Research and comparison of existing data and databases and design of protocols for monitoring invasive species in fisheries and aquaculture

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Draft Version of November 2022

Deliverable Number D.4.1. and D.4.2

Ruđer Bošković Institute

Project Acronym	ARGOS
Project ID Number	10255153
Project Title	Shared Governance of Sustainable Fisheries and Aquaculture Activities as Leverage to Protect Marine Resources in the Adriatic Sea
Priority Axis	3 - Environment and cultural heritage
Specific objective	3.2 - Contribute to protect and restore biodiversity
Work Package Number	WP4
Work Package Title	Knowledge-based decision-making process
Activity Number	4.1.
Activity Title	Survey and comparison of existing data and databases
Activity Number	4.2.
Activity Title	Common scheme for the management of fishery activities at local level
Partner in Charge	PP2 – Emilia-Romagna Region
Partners involved	PP6 – Istrian Region
URL	https://www.italy-croatia.eu/web/argos
Status	Draft version
Distribution	Confidential
Date	15 December 2022

Client:	Service provider:
Region of Istria **Dršćevka 3, HR - 52 000 Pazin** **through the Administrative Department for Agriculture, Forestry, Hunting, Fisheries and Water Management, M.B. Rašana 2/1** **HR - 52,000 Pazin**	**Ruđer Bošković Institute** **Bijenička cesta 54** **HR - 10000 Zagreb**
Service contract for "Research and comparison of existing data and databases and design of protocols for monitoring invasive species in fisheries and aquaculture" as part of the "ARGOS" project from the Italy-Croatia Cross-Border Cooperation Program 2014-2020. CLASS: 901-09/22-01/01 and ID number: 2163-03/1-22-18	

Research and comparison of existing data and databases and design of protocols for monitoring invasive species in fisheries and aquaculture

Contract 901-09/22-01/01 dated May 13, 2022,
PROJECT TASK:

- **Point 1. Recent threats and the appearance of invasive species in shellfish aquaculture areas in the Region of Istria;**
- **Point 2. Recent threats due to invasive species and unusual occurrences in coastal and offshore waters, i.e. fishing zones of the Region of Istria.**

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Zagreb, November 2022

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ABSTRACT

The Region of Istria, Croatia, as a project partner, participates in the implementation of the project ARGOS – "shARed GOvernance of Sustainable fisheries and aquaculture activities as leverage to protect marine resources in the Adriatic Sea" within the Cross-border Cooperation Programme INTERREG V-A Italy – Croatia. The objective of the ARGOS project is to promote a common integrated approach to the protection of fish and marine resources, improve the quality of the marine environment and further sustainable development of the region. This report refers to the project assignment obtained in the tender announced by the Region of Istria, Croatia, as part of the ARGOS project planned activities (procurement record number 46.1-22-JN; RBI-IC Contract 901-09/22-01/01, 4 May 2022). This project task is one of the expected results of the ARGOS work package 4, which contributes to the strengthening of evidence based decision-making and the formation of a common framework for managing fishery and aquacultural activities within the Adriatic Partnership.

The Current biological and ecological dynamics – state i.e., the effects of climate change on the marine environment and the presence of alien invasive species are pivotal in the establishment of a common management framework. The impact assessment of invasive species and abnormal phenomena on fish stocks and catches, and for the cultivation of shellfish and fish in aquaculture in the Region of Istria, it is envisaged to design and create a single protocol on the collection of data and the treatment of these threats.

This Report of the project task - Point 1: "Recent threats and occurrence of invasive species in aquaculture in breeding areas of shellfish in the Region of Istria" includes an overview of relevant data from the scientific literature, newspaper articles, databases on phenomena and species, intensity, trends, ecological conditions, sea status according to the Marine Strategy Framework Directive- (good environmental status and climate change) in the area of affected farms, shellfish production in farms, incurred damage and additional costs for the purpose of mitigation of breeders, proposing measures, subsidization and/or compensation by competent institutions and available funds based on examples of recent occurrence of foreign invasive species such as *Clavelina oblonga*, Herdman, 1880.

Point 2. "Recent threats due to invasive species and unusual phenomena in coastal and offshore waters, i.e., fishing zones in the Region of Istria" includes the design and creation of a protocol on the treatment of the affected area of the Region of Istria by these threats, and includes the collection of relevant data from scientific literature, newspaper articles, the creation of a database of phenomena and species, the intensity, trends, ecological conditions, status of the sea according to the Marine Strategy Framework Directive - MSFD (good environmental status and climate change) in the area of the affected sea-fishing zones, the type of fishing gear used, the usual catch for that month, season or year, documenting the damage caused by non-going to the sea and additional costs for the purpose of mitigation of fishermen, and proposing measures, subsidies and/or indemnities by competent institutions and available funds based on examples of the recent occurrence of an unusually large number of jellyfish species *Rhizostoma pulmo* (Macri, 1778).

For this purpose, relative data were collected and analyzed at the local-regional level as a basis for defining common scenarios and creating protocols for sustainable fisheries and aquaculture management within the framework of national laws and EU directives.

1. INTRODUCTION

The Adriatic Sea is a biogeographic subunit of the Mediterranean Sea located between the Balkan and Apennine peninsulas. With a length of 783 km and an average width of 248.3 km, the Adriatic Sea, with an average depth of 173 m, covers an area of 138,595 km2. Surface temperatures in the northern part of the Adriatic Sea are around 8°C in winter, while in the southern part the winter temperature is around 13°C. Summer temperatures are uniform and reach around 25°C. Salinity in the northern part of the Adriatic Sea increases towards the south, from 35 to around 38.5. The shallowest part of the Adriatic Sea, the northern Adriatic, is the place of inflow of about 60% of fresh water into the Adriatic Sea. Due to atmospheric influence, the complex system of water mass circulation, the inflow of high salinity water, and the inflow of fresh water, the northern Adriatic has seasonal and long-term oceanographic and biological dynamics. The trophic index (TRIX) uses variables such as oxygen saturation and nutrient salts such as dissolved inorganic nitrogen and total phosphorus, and characterizes the northern Adriatic as a border between oligotrophic and mesotrophic seas (Fiori et al., 2016). The total water mass movement of the Adriatic Sea is cyclonic, and in the northern Adriatic, during the pronounced stratification of the water column in the warmer part of the year (late spring and summer) due to the influence of freshwater inflow, cyclonic and anticyclonic eddies develop (Orlić et al., 1992).

The Adriatic Sea is recognized as a hotspot of Mediterranean biodiversity, although the exact number of species and subspecies that actually live or breed in the Adriatic is still unknown. According to rough estimates, it ranges between 7,000 - 8,000, and recent findings indicate that the total number of species and subspecies could be greater than 12,000. Of these, there are more than 5,500 marine invertebrates, about 600 species of algae, 449 species of fish, 10 species of marine mammals and four species of marine flowering plants (Seagrasses).

Under the influence of globalization and global climate changes, the Republic of Croatia faces the problem of the introduction of foreign species through anthropogenic activity, as well as the arrival of species from other regions of the Mediterranean Sea and neighboring oceans through active migration. Zenetos et al. (2010) list 53 invasive or potentially invasive species for the Adriatic Sea area. Climate change is one of the greatest challenges of modern civilization. An increase in the temperature of the Adriatic Sea by 1.6 to 2.4°C by 2070 may result in the migration of marine organisms, especially shrimp and hake, to deeper waters and to the north, a greater number of invasive alien species and the reduction or disappearance of native fish species, as well as a change in the selection of species for cultivation (Strategy of adaptation to climate change in the Republic of Croatia for the period up to 2040 with a view to 2070, NN 46/20).

Pečarević et al. (2013) provide a list of all species that they assume have recently entered the Adriatic Sea through anthropogenic or natural means. The list includes a total of 113 species (15 phytoplankton, 16 zooplankton, 16 macroalgae, 44 zoobenthic species and 22 fish species). However, this list should

be considered with caution, especially regarding planktonic species, since the discovery of these species is closely related to the development of research methodology and a significantly higher frequency of research with regard to the spatial and temporal component. It is important to note that one of the main ways of entry of foreign species into the Adriatic Sea is the active migration of Lessepsian migrants, i.e. species that reached the Mediterranean Sea by migrating through the Suez Canal.

Invasive species are non-native species that can have an extremely negative effect on ecosystem biodiversity. In the area of introduction, invasive species can suppress native species, change the structure of communities and food webs, and can also change nutrient cycling and sedimentation (Molnar et al., 2008). In 2014, the European Union recognized the presence of about 12,000 non-native species in the territory of the Union, with an estimate that 10 to 15% are invasive (EU Regulation, 1143/2014). In European seas, including the Mediterranean and thus the Adriatic Sea, a large number of invasive species have been recorded, considering the world level, whose most frequent routes of entry are ballast water and mariculture (Molnar et al., 2008). Increased maritime traffic, a consequence of globalization, is recognized as one of the primary routes of introduction of invasive species via ballast water. The importance of ballast water management was first recognized by the International Maritime Organization in 2004, and it is based on mechanical, physical, chemical and biological processes, either one or more of them, with the aim of removing, neutralizing, or otherwise avoiding the introduction of harmful and pathogenic aquatic organisms within ballast water or sediment (IMO, 2004). In the Republic of Croatia, the Rulebook on the management and supervision of water ballast is prescribed, which describes the rules for changing, processing, unloading and keeping ballast (NN 181/04). The invasion process can be divided into the following steps (Figure 1): transport of the species from the native area to a new area where the species is non-native, establishment of a population in the new area, period of lag (adaptation), period of population expansion, impact on the ecosystem, impact on people (Sakai et al., 2001). Management at the level of prevention is possible by acting on the conditions of transport, at the level of eradication until the moment of the spread of the population in a new area, control or restoration of the ecosystem after the spread of the population. Metapopulation dynamics of sink-source populations is crucial in the phases of population lag and expansion.

