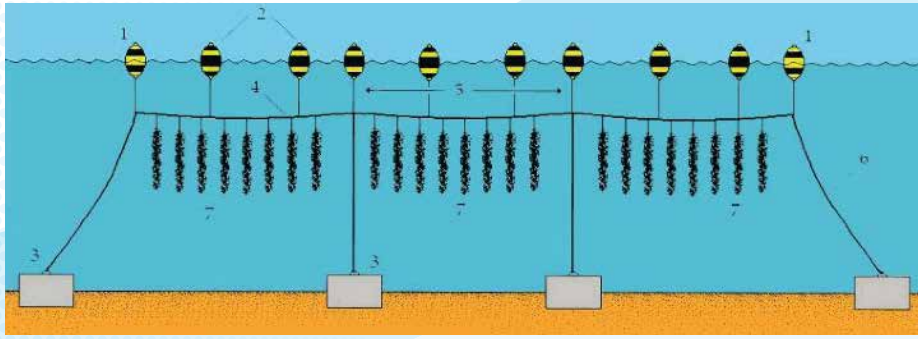

Figure 24: Traditional long-line mussel farm with plastic socks

- New Zealand technology with three continuous ropes between 2 and 6 meter of depth with a density of 3, 5 and 7 kg for linear meter with cotton net (Figure 25).

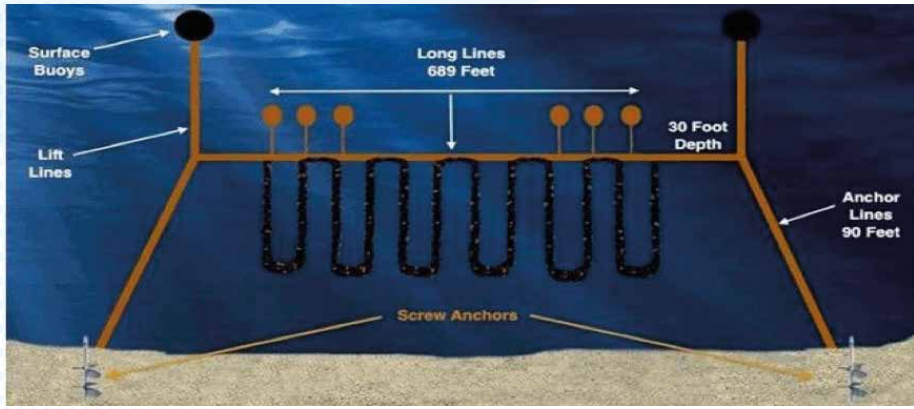

Figure 25: New Zealand long-line mussel farm with continuous rope

The mussel seeds were collected from the same origin and had similar size (average length at the start was around 3.5 mm), and initial conditions were measured and recorded to compare the growth

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and condition index in the laboratory of University of Zadar, to evaluate and compare the production of mussels in common technology (using the pergolari) with continuous longline production (New Zealand technology).

Common technology:

Farmer placed mussels in common technology at 2 depths: 2 and 6 meters in three different densities: 3, 5 and 7 kg per 1 m of pergolari(Figure 26).

Figure 26: Traditional long-line mussel farm with plastic sock

New Zealand technology:

For the continuous technology farmer used 3 ropes of 100 m of length, deployed to cover the depths from 2 to 6 m. Each rope had a different stocking density: 3, 5 and 7 kg per 1 m of rope for linear meter with cotton net(Figure 27).