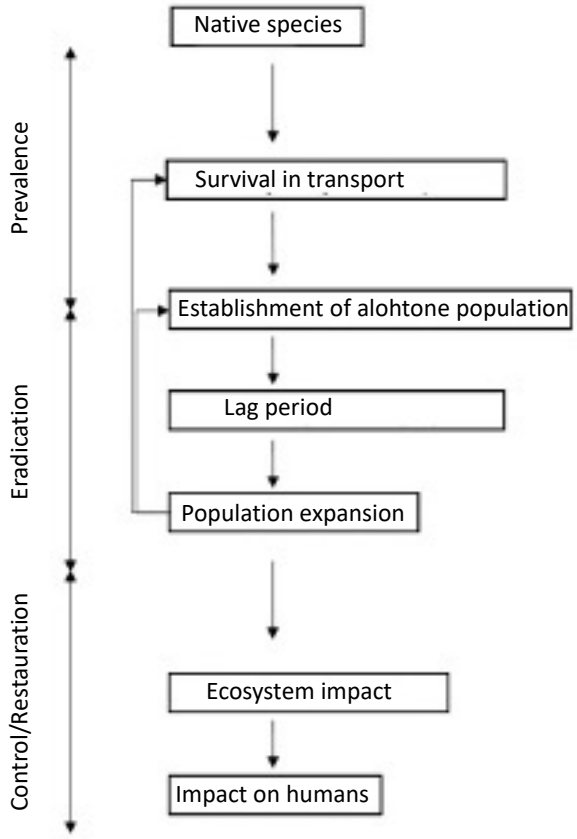


Figure 1. General steps of the species invasion process and relationship with invasive species management (Sakai et al., 2001).

In a review, Pećarević et al. (2013) list non-native species in the eastern part of the Adriatic Sea, whose routes of entry are primarily ballast water and aquaculture, and recognize three biogeographical regions, among which is the northern Adriatic. They also point out that biodiversity is affected by water masses from the Mediterranean Sea, especially circulation changes in the Ionian Sea, which mix high-salinity Aegean/Levantine seawater with lower-salinity seawater of Atlantic origin, which are the source of Atlantic species. For the northern Adriatic, they state that ballast water is an important source of introduction of non-native species into the Adriatic. The manual for the protection of the sea and recognition of the living world of the Adriatic (Prvan et al., 2016) states that of the 100 species on the list of the most invasive species in the Mediterranean, at least 30 are present in the Adriatic Sea, and of the 19 most invasive algae according to the same list, at least 11 are already present in the Adriatic (Table 1). Lessepsian species make up the majority of allochthonous species in the Adriatic.

Table 1. Some of the invasive species present in the Adriatic.

ALGAE	SNAILS	CRABS	FISHES
Caulerpa taxifolia (Vahl, 1802)	*Melibe viridis* (Kelaart, 1858)	*Percnon gibbesi* (H. Milne Edwards, 1853)	*Lagocephalus sceleratus* (Gmelin, 1789)
Caulerpa cylindracea Sonder, 1845	*Aplysia dactylomela* Rang, 1828	*Callinectes sapidus* Rathbun, 1896	*Fistularia commersonii* (Gmelin, 1789)
Asparagopsis taxiformis (Delile, 1845)			*Siganus luridus* Rüppell, 1829
			Stephanolepis diaspros Fraser-Brunner, 1940

Endangerment of the Adriatic Sea by invasive species

REGULATION (EU) no. 1143/2014 OF THE EUROPEAN PARLIAMENT AND COUNCIL of October 22, 2014 on the prevention and management of the introduction and spread of invasive alien species and the Act on the prevention and management of the introduction and spread of alien and invasive alien species (NN 15/18 and 14/19) differentiates and defines: native species that naturally inhabit a certain ecosystem of an area; alien species and invasive alien species.

Furthermore, there are cryptogenic species, which are species of unknown origin that cannot be defined as either native or foreign species, and pests, not necessarily foreign species present in the environment where they are undesirable and where they have a negative impact on the environment, economic factors or health People. Pests can be native, cryptogenic or foreign species.

Definition of INVASIVE ALIEN SPECIES (IAS):

- species that do not naturally live in an area, but have arrived intentionally or accidentally and have a negative impact on biodiversity, human health or cause economic damage.
- an alien species whose introduction or spread has been determined to threaten or adversely affect biodiversity and related ecosystem services.

There are about 1,500 IAS in the EU, which is 10-15% of the total number of foreign species, and in the Republic of Croatia, about 130 are known to date. (https://ec.europa.eu/environment/nature/invasivealien/index_en.htm).

Invasive species are non-native species that can have an extremely negative effect on ecosystem biodiversity. In the area of introduction, invasive species can suppress native species, change the structure of communities and food webs, and can also change nutrient cycling and sedimentation (Molnar et al., 2008). The most common routes of entry are ballast water and mariculture (25% intentional and 75% accidental).

Responsible institutions for collecting data on invasive alien species in the Republic of Croatia

- ***Ministry of Economy and Sustainable Development (MINGOR)***

The Ministry of Economy and Sustainable Development of the Republic of Croatia maintains a catalog and record of invasive alien species in the Republic of Croatia (https://invasivnevrste.haop.hr). Observations and findings of invasive alien species (IAS) can be reported through the Invasive Species in Croatia mobile application or through the web form for reporting findings. Data on the distribution of invasive alien species are important for management, i.e. reducing their negative impact on biodiversity and related ecosystem services. Reporting the discovery of foreign species will contribute to the early detection of new foreign species in Croatia, thereby preventing their spread and preserving Croatia's nature.

Ministry of Economy and Sustainable Development Department for Environmental and Nature Protection Radnička cesta 80/7, 10000 Zagreb 10000 Zagreb	Tel: +385 (0)1 5502 900 Fax: +385 (0)1 5502 901 Web: mingor.gov.hr E-mail: zavod@mingor.hr

In the Republic of Croatia, the Act on the Prevention of the Introduction and Spread of Alien and Invasive Alien Species and Their Management is in force (NN 15/2018, 14/2019), which prohibits the introduction of alien species into nature and/or into ecosystems where they do not naturally inhabit, breeding of foreign species and placing them on the Croatian market. The introduction of foreign species, their cultivation and placing on the Croatian market is exceptionally permitted if they do not pose a threat to biodiversity, ecosystem services and/or human health, taking into account possible adverse effects on the economy as an aggravating factor. This is determined in the process of obtaining permission from the Ministry of Economy and Sustainable Development, and it is necessary to submit an application in accordance with Articles 12, 14 and 17 of the Act on the Prevention of the Introduction and Spread of Foreign and Invasive Alien Species and Their Management (NN 15/2018 and 14/ 2019).

The alien species catalog includes data on the distribution of alien and invasive alien species, basic data on the biology and ecology of alien species, assessments of the risk of invasiveness of alien species, routes of introduction and spread of alien species, management and eradication measures, and other important information related to the invasiveness status of species (https://invasivnevrste.haop.hr/katalog). All data entered in the catalog for each individual species can be downloaded from the catalog in the form of templates and used further (Figure 2). The catalog contains 980 notes (Scientific name of the species, Croatian names, Status in the Republic of Croatia, Contents on the lists, Type of habitat, Presence of foreign species in the Republic of Croatia). There are no recent threats of the tunicate *Clavelina oblonga* Herdman, 1880 present in shellfish farms / breeding areas in the Region of Istria. The list of species and the map of findings-observations do not

provide practically any useful information about recent threats and the occurrence of IAS in the growing areas of the Istrian County (https://invazivnevrste.haop.hr/karta).

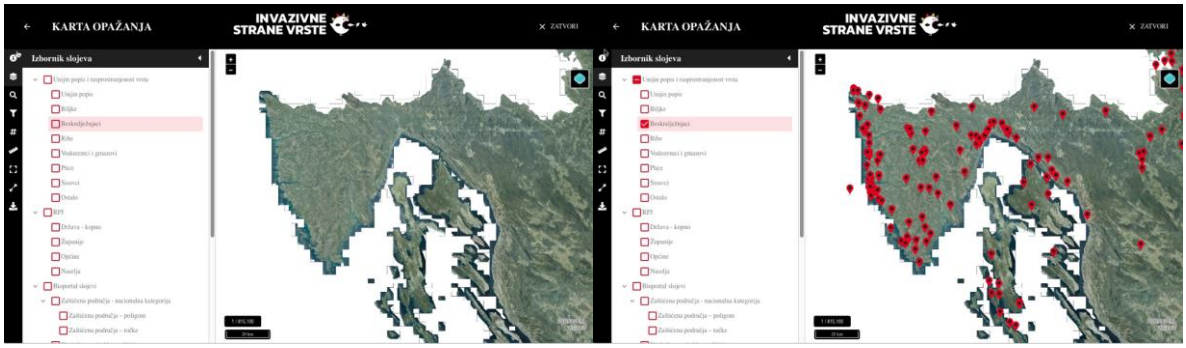


Figure 2. List of species and map of findings and observations of invasive species (MINGOR, HAOP).

Mobile application "Invasive species in Croatia"

The Ministry of Economy and Sustainable Development has also created a mobile application "Invasive species in Croatia" which is intended for the general public and through which citizens can send reports about the findings of foreign and invasive alien species that they see in nature (so-called Citizen Science).

Figure 3. The mobile application "Invasive species in Croatia" was created as part of the project Establishing a national system for monitoring invasive alien species, co-financed by the European Union from the Cohesion Fund.