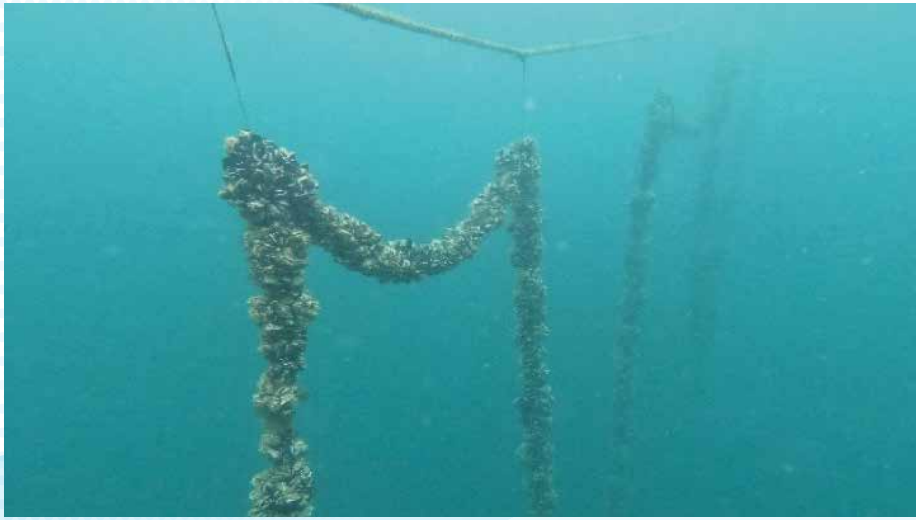

Figure 27: New Zealand long-line mussel farm with continuous rope

They measured the initial condition index of the mussels in January 2019. After that, each month they were sampling mussels from both types of farming methods, from the 2 different depths (2 and 6 m) and 3 different densities (3,5 and 7 kg) and comparing the growth and condition index of the sampled mussels in the laboratory of University of Zadar. Also, we are documenting the fouling of the mussels. Monitoring and analysis of biological parameters in comparative farming with Classical and New Zealand method of shellfarming technology.

Figure 28: Monitoring and analysis of biological parameters

From the analysis of the acceptance of the seed to the collector rope should be assessed the efficiency of the collector and the area / depth where the best acceptance of younger mussels was observed. From the initial information on the cost-effectiveness of the New Zealand method over the classical one, we learn that the new method is more useful at the beginning of planting. NZM requires less people and physical work using the machine, as opposed to manual work of the classic method. Setting up is faster, making stay at sea are shorter and increasing productivity. Environmental friendly acceptable, biodegradable materials are used in relation to plastics use. The results should indicate the effectiveness of the new method for mussel cultivation that has not been used in Croatia previously, compared to the common farming method. The results of the analyses performed should point on the appropriate stocking density for cultivation of mussels with continuous ropes in the conditions of the Adriatic Sea.

Final Considerations

During the supervision of the mussel farm, together with the Zadar University, positive evidences and problems were found especially regarding the continuous rope.The operators observed that both depth and density (kg/m) influence the production with New Zealand technology (as happens with classical pergolari). Moreover, they evidenced problems with cotton socks; these specific cotton socks biodegrade too much quick so mussels were not able to attach to the rope falling down to the bottom.

Another problem concerns the fouling that grows over the mussel's ant the rope that perhaps can create phenomena of anoxia, increasing of rope weight and problems during harvest. The research in progress by Zadar University might answer if there is a correlation between depth and fouling or between density and fouling.

The question, that cannot be solved in a short time, is to set the right density of mussels (kg/m) and the right depth to obtained the best performance by New Zealand method. Up to now the Italian farmers are still modifying some setting of farm and they believe that this should be a continuous in progress but as the Italian operators even the Croatia farmers realized that this new technology can help them with less working time, less strength use and more work safety.

4.5 MARCHE REGION PILOT ACTIVITY

Introduction and objective

Within the DORY project, Marche Region, capitalizing on ECOSEA and DORY approach conducted a regional analysis for mapping the mariculture sector's innovation needs towards environmental sustainability in order to better plan for the next programming period. To the purpose, data and information about the Marche Region mariculture state of play were collected by desk review and direct survey on mussel farms and then elaborated in a short overview.

Project implementation

MARCHE REGION MARICULTURE SECTOR AT A GLANCE

On 2016, the Marche Region counts 15 mussels' farms with a total production of 1.860 tons, the 3% of the national production. The regional data analysis shows a number of 30 off–shore marine areas in concession but three are meant for research purposes only (Tab.1). 20 is the number of the companies holding a concession for a total of 27 areas in state propriety concession for production purposes. The geographical distribution in the regional maritime districts is: 8 in Pesaro, 10 in Ancona and 9 in San Benedetto del Tronto (cartography is available at: http://www.regione.marche.it/Regione-Utile/Agricoltura-Sviluppo-Rurale-e-Pesca/Demanio-marittimo-pesca-e-acqualtura#Cartografia).

Tab. 1 – Summary of the state property concessions in Marche Region – year 2019 (source Regione Marche, PF Economia Ittica, 2019)

n	District	Code	Surface (smq)
1	ANCONA	RM8a	3.300.570
2	ANCONA	RM10	2.000.000
3	ANCONA	RM12	1.098.863
4	ANCONA	RM13	582.355
5	ANCONA	RM14	1.500.000
6	ANCONA	RM15	360.000

7	ANCONA	RM9	2.192.943
8	ANCONA	RM2	1.127.500
9	ANCONA	RM16	1.102.500
10	ANCONA		2.000.000
11	ANCONA		132
12	ANCONA	RM5	1.102.500
13	PESARO	RM1	1.411.436
14	PESARO	RM17a	1.870.292
15	PESARO	RM11b	795.500
16	PESARO	RM11a	1.000.000
17	PESARO	RM17b	1.000.000
18	PESARO	RM3	700.000
19	PESARO	RM18	90.000
20	PESARO	RM19	1.312.500
21	SB TRONTO	RM4	1.500.000
22	SB TRONTO	RM20	1.000.000
23	SB TRONTO	RM7a	216.000
24	SB TRONTO	RM7b	367.500
25	SB TRONTO	RM7c	1.500.000
26	SB TRONTO	RM7d	1.471.560
27	SB TRONTO	RM7e	1.499.980
28	SB TRONTO	RM7f	1.499.166
29	SB TRONTO	RM8b	1.490.000
30	SB TRONTO		68.450
	Total		35.159.747
	Total production		33.091.165

The comparison between the state property concessions in 2019 and 2008 points outs a significant increase in the number of areas in concession (from 23 to 30) and the increase of the surfaces in concession equal to 22%. Noteworthy is the turnover of the companies' holding concessions. Currently, compared to 2008 less than the 30% of the areas in concession have the same holding companies

The production areas of bivalve molluscs from off-shore farms of Marche Region are shown in Tab.2 (source: Regione Marche del.574/2019).

In summary, Marche Region counts 20 areas of production of type "A" for off-shore farming of Mytilus galloprovincialis, of which one also is devoted to Ostrea edulis and Crassostrea gigas. In Marche Region, all the mariculture companies breed Mytilus galloprovincialis. All companies are equipped with a mussel declumper machine, a socking machine and a socking while only the 36% holds also the washing tunnel.

Tab.2 – List of bivalve molluscs off-shore farms

n	Code	Zone	Note 1	Species 1	Species 2	Species 3	Note 2
1	002AN807	A		Mytilus galloprovincialis			
2	013PUA37	A		Mytilus galloprovincialis			
3	017AP157	A		Mytilus galloprovincialis			
4	019PU021	A		Mytilus galloprovincialis			
5	027AN011	A		Mytilus galloprovincialis			
6	032AN604	A		Mytilus galloprovincialis			
7	032AN605	A		Mytilus galloprovincialis			
8	034FM018	A		Mytilus galloprovincialis			
9	034FM019	A		Mytilus galloprovincialis			
10	043MC392	A		Mytilus galloprovincialis			
11	044PUF30	A		Mytilus galloprovincialis			
12	044PUF35	A		Mytilus galloprovincialis			
13	044PUF36	A		Mytilus galloprovincialis			
14	044PUH35	A		Mytilus galloprovincialis			
15	044PUH70	A		Mytilus galloprovincialis			
16	045AN996	A		Mytilus galloprovincialis			
17	045AN997	A		Mytilus galloprovincialis			
18	066AP168	A		Mytilus galloprovincialis			
19	066AP169	A		Mytilus galloprovincialis			
20	042MC084	A		Mytilus galloprovincialis	*Ostrea edulis*	*Crassostrea gigas*	
21	044PUH71	A	Relaying	Mytilus galloprovincialis			
22	042MC083	A/B	A 1/6 - 30/9 - B 1/10 - 31/5	Mytilus galloprovincialis			
23	033FM005	B		Mytilus galloprovincialis			
24	043MC393						Not classified
25	034FM053			Mytilus galloprovincialis			In classification-phase