After installing the application, it is necessary to register the user (email and password), upgrade - update the catalog of species and entries recorded so far, and then the application is ready to enter your own observations "My species observations". Observations can be collected and when all necessary mandatory information is filled in, the subject observation can be sent (Figure 3 and 4).

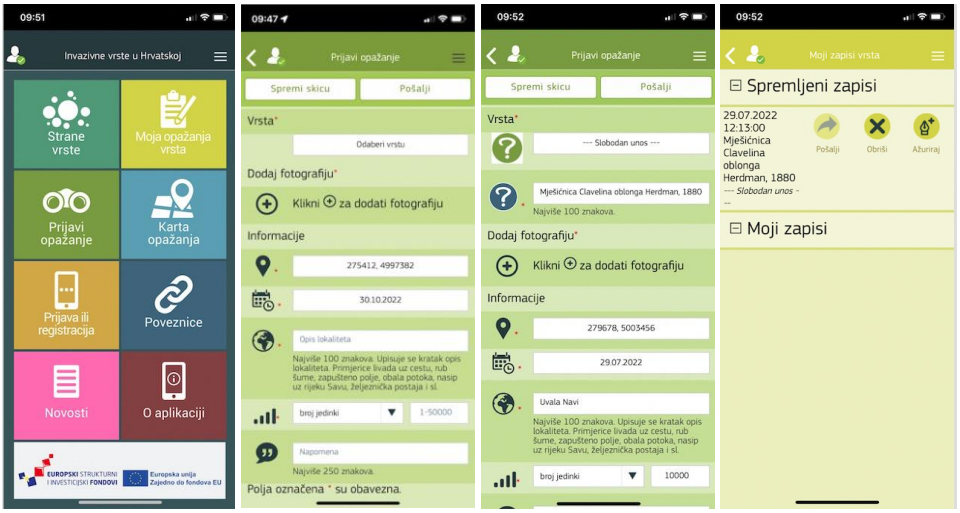


Figure 4. Entry and reporting of new observations of invasive species through the application Invasive species in Croatia. Example of recording observations of the invasive alien species *Clavelina oblonga* Herdman, 1880 in the shellfish farm in the Lim Bay.

- ***Institute for Agriculture and Tourism - Center for Invasive Species***

The Center for Invasive Species (CIV) is part of the Institute for Agriculture and Tourism in Poreč, where it is located. In addition to the employees of the Institute, numerous external collaborators, volunteers, students, professors and all interested citizens contribute to the work of the CIV. The Center for Invasive Species was born out of the need for a coordinated approach to scientific research, education and raising public awareness of the importance of the problem of invasive species and their harmful effects on human health and the environment. The goal of the CIV is to actively involve all competent institutions in the area of he city of Poreč and beyond, as well as children and citizens in the preservation of health and our unique and extremely valuable natural heritage.

Institute for Agriculture and Tourism CENTER FOR INVASIVE SPECIES Karla Huguesa 8 52440 Poreč	Web: http://civ.iptpo.hr/ E-mail: civ@iptpo.hr Tel: 052 408 304

On the CIV website, it is possible to view useful information (Figure 5) about plant, agricultural, marine and animal invasive species, and we highlight useful educational materials about marine invasive species:

- Leaflet for identifying the most common types of jellyfish and comb jelly in the Adriatic
- Brochure "The most common invasive alien species in Istria"
- Brochure "The most common types of jellyfish in the Adriatic"
- Manual "Mini marine school" - educational brochure for identifying the most common marine species in the tidal zone in the Adriatic, 2019.

Figure 5. CIV flyer - website where you can view useful, but numerically limited information about plant, agricultural, marine and animal invasive species, because there is no data on the findings and distribution of marine invasive species in shellfish farms in the Region of Istria.

- ***MINGOR- National monitoring according to the Marine Strategy Framework Directive***

Marine environment and coastal zone management strategy
Directive 2008/56/EC establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive) requires member states to take measures to achieve or maintain a good state of the marine environment by 2020 at the latest. For this purpose, marine strategies are developed and applied within the framework of which an ecosystem approach to the management of human activities is applied. The directive also represents an 'environmental pillar' in all EU policies oriented towards the sustainable management and use of natural resources of the marine environment.

The application of the Framework Directive on Maritime Strategy in Croatia consists of:

- harmonization of national legislation with the provisions of the MSFD,
- creation of marine strategy documents for marine waters under national jurisdiction with realization/continuation of sub-regional cooperation with neighboring countries, regional cooperation within the framework of the Barcelona Convention and cooperation at the EU level.

With the adoption of the Decree on the establishment of a framework for the activities of the Republic of Croatia in the protection of the marine environment (NN 136/2011) and the Decree on the preparation and implementation of documents of the Strategy for the Management of the Marine Environment and Coastal Area (NN 112/2014, 39/2017, 112/2018), transposed into the national legislation is the MSFD 2008/56/EC. The regulation regulates the starting points and benchmarks for the creation, development, implementation and monitoring of the implementation of the Marine Environment Protection Strategy or the so-called "Marine Strategy", which has its legal obligation to create in the Environmental Protection Act (NN 80/2013, 78/2015, 12/2018, 118/2018).

The main purpose of the Directive transposed by the Regulation is to achieve and maintain a good state of the marine environment by 2020 through the achievement of the general objectives of the protection of the marine environment, including:

1. protection, preservation, enabling recovery and restoration of marine and coastal ecosystems and sustainable use of ecosystem services;
2. preservation of protected areas in the sea and ecologically significant EU NATURA 2000 areas;
3. reduction of pollution in the marine and coastal environment in order to preserve the health of people, the ecosystem and enable the use of the sea and coast;
4. establishing and/or maintaining a balance between human activities and natural resources by applying an ecosystem approach.

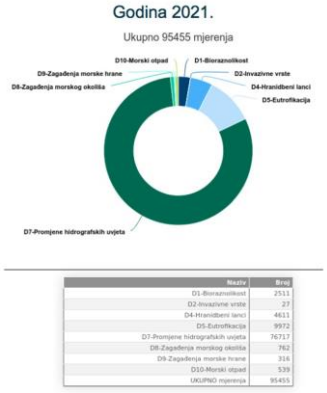
Pursuant to paragraph 2 of the Decision on the Adoption of the Action Program of the Marine Environment and Coastal Area Management Strategy: Monitoring and Observation System for Continuous Assessment of the State of the Adriatic Sea (Official Gazette 153/2014), and in accordance with the Decree on the Creation and Implementation of Marine Environment and Coastal Area

Management Strategy Documents (NN 112/2014, 39/2017 and 112/2018), the Ministry of Environmental Protection and Energy is the coordinator of the implementation of the Monitoring and Observation System for the constant assessment of the state of the Adriatic Sea.

The monitoring and observation system was created according to the initial assessment of the state of the marine environment and the established set of goals and is harmonized within the marine subregion and marine region and is based on the appropriate provisions of special regulations of the Republic of Croatia and the European Union, including international agreements regulating the protection of environmental components and load protection. The monitoring and observation system, for the purpose of connection and compliance with other monitoring programs in the subregion, strives to ensure the consistency of monitoring methods in the subregion and the marine region in order to facilitate the comparability of monitoring results and to take into account important transboundary impacts and transboundary features.

The monitoring and observation system for the continuous assessment of the state of the Adriatic Sea includes the Integrated Monitoring and Assessment Program of the Mediterranean Sea and Coast (IMAP IG.22/7), developed and accepted within the framework of the work of the Mediterranean action plan, United Nations Environment Program (UNEP/MAP). Prescribed specifications and standardized methods for monitoring and assessing the state of marine sub-regions and regions in the European Union and within the framework of the Barcelona Convention are the basis for amendments to the documents adopted pursuant to the Regulation, including documents related to the Monitoring and Observation Program for the continuous assessment of the state of the Adriatic Sea.

With the aim of fulfilling the obligations from Directive 2008/56/EC of the European Parliament and the Council, which establishes a framework for Community action in the field of marine environmental policy, MSFD (SL.L.164 of 18.6.2008) and the Integral System for Monitoring and Assessing the State of the Mediterranean Sea and coasts (IMAP IG.22/7) The Republic of Croatia is obliged to implement a monitoring program for the continuous assessment of the environmental condition of marine waters under its sovereignty. The goal of the ODMS is to achieve a good environmental condition of European seas by 2020 and more effective protection of the marine environment as well as the protection of resources on which economic and social activities related to the sea depend. Directive 2008/56/EC defines 11 descriptors that measure the state of the marine environment in EU countries:

D1 - Biodiversity **D2 - Invasive species** **D3 - Commercial fishing** D4 - Food chains D5 - Eutrophication D6 - Integrity of the seabed D7 - Changes in hydrographic conditions D8 - Pollution of the marine environment D9 - Contamination of seafood D10 - Marine waste D11 - Input of energy (underwater noise, etc.).	

Maritime Strategy Framework Directive
Descriptors

Qualitative descriptors for determining the good state of the marine environment:

(1) Biological diversity has been maintained. The quality and occurrence of habitats and the distribution and number of species are in accordance with the prevailing physiographic, geographical and climatic conditions.
(2) Non-indigenous species introduced by human activities are at such levels that they do not harm ecosystems.
(3) Populations of all commercially exploited fish, crustaceans and molluscs are within safe biological limits, and the population distribution by age and size indicates that the stock is healthy.
(4) All elements of marine food webs, to the extent that they are known, occur in their usual abundance and diversity and are at levels that can ensure the long-term abundance of species and the preservation of their full reproductive capacity.
(5) Human-caused eutrophication is minimized, especially its harmful effects, such as loss of biodiversity, ecosystem degradation, harmful algal blooms, and oxygen depletion in bottom waters.
(6) The integrity of the seabed is at a level that ensures that the structure and functions of the ecosystem are protected and that benthic ecosystems in particular are not affected by harmful effects.
(7) Permanently changing hydrographic conditions do not harm marine ecosystems.
(8) Concentrations of pollutants are at levels that do not cause pollution.
(9) Pollutants in fish and other seafood for human consumption do not exceed the levels established by Community legislation or other relevant standards.
(10) Properties and quantities of waste in the sea do not harm the coastal and marine environment.
(11) Energy input, including underwater noise, is at levels that do not harm the marine environment.