Fig.29A
Socking loader

Fig.29B
Mussels declumper machine

In accordance with the current legislation, only 14% of the companies has its own Molluscs Depuration Centre - while only the 36% has its own Shipping Centre- all in shore-based facilities expect for one company. Only one of the company involved in the survey has a mussels relaying area at the sea.

From a statistical point of view, it can be highlighted the lack of complete data on production in recent years and causing problems regarding data comparison. However, it is clear that in the last 20 years the sector recorded a notable increase: from a total annual production of 700 tonnes to 4.000 tonnes. In addition, the number of companies has doubled as well as the number of farms: 7 on 1999 and 23 on 2018. Finally, the production data have considerably decreased from 2015 and 2016, this is may be related to the difficulties in data collection and data availability. EUROSTAT in fact does not provide the Italian production data for the year 2016.

LOGISTIC AND MANAGEMENT

From a logistic point of view, the regional mussel farms are located in type "A" production zones, at a mean distance of 2.33 nautical miles from the coast, 4.61 nautical miles from the port of pertinence of the operating boat. The farms are located at an average bathymetric of 13.06 metres. The seabed is muddy and sandy. The average length of long-lines is 16.373 metres, with maximum value of 28.000 metres and a minimum of 5.600 metres. The average coverage of the concessions 1.455.469 sq.

All the regional mussel farms are managed directly. It is estimated a total amount of 120 employees of the sector of which 79% with annual contracts and the remaining with seasonal contracts

The distribution per age highlights the prevalence of employees aged between 21-30 , equal to the 45%, 41 years, followed decreasingly by the others. About the farming methods, the use of boat or boats is crucial for production dynamics. The most part of the companies operate with a boat only. The 65% of the boat licences are in proprietary.

COMMERCIALIZATION

The 93 % of the companies sell the product on their own; for the remaining 7%, the 50% of the product is sold on their own while third parties distribute the emaining 50%.

The 49% of product is commercialized into the national wholesale, the 12,9% in regional wholesale and the 37,2% in the international ones. From data elaboration per typology, it emerges that in Marche region the majority of mussels is commercialized as socked - with a percentage close to 70 of the total product sold - compared to those sold as declumpered. None of the companies surveyed declared to have any certification of process/control.

Regional Innovation needs detected

From the direct survey on regional mariculture operators emerges that environmental sustainability is a crosscutting issue for all companies. In particular, during the stakeholder consultations sustainability has resulted to be closely related to sectoral needs.

In fact, the 90 % of interviewed companies points out the following needs:

- Specific operations for reducing environmental impact of the farms
- Specific operations for increasing the job quality.
- Operations on the on-board equipment and gears for ensuring the quality of products

Half of the interviewed companies also outline the need of diversified the breeding method even if the longline system is standardized.

All the companies reports the need of vocational training to increase the quality of product in terms of both environmental sustainability and market opportunities. The most part of operators recognizes the relevance of the quality brands; however, the adhesion process should be simplified.

The most part of companies also highlights as key issue the knowledge of the funding panorama and financial instruments for supporting their operations in a competitive and constantly evolving

market.