Descriptor 2. Non-native species (D2)

Definition of descriptor D2: Alien species (synonyms: exotic, non-native, allochthonous, invasive species) are species, subspecies or lower taxonomic units that have been introduced into the environment outside their natural range. This definition also includes parts, gametes or propagules of

such species that can survive and reproduce in a new environment. Their presence in the new environment is the result of intentional or unintentional introduction by anthropogenic activity. Species that have expanded their range under the influence of natural factors (e.g. the impact of climate change, being transported by sea currents...) are not considered foreign species. However, secondary introduction of foreign species into new areas is possible by natural means from areas where they were previously introduced by anthropogenic activity.

Definition of Good Environmental Status (GHS): Alien species introduced into the environment as a result of human activities are at such levels that they do not adversely affect the ecosystem.

According to the Decision of the EU Commission on criteria and methodological standards for achieving a good state of the marine environment, this descriptor is defined through the following criteria:

D2C1 - Primary
The number of new non-indigenous species introduced into the wild as a result of human activity, per assessment period (six years), measured from the reference year from the initial assessment based on Article 8 paragraph 1 of Directive 2008/56/EC, has been reduced where possible and reduced to zero.

D2C2 - Secondary
The number and distribution of established non-indigenous species, especially invasive species, which greatly increase the harmful effects on certain groups of species or broad types of habitats.

D2C3 - Secondary:
The proportion of a species group or area of a broad habitat type that is adversely affected by non-native species, particularly invasive non-native species.

Marine Strategy Framework Directive (MSFD)
http://jadran.izor.hr/geo/msfd_mon.html
http://baltazar.izor.hr/azopub/bindex

Action program of the marine environment and coastal area management strategy: monitoring and observation system for continuous assessment of the state of the Adriatic Sea for the period 2021-2026. (NN 28/2021) defines for Descriptor D2 defines: area, dynamics and methodology of sampling. The control of individual species and risk areas depends on the individual case. The proposal of the dynamics based on the list of alien species established so far and places of increased introduction is shown in Table 2.

Table 2. Proposal for monitoring risk areas and target species for the purposes of Descriptor 2.

RISK AREA /TARGET SPECIES	AREA	FREQUENCY; SEASON
Tuna farms	Grška (Brač), odabrano o uzgajalište na zadarskom području	annualy; Spring and Autumn
South Croatia	Područja Dubrovnik - Molunat i Mljet	Per year; as needed
Harbour areas	Split, Kaštelanski zaljev	Per year; season
Lophocladia lallemandi	o. Blitvenica	Per year; as needed
Caulerpa taxifolia	Starogradski zaljev	Per year; as needed
Caulerpa racemosa var. *çylindracea*	Sjeverni Jadran (odabrani lokaliteti) Srednji Jadran (odabrani lokaliteti)	Per year; as needed
Acrothamnion preissi	prema procjeni	Per year; as needed
Asparagopsis armata	prema procjeni	Per year; as needed
Womersleyella setacea	prema procjeni	Per year; as needed
Hypnea spinella	prema procjeni	Per year; as needed
Paraleucilla magna	prema procjeni	Per year; as needed
Oculina patagonica	Kaštelanski zaljev	Per year; as needed
Ficopomatus enigmaticus	Šibenik, Ploče	Twice per year; as needed
Percnon gibbesi	Vis	Per year; as needed
Callinectes sapidus	Južni, Srednji i Sjeverni Jadran	Per year; as needed
Fistularia commersonii	Južni i Srednji Jadran	Per year; as needed
Siganus luridus	Južni, Srednji i Sjeverni Jadran	Per year; as needed
Lagocephalus sceleratus	Južni, Srednji i Sjeverni Jadran	Per year; as needed

As part of the integral system for monitoring and assessing the state of the Mediterranean Sea and the coast (IMAP IG.22/7), the Republic of Croatia implements a monitoring program for the continuous assessment of the environmental state of marine waters under its sovereignty as part of the Marine Strategy Framework Directive (MFSD) and the Reference Center for Sea of the Environmental Protection Agency (https://acta.izor.hr/wp/novost/referentni-centar-za-more/).

During the monitoring cycle, the presence of new non-native species will be determined or new areas of already present NIS species will be recorded. Since it is not possible to predict the time and place of

appearance of such species, for them, according to expert assessment, the possibility of additional monitoring through research monitoring is left.

Fieldwork methodology varies depending on the area or species monitored. Benthic species and areas are mostly monitored using standard benthic survey methods that include visual inspection, photo documentation and sample collection. These activities are carried out by autonomous diving, snorkelling or survey and collection from the shore. A specific fieldwork procedure is always related to a specific area of research or a specific species, and should be proposed by an expert for a specific situation. Sampling of benthopelagic fauna and mobile epifauna (fish, crustaceans) will be done primarily by the method of visual census (autonomous diving and snorkelling) with photo documentation. Given that commercial fishing catch monitoring programs already represent a kind of sampling with active and passive fishing tools, data from such programs will be used for the purpose of their detection (data collected through D3 - populations of economically important fish, crabs and shellfish). New scientific knowledge has also recognized local ecological knowledge (LEK) as a very efficient way of obtaining information about non-native species, and the same will be used for this purpose. It is about conducting targeted interviews with fishermen, which would thereby contribute to knowledge about the occurrence of non-native species in the areas where they fish. Data collection is also done by including the public in the observation network (citizen-scientist principle) through the publication of calls for participation in various media.

The methodology of data processing is in most cases specific to a particular type or area. The conducted research and data processing should be designed in such a way as to enable the assessment of the given criteria (D2C1, D2C2 and D2C3), and result in:

- distribution maps of foreign species
- determining the vectors and paths associated with input
- by assessing the number of new findings as a result of primary intake and secondary spread
- assessing the influence of foreign species
- by determining the basic biological properties of individual species
- determining the change in impact (if earlier data exists) - assessing further expansion
- plan and suggestions for monitoring and control
- public presentation of the species.

Descriptor 3 (**D3 - Populations of fish, crustaceans and molluscs exploited for commercial purposes**) refers to commercially exploited populations of marine fish, crustaceans and molluscs. This Descriptor is related to the Common Fisheries Policy of the EU.

Exploited fish, crustacean and shellfish populations in Croatia are assessed and therefore managed at the regional level (GSA 17 and GSA 18), with the exception of some coastal populations that are assessed at the national level and are managed at that level, given that it mainly deals with marine species that are shared between all the countries of the Adriatic region. Assessments of the state of exploited populations, which includes the definition of reference points for management purposes, are carried out as part of STECF and GFCM. GFCM and STECF do not conduct assessments or provide

reference points for all populations that are subject to exploitation in the Republic of Croatia. Therefore, GDS assessment for criterion D3C1 (fishing mortality rate) and criterion D3C2 (Biomass of stock for spawning populations i.e. their reproductive potential) cannot currently be carried out for all exploited populations based on estimates and reference points defined by GFCM and STECF -And. Furthermore, STECF does not provide scientific assessments or reference points related to criterion D3C3 (age and length structure of the population). In order to harmonize the GES assessment for Descriptor 3 at the regional level, the estimated biomass will be used as well as its defined reference values obtained at the GFCM/STECF level.

The key species for this descriptor are the following: demersal (*Merluccius merluccius*, *Mullus barbatus* and *Nephrops norvegicus*), pelagic (*Engraulis encrasicolus*, *Sardina pilchardus*), littoral (*Solea solea*, *Spicara smaris*) and bivalves (*Pecten jacobaeus*). Precisely these species are due to their geographical distribution (Mediterranean and Adriatic Seas), national significance (management plans, regulations on minimum hunting size) and international regulations and directives (1967/2006/EC, CFP, etc.), and indicator methods developed in within the scope of CFP, MSFD and WFD, suitable for determining GES according to defined criteria and indicators.

- ***Reference center for the sea (AZO-HAOP-MINGOR)***

The first expert meeting of the consortium of the Reference Center for the Sea (RC-sea) of the Institute of Oceanography and Fisheries and the Ruđer Bošković Institute was held in Split (June 7, 2019). The reference center for the sea is designated on the basis of the Law on Environmental Protection (NN 110/07) for the needs of professional and scientific support to the Agency in the collection, processing and analysis of data on the state of the marine environment, fisheries and mariculture, and for the needs of the Sea Information System and reporting in particular according to the European Environment Agency (EEA). The establishment and management of a complete marine information system, which serves as a source of data for the European water information system, is one of the activities foreseen by the Regulation on the establishment of a framework for the activities of the Republic of Croatia in the protection of the marine environment (NN 136/11), which regulates management, protection and conservation of the marine environment in the Republic of Croatia. The aforementioned Regulation transposes Directive 2008/56/EC of the European Parliament and the Council, which establishes a framework for Community action in the field of marine environmental policy, into national legislation.

The Reference Center for the Sea provides: it continuously provides the technical, personnel, material and other necessary administrative conditions, including the necessary authorizations and accreditations of the competent authorities to perform testing and evaluation of the required parameters that are within the scope of the Reference Center for the Sea.

Areas of operation of RC-sea:

1. Implementation of a monitoring and observation system for continuous assessment of the state of the Adriatic Sea, data collection and management (JADMON)
2. Preparation of a report on indicators of the state of the marine environment, fisheries and mariculture
3. Support for the development and implementation of the marine environment protection policy and cooperation in the preparation and implementation of projects
4. Preparation, creation and coordination of the preparation and production of reports and publications and evaluation of reports and publications
5. Support for the development of the Marine Information System (ISZMO) module within the Environmental Protection Information System (ISZO)
6. Coordination of work of RC-sea and other tasks.

The Marine Reference Center performs the following tasks for the Environmental Protection Agency (HAOP):

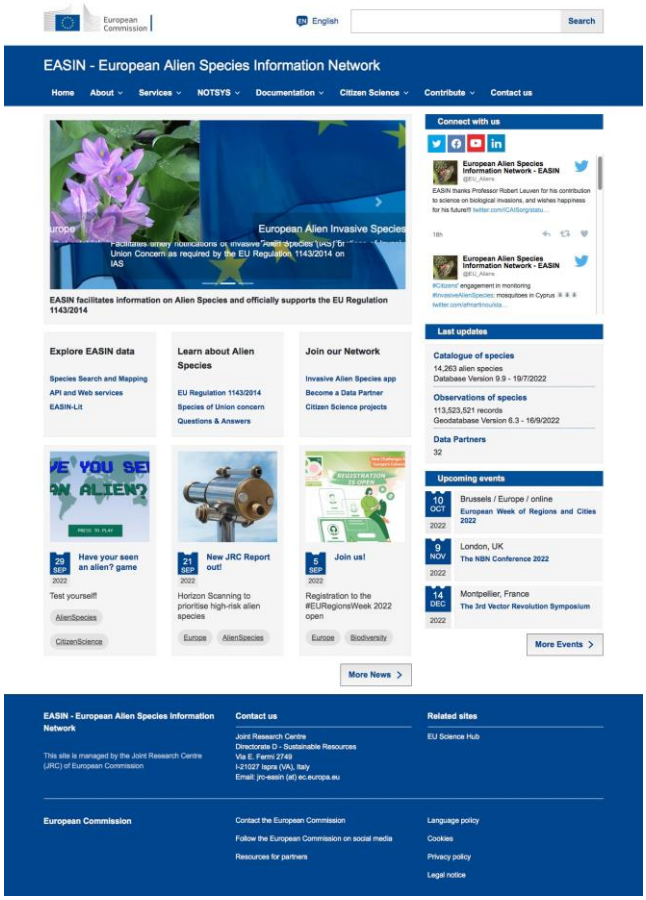
- collects, consolidates, analyzes and evaluates data on monitoring the state of the marine environment, fisheries and mariculture carried out by competent bodies and institutions according to special regulations and international agreements, and participates in proposing and establishing a monitoring network as well as creating plans for monitoring the state;

- in cooperation with the Environmental Protection Agency, maintains and updates indicators on the state of the marine environment, fisheries and mariculture, including the National List of Indicators, and creates trend analysis for them and develops and creates new indicators;
- provides technical assistance related to the implementation of regulations that have been transposed, i.e. which provide a framework for the implementation of the acquis of the European Union in the field of marine environment protection, fisheries and mariculture, and participates in the work of expert bodies and working groups of the European Environmental Agency on the preparation and implementation of projects marine environment protection;
- provides scientific, professional and technical assistance in the preparation, creation and validation of reports and prepared assessments on the state of the marine environment for the purposes of reporting according to special regulations and international agreements;
- provides support in the development and establishment of the Sea Information System, which is an integral part of the Environmental Protection Information System, including the establishment of relevant databases and georeferenced browsers, along with the development of technologies, and develops models, analytical methods and forecasts as tools to support the development of sea state monitoring programs , plans and measures for the protection of the marine environment, national and regional strategies;
- participates in the work of expert bodies and working groups within the European Thematic Center for Sea and Water for the needs of the European Information Monitoring Network and the European Information System for Water.

The manner of performing the duties of the Reference Center for the Sea is defined by the annual work program, which is coordinated with the Work Plan of the Environmental Protection Agency. Financial resources for the work of the Reference Center for the Sea are provided from the state budget of the Republic of Croatia in accordance with the annual work program of the Reference Center for the Sea, after obtaining the opinion of the Environmental Protection Agency.

The RC-sea is obliged to promptly deliver all data related to the monitoring of the state of the thematic area, indicators and results of analyzes to the Environmental Protection Agency, and for this purpose continuously ensures technical, personnel, material and other necessary administrative conditions.

- **Additional information about IAS in the EU can be found on the page (**EASIN - http://easin.jrc.ec.europa.eu/).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2. PROJECT TASK: Research and comparison of existing data and databases and design of protocols for monitoring invasive species in fisheries and aquaculture

2.1 Point 1. Recent threats and occurrences of invasive species in shellfish aquaculture areas in the Region of Istria.

This point includes the design and creation of a protocol on how to proceed in the event that the area of interest of the Region of Istria is affected by the mentioned threats, and includes the collection of relevant data and scientific literature-newspaper articles, the creation of a database on phenomena and species, intensity, trends, ecological conditions, the status of the sea Marine Strategy Framework Directive - (good environmental status and climate change) in the area of affected farms, shellfish production, damage and additional costs for the purpose of farmers mitigation, proposing measures, subsidies and/or compensation by competent institutions and available funds based on examples recent occurrences of the invasive alien species *Clavelina oblonga* Herdman, 1880.

Situation and pressures in the area of Region of Istria

The Northern Adriatic is the shallowest part of the Adriatic Sea, with an average depth of 35 m. The Northern Adriatic is the most distinctive part of the Adriatic Sea with recognizable ecological conditions and is also the area of the largest primary production in the Adriatic and the Mediterranean.

The greatest pressures on the marine environment in the area of the Region of Istria arise as a result of anthropogenic activities and climate change. The increase in the number of inhabitants in the coastal area, the development of tourism and maritime traffic, the pollution of inland waters, etc., have a negative effect on the ecological conditions in the sea. The pressures evident in coastal areas are from communal activities in cities and towns, and economic activities that use marine resources such as industry, agriculture, maritime transport, fishing (and mariculture), tourism and shipbuilding should also be emphasized. The Adriatic Sea is under great fishing pressure, both from Croatian and foreign, mostly Italian, fishermen.

In addition to climate change, which affects the abiotic and biotic factors of the marine ecosystem and the appearance of invasive alien species, the quality of marine habitats is satisfactory (data available on the Database and indicators of the state of the marine environment, mariculture and fisheries, HAOP, http://baltazar.izor.hr/azopub/bindex).

The state of coastal and transitional waters in the Region of Istria

Determining the degree of eutrophication and the general ecological condition of the coastal sea of transitional and coastal waters is of fundamental importance in the planning and management of space in the coastal area. Therefore, data on the ecological state of transitional and coastal water bodies are collected within the framework of supervisory monitoring carried out by Croatian waters. Supervisory monitoring includes basic physical and chemical indicators, biological elements of quality (phytoplankton, macrozoobenthos, fish, macroalgae and marine flowering plants), specific pollutants

and priority substances, in accordance with the Regulation on quality standards (NN 73/2013, 151/2014, 78/2015, 61/2016).

Transitional waters are surface waters near the mouth of the sea, which are partially salty due to the proximity of coastal waters, but are significantly influenced by freshwater flows (Act on Waters NN 153/2009, 130/2011, 56/2013, 14/2014, 46 /2018). In the territory of Istria County, transitional waters are located in three areas: Savudrijska vala, the mouth of Mirna Tarska vala and Raša Bay. Coastal waters are surface waters within a line one nautical mile away from the starting line from which the width of the waters of the territorial sea is measured in the direction of the open sea, and in the direction of the land they extend to the outer limit of the transitional waters. According to Croatian Waters, all coastal water bodies as well as transitional waters are in good (satisfactory) condition.

Mariculture in the Region of Istria

Mariculture is an alternative source of fisheries production and it accounts for a significant part of the total EU production of fish and shellfish. However, aquaculture is also highly dependent on fish feed, which again largely consists of fish products. The conversion coefficient of fish feed for animals is low, that is, it takes quite a lot of fish feed to get a kilogram of farmed fish, so the catch of fish for the production of fish feed is a limiting factor for the development of aquaculture. The County of Istria has significant resources and potential for the cultivation of shellfish, and they have not been fully utilized, that is, the cultivation is very small compared to the possible capacities.

The following locations are intended for mariculture: Piran Bay/Savudrijska Vala, the area west of Cape Sveti Pelegrin to Cape Molino, the area from Soline Bay to Cape Busuja, Mirna estuary, regulated channels of the Mirna River, Santa Marina Bay, Lim Bay, Sv. Ivan, Pomer Bay, Valun and Valmižeja Bays, Budava Bay and separate parts of the Raša Bay. The Lim Bay, as a traditionally very important locality, also stands out for the cultivation of shellfish, and the area includes a capacity of over 500 tons, and together with the shellfish farms located in the Vabriga area, they round off the whole of over 700 tons of total registered capacity.