Final Considerations

Since the mid-2000s, the Marche Region – by Regional Decree No.5/2000 – introduced the maritime spatial plans to which the state property concessions for aquaculture belong, already doing what happened lately at national level with the recent initiatives for the "Maritime Spatial Planning"and the identification ot the AZA – Allocated Zone for Aquaculture based on number of social and environmental criteria.

In addition, The Marche Region demonstrated a remarkable use of financial instruments supporting fisheries and aquaculture from the participation – together with the regional research bodies - to international projects for the sustainable growth of these two sectors.

Despite these favourable conditions, the regional mariculture sector struggles to achieve the expected results and to play a leading role in the regional production systems since some criticalities still affecting the homogenous development of the sector in the regional territory.

Among those constrains, the sectoral instability is highlighted by the frequency with which the concessions – and the related farming plants – cease their activities or pass the activities to other companies. This aspect is common also to other regions even is more pronounced in Marche. One of the reasons could be the regional farms productivity that, in most cases, is far below the productivity of neighbouring region such as Emilia-Romagna. These could be attributable, on one hand, to the environmental characteristics and the related supply of nutrients and on the other to the farming techniques and level of technological innovation of the equipment. This could be also associated with the lack - complained of by the operators themselves - of networking among the enterprises and the join promotion and product valorisation.

Apart from the adhesion to national sectoral associations - with a limited freedom of movement when tackling local problems – there is a lack of associative and cooperative forms able to overcome the port of landing and involve producers in a wider development and marketing strategies for the product promotion and valorisation in the regional and interregional context. Regional FLAGs can play a relevant role in providing this kind of support. Without an appropriate trade policy and the consequent economic return, the above-mentioned criticalities may not to find the attention of the operators that are busy producing and selling products on their own. Moreover, it will be difficult for the regional operators to ensure the financial capacity for technological adaptation of equipment and boats and to acquire motivated and qualified staff.

5 TRANSFERRING KNOWLEDGE AND EXPLOITATION OF DORY RESULTS

DORY also implemented several activities to build-up the environmental compliance culture of Italian and Croatian fishermen and aquaculture operators by the effective identification and exchange of feasible solutions for the reduction of the ecological impact of their activities.

Furthermore, the project has promoted the systematic use of common cross-border models and tools – arisen from DORY for the joint planning of conservation measures, the setting up cross-border marine protected area and the increase of the institutional ability in preserving and jointly managing the Adriatic marine resources, mainstreaming the tested science based and ecosystem approach into fisheries policies programming and implementation framework.

5.1 – KNOWLEDGE TRANSFER TO FISHERIES AND AQUACULTURE OPERATORS

The project has set up various opportunities for exchanging knowledge between fisheries and aquaculture operators, included cross-border exchange including training session and on-the field visits. The first knowledge transfer was organised by Zadar County and the Development Agency of the Split-Dalmatia County (RERA) on the 2nd, 3rd and 4th October 2018. The second knowledge transfer was organised by the Friuli Venezia Giulia Region with the support of the Veneto region on 19th, 20th and 21st March 2019. Al the institutional representatives of DORY partnership as well as some delegations of fishing and aquaculture operators joined the two events.

Knowledge transfer in Croatia – Zadar and Split (2 – 4 October 2018)

The event began at the fishing port of Zadar, where a brief meeting between Italian and Croatian operators took place. Subsequently the group carried out a visit to the fish processing industry of “Cromaris” company, equipped with the most innovative technological equipment for the selection, decapitation, evisceration, filleting and packaging of fish farmed at sea, mainly Sea breams (Sparus aurata) and Sea basses (Dicentrarchus labrax). Characterised by a production capacity of approximately 160 kg of fish per minute, fishes are refrigerated or threaded and stored in Protective Modified

Atmosphere and finally traded mainly in Italy and Germany. After the visit to the industry, the group joined a boat trip to visit to the "Cromaris" fish farming facilities at sea, by Ugljan island. The group was informed about the efficiency of the farms, consisting of 60 offshore cages with a diameter of 20 to 32 meters and a height of 38 meters and on the functionality of the technological system for feeding the farmed fishes.

Later the group joined the fish farming areas for the Bluefin Tuna (Thunnus thynnus), owned by "Kali Tuna" company. The facilities,

consisting of 24 large floating cages (about 36 meters in diameter and 40 meters deep), provides for the fattening of specimens of Bluefin Tuna, caught at a size of about 10 kg and fed with blue fish (anchovies, sardines, herrings) up to a size ranging between 45 and 70 kg. All the bred product is sold on the Japanese market. At the end of the visit to the breeding facilities, the delegation was taken back to the port of Zara for a meeting with local operators.

The second day began at the tourist port of Split with destination Supetar, on Brač island. Upon arrival, the delegation was welcomed by a group of Croatian operators who led the participants to Postira, at the "Sardina" fish processing company. The industry, working since 1907, was expanded and restructured in 2013 thanks to

EC funds, to the actual production capacity of 40 million boxes of fish product per year. The industry mainly processes Sardines (Sardina pilchardus), Mackerels (Scomber scombrus) and Yellow-fin Tunas (Thunnus albacares). Fish products are steam cooked and placed manually in special packets; subsequently the mechanised line proceeds to insert them in closed boxes, labelled and sterilized at temperatures above 100°C and subsequently prepared for the marketing. The plant is completely autonomous and has freezing cells, areas dedicated to making meal fish and oil fish.

At the end of the visit there the additional activities of the company were illustrated: 7 fishing boats operating with the purse-seine system for small pelagic, several aquaculture plants that produce annually more than 1200 tons of valuable fish (sea bream, sea bass and Bluefin tuna) and a site for the production of the Mediterranean Mussels (Mytilus galloprovincialis). The company also owns some sales points for the marketing of its own product. The event closed the third day at the Institute for Oceanography and Fisheries in Split with the discussion of two topics: establishment of a restricted zone for fisheries and envisaged measures for the Pomo pit; results from the meetings with operators and proposed management measures for Cuttlefish and Sole stocks as scenarios developed by the "DISPLACE" tool for maritime spatial planning. At the end of the discussion, the members of the technical board and the steering committee continued working on the progress of DORY project while the operators carried out a guided tour of the Institute premises.

Knowledge transfer in Italy – Friuli Venezia Giulia and Veneto regions (19 – 21 March 2019)

The knowledge transfer began with a visit to the purifying and dispatch centre managed by ALMAR Soc. Coop. at San Giorgio di Nogaro (UD). The responsible biologist, dr. Aurelio Zentilin, led the delegation in the main productive sectors of the centre and illustrated the activities dedicated to the reproduction and pre-fattening of the shellfish, as well as the management of the culture parks and the fishing of bivalve molluscs in the Northern Adriatic, in particular the Manila clam (Tapes philippinarum) reared by the lagoon mudflats and the Mediterranean mussel (Mytilus galloprovincialis) reared in suspension on the water column (long-line method). The marketing sector is however also addressed to other species of bivalve molluscs collected in the Gulf of Trieste marine areas, in particular

the Striped Venus clam (Chamelea gallina), the Smooth clam (Callista chione) and the Razor shell (Ensis minor).

After the visit to the purifying and dispatch centre, the group moved to Marano Lagunare (UD) and joined a boat trip to visit the production areas and the aquaculture facilities located in the Marano lagoon. There are more than 700 hectares of lagoon mudflats dedicated to clams cultivation and collection, most of which are managed directly by ALMAR, also in association with other companies. Italian and Croatian guests were able to learn the phases of sowing and harvesting that make up the "Marano model".

After the boat trip in the lagoon, a dedicated workshop was held in Marano Lagunare (UD) on the results of the "pilot action for the restocking of the Cuttlefish (Sepia officinalis) stock", an activity provided by the WP4 of DORY project and carried out by COGEPA, the local Consortium of small-scale fishermen. The important role of the fishermen for the protection of Cuttlefish eggs has been renewed here and consists on self-regulation fishing procedures that provide for the scraping of the eggs laid both on the fishing traps (fyke nets) and on special hand-made collection devices and their protection due to the transferring to a dedicated nursery area.