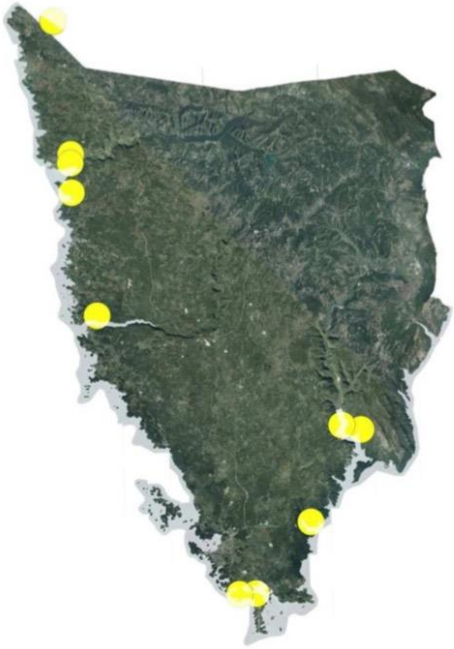


Figure 6. Aquaculture areas of marine organisms in the Region of Istria (source: Strategic environmental impact study of the National Strategic Aquaculture Development Plan for the period 2014-2020).

Table 3. Fish and Shellfish aquaculture areas in Region of Istria.

Aquaculture areas	Organisms
West coast of Istria Savudrijska draga, Plič Čivran i uvala Soline kod Tara i Vabrige, Limski zaljev, uvala Valun kod Premanture, Pomerski zaljev	Shellfish
East coast of Istra uvala Budava, Raški zaljev	Fish (Budava) and Shellfish

Shellfish farming (mainly mussels and oysters) in the Region of Istria is carried out by > 12 entities, of which the largest concessionaire is Istrida d.o.o. with farms in the Lim channel and the largest producer of RZ Sargus in Savudrijska vala, which, due to its geomorphological and climatic conditions, represents an ideal location for breeding. The annual production of shellfish in the County of Istria varies from year to year, around 400 tons of mussels and a negligible amount of oysters. For the most part, the entire quantity meets the demands of the domestic market through catering facilities and retail outlets.

In Croatia, invasive foreign species are also among the main reasons for the threat of biodiversity. Most often, these are non-native species introduced into a new ecosystem where they do not naturally inhabit and where, due to the lack of natural enemies, they strongly (sometimes irreversibly) suppress indigenous species, reducing their population numbers. It is estimated that amphibians, freshwater fish, reptiles, marine fish, and dragonflies are the most threatened by invasive alien species. Consequently, they cause the degradation and extinction of native species and habitat types, with possible serious economic or human health damage. In the territory of the Istrian County, we find a large number of plant and animal invasive species, of which only a few are systematically monitored by monitoring (Table 4).

Table 4. Invasive alien species recorded in the Region of Istria.

GROUP	SCIENTIFIC NAME	CROATIAN NAME
Seaweed	*Caulerpa cylindracea* *Caulerpa racemosa*	Grozdasta kaulerpa Zelena kaulerpa
Diatoms	*Pseudonitzschia* spp	
Bryozoa	*Bugula fulva*	
Ctenophora	*Mnemiopsis leidyi*	Morski orah
Appendicularia	*Appendicularia sicula*	
Tunicates	*Clavelina oblonga*	Mješićnica
Molluscs	*Dreissena polymorpha* *Crassostrea gigas*	Raznolika trokutnjača Pacifička kamenica
Crabs	*Hemigrapsus sanguineus* *Pacifastacus leniusculus* *Parvocalanus crassirostris*	Signalni rak
Insects	*Aedes albopictus* *Aedes koreicus* *Cinara cedri* *Harmonia axyridis*	Azijski tigrasti komarac Korejski komarac Lisna uš Harlekinska božja ovčica
Fishes	*Gambusia holbrooki* *Oplegnathus fasciatus* *Pomatomus saltatrix* *Pseudodiaptomus marinus*	Gambuzija Prugasti kljunaš Strijelka

Invasive alien species most often come to the Adriatic through ballast water, accidental introduction, escape from aquariums/aquaculture or naturally from warmer seas as a result of global warming or oceanographic changes. Some types of algae are often invasive, they spread quickly and successfully through vegetative growth because they have no natural or effective predator to control their populations, creating very dense layer on the seabed (e.g. *Caulerpa* spp.).

Since 2015, the City of Poreč in cooperation with the Institute for Agriculture and Tourism (Center for Invasive Species) has been promoting the coordination of activities related to the management of invasive species in Poreč and the surrounding area for better implementation of species monitoring, assessment of invasiveness and definition of invasive species management plans. In the period 2015 - 2016, the City of Poreč financed the project: Inventory and monitoring of invasive species in Poreč and

its surroundings, to collect data on the presence of two invasive species: clustered caulerpa and pajasen. The cities of Poreč, Rovinj and Novigrad, in cooperation with the Institute for Agriculture and Tourism from Poreč and the Center for Marine Research of the Ruđer Bošković Institute from Rovinj, conducted a systematic monitoring of invasive species of the Northern Adriatic, especially the species *Mnemiopsis leidyi* in 2016, 2017 and 2018.

A large part of the county (28%) is under the area of the ecological network, which contributes to the strengthening of the system of implementation of the acceptability assessment and preserves non-fragmented, complete natural areas. Some of the projects of public institutions, as well as non-governmental organizations, are related to the suppression of the spread of invasive species, which contributes to the fight against invasive alien species. (e.g. the activities of the CIV Poreč). On the other hand, a big problem for marine ecosystems is the indiscriminate and excessive use of fish stocks, the destruction of the seabed by trawling and other poorly selective tools, and the impact of mariculture in terms of organic pollution of the sea. In 2015, a new invasive species of the ascidian tunicate *Clavelina oblonga* was observed in the Bay of Trieste and in the Savudirjska Vala (Mioković, 2016). After field inspection and discussions with growers during 2020-2022. its presence was also confirmed in other farms on the western and southern coast of Istria. Due to the rapid growth of *C. oblonga*, it fouls and overgrows the mussels, physically limiting their growth and feeding and additionally burdening the load-bearing infrastructure (Figure 7) (Majnarić et al., 2022).

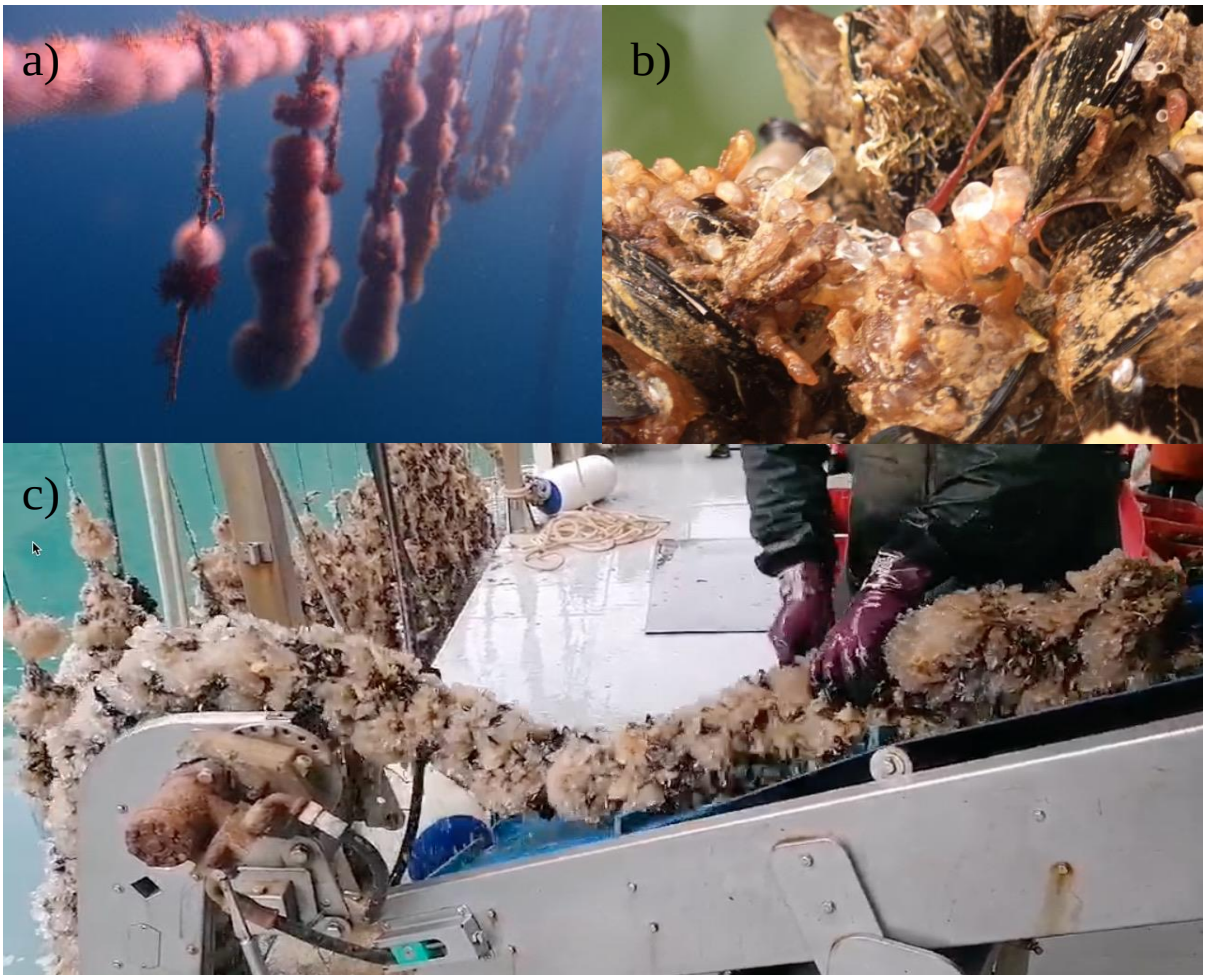


Figure 7. The tunicate *C. oblonga* fouls and overgrows the mussels, and puts an additional burden on the load-bearing infrastructure. An example of the affected farms in the Lim Bay: a) overgrown mussels in pergolas (September 2020); b) overwintering of the remaining parts of the buds of the colonial corpus with young zooids as a result of vegetative propagation (February 2021); dc) mussels overgrown with tunicate after sexual reproduction and re-invasion (September 2021).