In the evening the Italian-Croatian group moved to Chioggia (VE) to optimise the timing of the visits planned for the following days in the Veneto region productive areas. The visit of the second day started from the Scardovari Cooperative headquarters, "RO Consorzio Cooperative Pescatori del Polesine", the first in Italy for the production of bivalve molluscs. Here a meeting was held between operators where the main productive and socio-economic characteristics of the consortium were illustrated, as a total of 14 cooperatives and 1450 employees as a whole. Also, here, as in the Marano lagoon, the productive areas are located in the lagoon waters, an extremely productive area, with main production of Clams and Mussels.

Subsequently the two Mollusc collection and packaging centres in the Scardovari area were visited. The visits allowed the guest operators to appreciate the highlights of a supply chain that aims at high quality production. In the last few years, the consortium has succeeded in having the "Mussel of Scardovari" and the "Polesine Clam" labels included in the Register of Italian traditional products recognised with 18.07.2000 Decree of the Ministry of Agricultural Policies and then registered its own trade mark.

Afterwards the group moved to the headquarters of the "fishermen's cooperative of the Adriatic " where the results of the pilot actions of the DORY project obtained at the local level were illustrated.

The final knowledge transfer started at the administrative headquarters of the Chioggia (VE) fish market, where the activity of the fish market was illustrated with in-depth information mainly on the controls concerning health aspects. The group visited the Chioggia fish market just following the official opening of the negotiations, which are not held here by an electronic auction, but still take place in a completely traditional manner with purchase proposals that are whispered in the hawker's ear, keeping them untold until the effective sale.

A further exchange has been implemented in the month of August in the Zadar Area focused on sustainable aquaculture methods and technology with the common purposes of operators to increase know how of lower environmental impact farming methods.

6 CONCLUSION

The above described project results led to **new cross-border management models for sustainable fisheries and innovative tools to increase biodiversity and halt the ecological impact of aquaculture**, serving as evidence-based good practices to be considered and included into ordinary management and programmes.

Taking into account the capitalization process of the previous ECO-SEA initiative and the further results obtained through DORY, the involved Adriatic Regions played a relevant role in the implementation of the EU principles towards the integrated and common management of resources and the protection of ecosystem in fisheries governance.

In addition, the project promoted a well-coordinated stakeholders engagement process, where the needs of fisheries sector and the cross-border proposed management measures have been constantly shared and agreed with the operators at regional and inter-regional level.

Furthermore, **several fishermen and aquaculture operators have been directly involved in the planning and the implementation**

of the pilot activities, triggering a virtuous cooperation process among entrepreneurship, scientist and public institutions for the improvement of sectoral policies. Moreover, this strict cooperation led the operators to a greater awareness on sustainability principles and on the need for common management and planning.

At sectoral level, **the European Maritime and Fisheries Fund (EMFF) represent the privileged instrument to promote a large-scale adoption of good practices**, especially those tested and refined within DORY pilot actions aimed to improve the stability of fish stocks and to ensure increased environmental sustainability of aquaculture activities. Managers and policy decision-makers are called upon to foster the integration of good practices, models and approaches into their process to define and implement local, national and Communities regulations.

The actual EMFF 2014-2020 includes some measures, adopted -by both Italian and Croatian Operational Programmes - that can take into account the DORY achievements detailed in this report. Many measures provided for by the EMFF in the field of "fisheries development" priorities can incorporate DORY approaches. The measure "Partnerships between scientists and fishermen" represents a privileged channel to include the "Scientific Advisory" approach used within DORY when defining studies, practices and pilot projects. Similarly, the measure "Protection and restoration of marine biodiversity and ecosystems and compensation regimes in the framework of sustainable fishing activities" seems to be the privileged instrument to replicate DORY models especially with reference to ecosystem services that can be provided by fishermen.