Tunicates are a group of marine invertebrates that inhabit all seas and live from the shallows to depths of several thousand meters. The largest group of tunicates are bursae. Most of the tunicates are sessile (sedentary) species that live permanently attached to the seabed. Other species, such as salps, doliolids and pyrosomes, swim in the pelagic zone and spend their entire life as plankton. The tunicate's body is surrounded by a thick sheath made of tunicin, a substance that is chemically similar to plant cellulose. This external skeleton is transparent, thin and gelatinous in some species, while in others it is thick, firm and hard, and is unique in that it can grow together with the animal. Inside the tunic is a mantle composed of connective tissue, muscles, blood vessels and nerves. Cellulose production in animals is uncommon, and tunicates are the only animals that produce cellulose in significant quantities. Tunicates feed by filtering seawater and compete for the same food source as bivalves. However, as they grow extremely fast and have no natural predators to feed on them, young mussels outgrow them very quickly and prevent their further growth.

In the larval stage, many sessile species of tunicates swim freely, have a tail and coil, and resemble tadpoles. Tunicates are relatives of vertebrates, which is visible in the structure of their larvae. The larva has a nerve cord along its back, a cerebral ganglion, an eyespot and an otolith that enables it to orient itself, and in the tail there is a notochord, a semi-flexible coil that can be compared to a spine.

Tunicate larvae mature very quickly, in a few hours. Larvae do not feed and have no mouth. They are attached as soon as possible to the appropriate surface on which they will spend the rest of their lives. When they are ready to accept the substrate, the sticky secretion allows them to stick head down to the chosen place. Then all the structures in the tail are reabsorbed and the other organs that serve for feeding and breathing develop.

It is known that *C. oblonga* reproduces by budding and creates colonies of two, four, up to a dozen or more individuals. Each group of individuals (zooids) has a common stalk that attaches them to the substrate. The zooids are about 2.5-4 cm long, and the entire colony can be up to 10 cm high. The tunic that envelops the individual appears gelatinous and transparent, and is basally hard. The lower part of the colony is yellow-brown. At the top, each individual has two tiny openings (siphons) that have a white border. *Clavelina oblonga* also reproduces sexually during the summer, creating larvae with a diameter of 0.8 mm that partially mature inside the mantle cavity of each individual. When the larvae get out into the surrounding sea, they swim using their tails and look for a suitable place where they will catch and create a new colony. Larvae do not have mouths and do not feed, so they live only a few hours before they attach to a solid substrate. We therefore assume that in this way the species can spread very slowly and at a distance of several tens of meters, depending on the sea currents. Dispersal over longer distances is possible only with the help of human activity, for example on ships, chains, anchors, buoys or by transporting shellfish, collectors or pergolas for the needs of aquaculture.

According to our own observations and research in the area of the Lim and Raša bays (2020-2022), we can say that colonies appear during May, and are maximally developed in September-October. During the winter, the colonies gradually disappear (Majnarić et al., 2022). Emergence of larvae (sexual

reproduction) was observed during summer and early autumn. The growth of this tunicate is correlated with the growth of temperature and chlorophyll a in seawater. This is still a tropical species and in its natural habitat temperatures do not fall below 10°C, but this group often undergoes regression during the winter months and survives in the form of buds from which zooids sprout again when living conditions become favorable. So far, no finds have been recorded on the coast and in natural habitats outside of mariculture.

What can be done to reduce damages in aquaculture? Regular cleaning of equipment, ships, platforms, buoys, anchors, chains and more is recommended to prevent further spread of the species. It is not recommended to transfer live bivalves to other farms or to lay collectors in farms affected by this threat. Current knowledge indicates that this species mostly inhabits clean substrates and is easier to catch if there is no other vegetation. This is why scientists from Spain recommend that works in mariculture be adapted to its life cycle (Ordonez et al., 2016). It is not recommended to transplant mussels during July, when there is the largest amount of tunicate larvae in the sea, and it would be best to plant young mussles only in mid-autumn (Mioković, 2016; 2018).

Through a series of activities, the IRBI CMR Rovinj, in cooperation with growers in the area of Region of Istria, monitors the appearance of the ascidian tunicate *Clavelina oblonga*, its spread, its effects and looks for possible measures to control this invasive species. Despite the undertaken own activities and all mandatory monitoring and regular supervision by the competent institutions (Veterinary Institute of Rijeka), the further spread of this invasive tunicate was not prevented.

It is known that once the growers in the Lim Bay moved the pergolas with clams to the very beginning of the bay and left the pergolas and grates exposed to the brackish sea water for the treatment to destroy fouling organisms. Our experimental exposure of cooperative bodies of *C. oblonga* to different salinities showed that during the total observation time (14 days of exposure to lower salinities and 14 days of recovery) there was no sexual reproduction, while salinities 20 and 11 caused a disturbance in food acceptance and feeding itself, which is led to a change in color and necrosis of the tissue, and finally to the disintegration and fragmentation of the corpus. In general, based on our preliminary results and the available literature, we can approximate and conclude that the translocation of mussel/shellfish pergolas with tunicate *C. oblonga* and exposure to the reduced salinity <20 for 7-10 days would be a possible natural way of eradication of this invasive species (Majnarić and et al., 2022).

2.1.1 Collection of relevant data on threats, occurrences and invasive species in the area of affected shellfish farms

In accordance with the project task of collecting relevant data and scientific literature-newspaper articles, creating a database on occurrences and species, intensity, trends, ecological conditions, it was determined that there is no data on the occurrence of invasive species and threats in aquaculture for farms in the County of Istria, or they refer to areas outside the existing concessions. Furthermore, there is still a lack of information on the exact locations of distribution, intensity and damages in mariculture caused by the recent threat - the spread of the invasive species of the tunicate, *Clavelina oblonga*.

The only shellfish grower in the Istrian County who spoke publicly about the situation and recent threats in his farming area is Mr. Emil Sošić (Istrida d.o.o.) - concession area in the Lim Bay (https://magazin.hrt.hr/price-iz- Croatian/last-shellfish-in-the-Lim-canal-9629824). In the attachment, E. Sošić explains that, although the Gulf of Lim is a real mecca for growing mussels and oysters, aquaculture is retreating in the face of tourism and recent threats. He has two fields in the concession, and has been growing mussels and oysters in polyculture for 18 years, somehow resisting the ever-increasing costs and lack of labor (Figure 8). Emil Sošić is the last shellfish grower in the Lim Bay, a similar or more difficult fate awaits some other farms and owners.

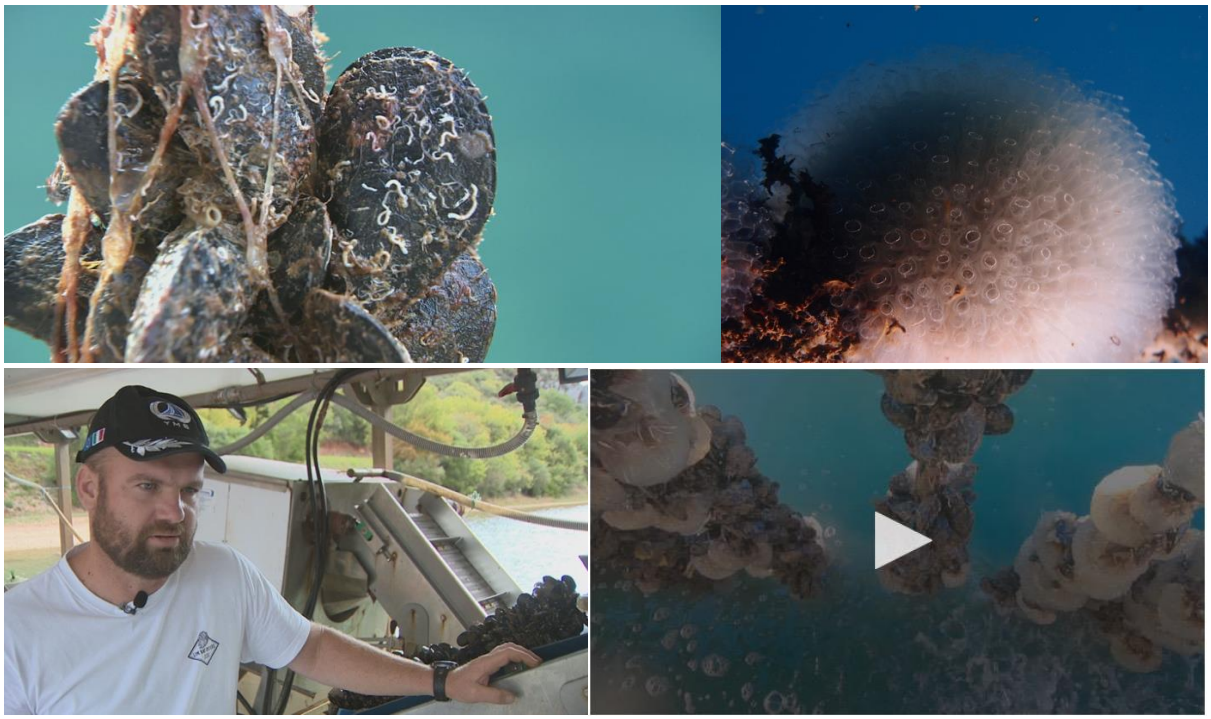


Figure 8. HRT magazine, report - the last shellfishmann in the Lim channel (https://magazin.hrt.hr/price-iz-hrvatske/posljednji-skoljkar-u-limskom-kanalu-9629824).