In respect to the measure "Temporary cessation of fishing activities" thanks to the cross-border model for Adriatic fisheries management set up within ECOSEA and enriched with DORY, the project providedfor alternative measures (temporal, spatial, selective) and management scenario. This also valuing fishermen's opinion, to help the sustainable exploitation of shared stock and supporting MSP approach evolution in the Adriatic Region by means of the advanced MSP tool "DISPLACE". A specific attention has been given to the testing of a particular scenario to set-up a **CB protected area within the so-called "Sole Sanctuary", the core spawning area for this species**, located in international water between the two countries, not protected and managed so far. A chapter of this report is dedicated to the recommendations for policy makers on the most efficient management options taking into account the bio- economic consequences for the fisheries and fish stocks of different fishermen decisions and management options.

As regards to priority no. 2 of the actual EMFF on the "development of aquaculture", **DORY contributed in terms of identification of environment-friendly aquaculture models and tools applicable to different farming methods and sea conditions.** The results of the testing activities can offer to decision-makers examples of practices already implemented at local level, monitored and positively assessed that could be applied in the framework of the measures regarding "Innovation", "Productive investments in aquaculture" and "Aquaculture providing environmental services".

It is also worth mentioning the measures related to "Community-led local development strategies" since the project have provided for examples of participatory local development of initiatives for the protection and improvement of resources and the development of local communities.

Regarding the EMFF of new programming period (2021-2027) Institutions at regional and national level are called to consider tested models and tools in the strategic planning and programming of the Partnership Agreement, taking into account the project contribution to the following priorities set for the blue economy sustainable development:

1. Fostering sustainable fisheries and the conservation of marine biological resources;
2. Contributing to food security in the Union through competitive and sustainable aquaculture and markets;
3. Enabling the growth of a sustainable blue economy and fostering prosperous coastal communities
4. Strengthening international ocean governance and enabling safe, secure, clean and sustainably managed seas and oceans.

Furthermore, the Italian Regions that promoted the project, acting as Intermediate Bodies of EMFF can incorporate the achievements as recommendation or reward criteria into their regional calls. Croatian Partners, participating in the Monitoring Committee can

prompt the EMFF Managing Authority to adopt DORY results into the provisions and selection criteria of central calls.

Considering the basin and the macroregional approach, DORY gave a notable contribution to the implementation of the EUSAIR strategy action plan with reference to the Pillar III addressing the issue of environmental quality, mainly in marine and coastal environment.The project stimulated the dialogueamong Adriatic Regions institutions ad stakeholder as well as the adoption of a common vision oriented to sustainability and maintenance of the good ecological status of Adriatic Sea. Moreover, the project tested advanced decision supporting tools, based on scientific approach, not only to “increase the marine knowledge” but also to ensure a best-shared governance of marine resources, promoting the “implementation of MSP and the ICM” principles.

Furthermore, DORY also gave several inputs for the PILLAR I (blue growth) implementation by improving the framework governance conditions for the marine sustainable growth in the Adriatic Regions and providing for a specific policy path for the implementation of CFP principles and the sustainable fishery management, based on inclusive and scientific based approach.

At operational level, the project triggers several actions contributing to topic 2, dealing with scientific cooperation on fisheries and fish stock, Sustainable management of fisheries, skills development and improvement of aquaculture environmental monitoring and quality scheme.

Lastly, the new European Territorial Cooperation Programmes for the programming period 2021-2027 will offer many possibilities to launch new initiatives and partnership driving innovative, sustainable and common growth for the fisheries and aquaculture sector in the Adriatic Regions while contributing to the respect of the marine and coastal ecosystems of the Region. Also, INTERREG Programmes will give the opportunities to support a further and wider transfer and capitalization of the project approach and tools.

Thanks to all the Partners which contributed to the implementation of the project activities

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This report was produced with the financial support of the European Union. Its contents are the sole responsibility of the project partners and do not necessarily reflect the views of the European Union.

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