Due to the appearance of the invasive species of ascidian tunicate *C. oblonga*, which appeared in his breeding area in 2020, and in 2022, as a related species, the flatworm *Imogine mediterranea* appeared in unprecedented numbers, which is obviously favored by intensive cover of tunicates. In cooperation with the scientists of the RBI CMR Rovinj, it was established that the mentioned flatform also attacks healthy mussels, i.e. it does not feed only on weakened mussels due to intensive fouling, which represents an additional threat (Hamer et al., 2022).

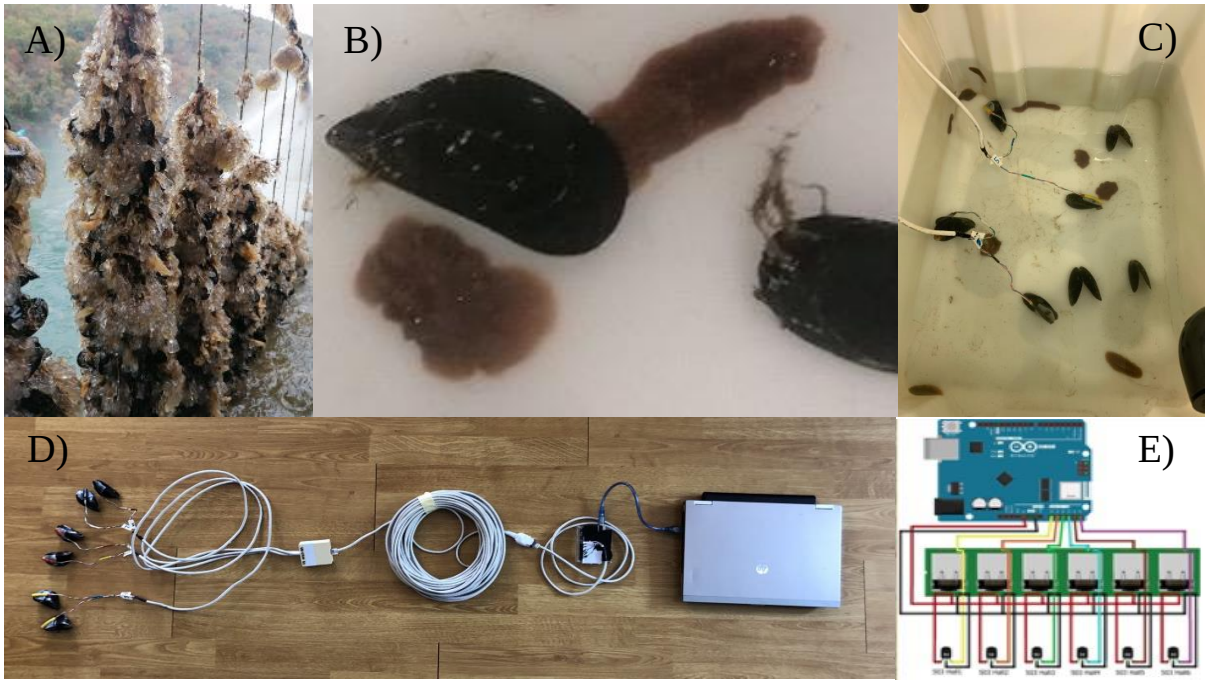


Figure 9. *Real-time* monitoring of the predation of the mussel *Mytilus galloprovincialis* by the flatworm *Imogine mediterranea* using the valve gapping mussel monitor (VGMM): A) The infrastructure of the shellfish farm in the Lim Bay threatened by the invasion of the tunicate *C. oblogna*; B) predation of mussels by flatworm *I. mediterranea*; C) experimental setup; D) VGMM with 6 sensors/mussels; E) Connection diagram of Arduino microcontroller and VG Hall sensor.

Collection of data on threats in shellfish areas in the Region of Istria

As part of the project task - Point 1. Recent threats and occurrence of invasive species in aquaculture in shellfish breeding areas in the Region of the Istria; A field survey of the conditions in the farms in the shellfish farming areas of the Istrian County was carried out, a survey and interviews were

conducted with informal representatives of the farming areas (May-November 2022), and a search of available data - journalistic and scientific articles.

The first notification of the aforementioned threat - the appearance of the invasive alien species *Clavelina oblonga* (Herdman, 1880) in the territory of the Region of the Istria, along with a morphological and genetic analysis, was made in 2016 by the Croatian Agricultural and Forestry Advisory Service in cooperation with the Center for Marine Research of the Ruđer Bošković Institute (D. Mioković i sur., 2018., Vukovar; https://hgk.hr/documents/vukovar2018-015-miokovic-nova-invazivna-vrsta-u-jadranskom-moruc-oblonga5c470a144bb8c.pdf)

Figure 10. Distribution area of the ascidian tunicate *C. oblonga* in the Mediterranean (Mioković i sur., 2018).

Based on reviews, surveys and interviews with unofficial representatives of production areas and individual shellfish farmers, a list of threats and problems of individual areas was made. Only one shellfish farmer out the survey sent to the representatives of the aquaculture areas. Although the survey and the relevant project activity of Drafting a protocol in the event of an IAS threat under the ARGOS project is in the direct interest of growers, due to their preoccupation with their main business, i.e. shellfish production, they simply ignore such inquiries and communication methods, with individual exceptions, of course. The terrain was inspected several times in the Raša and Lim Bays, where data loggers were installed to measure temperature (0.5 m; Trget, Obrt Dagnja) and temperature/salinity. (0.5, 3, 5, 10, 15 m; Lim, Istrida d.o.o.).

Table 5. Overview of conducted field observations and interviews on the threats present in the shellfish areas in the Region of Istria.

AQUACULTURE AREA	ACTIVITY	CONTACT
Lim Bay Istrida d.o.o.	Field observation, questionary, interview	Emil Sošić
Budava Cincin	Questionary, interview	Ivan Zupičić
Savudrijska vala SARGUS zadruga za proizvodnju i izlov ribe i školjkaša	Questionary, interview	Roberto Cozlovich , Claudio Cozlovich
Medulin Bay R.A.K.	Questionary, interview	Aldo Kočevar
Raša Bay Obrt DAGNJA, MARIDAGNJA	Field observation, interview	Dragan Peić, Dževad Dedić
Vabriga S.K.A.T.	Interview	Toni Stipić

Table 6. Overview of collected data on threats of the shellfish farming areas in the Region of Istria.

AQUACULTURE AREA	COLLECTED DATA AND OBSERVATIONS OF SHELLFISH FARMERS
Lim Bay	*Clavelina oblonga* is present in the production area in the Lim Bay from 2020 until today. The intensity of fouling on mussels (pergolas 1.5 - 2 m long) 60-80%, on ropes and buoys 80% of the surface. No increased mortality was observed. As a result of this threat, it suffers significant damage and undertakes additional cleaning and monitoring measures. Fouling is returned to the sea after cleaning. A related species of flatworm*, Imogine mediterranea*, was also observed in production area in the Lim Bay. Its abundance and biomass for now (2022) does not represent a threat, but only a potential threat that needs to be monitored. As a result of this threat, it does not suffer any significant damage, apart from the more detailed cleaning of mussels before sale, it does not take any additional measures. Among other threats, increased mortality of oysters due to high sea temperatures during the summer, weaker reception of young mussels, increasingly frequent predation of mussels (sea bream >3 kg), and the occasional appearance of jellyfish are the problems. As a result of these threats, it suffers significant damage, and among the measures it implements: increased monitoring of the conditions in the farms, washing of the installation, documenting the sea condition, experimental testing of the mortality of oysters and mussels by depth along with temperature and salinity measurements.
Budava	The tunicate *C. oblonga* was not observed in the mussel production areas. Due to this threat, there is no damage and no action is taken. The related species *Imogine mediterranea* was also not observed in the breeding grounds. Due to this threat, there is no damage and no measures are taken.
Savudrijska vala	The tunicate *C. oblonga* is present in the mussel production area in the Savudrija Bay from 2015 until today. The intensity of fouling on mussels varies, depending on the year and location, 10-50%. No increased mortality was observed. As a result of this threat, there is significant damage and additional cleaning measures are being taken, removing overgrown mussels and monitoring the condition of the breeding areas. Fouling is returned back to the sea after mussel cleaning. The related species *I. mediterranea* was also observed in production area in Savudrijska Vala. Its abundance and biomass for now (2022) does not represent a threat, but only a potential threat that needs to be monitored.

	As a result of this threat, no significant damage was recorded, apart from more detailed cleaning of mussels before sale, no additional measures are taken.
Medulin Bay	C. oblonga was observed in mussel production areas of Medulin Bay - Pomer from the summer of 2020 until today. The intensity of the occurrence is limited to ropes and buoys, infrastructure (20%), and the fouling on mussels (2.5 m long pergolas) is smaller (5-10%). No increased mortality was observed. Due to this threat, apart from more frequent monitoring of the conditions in the farm and more detailed cleaning of mussels before sale, no additional measures are taken. Fouling returns back to the sea after mussel cleaning. The related species *I. mediterranea* has also been observed since 2020. The intensity of its occurrence is limited, here and there one is found in an empty shell when cleaning mussels. As a result of this threat, the cultivation area does not suffer significant damage, apart from more detailed cleaning of mussels before sale, no additional measures are taken. Among the other threats, he cites the appearance of stronger fouling of mussels and oysters with mosses (2015), predation, weak acceptance of fry, and the presence of suspended matter due to construction works.
Raša Bay	The ascidian tunicate *C. oblonga* is present in the production areas in the Bay of Raša from 2020 until today. The intensity of fouling on mussels (pergolas 4 m long), depending on the depth, is 30-80%, on ropes and buoys less. No increased mortality was observed. As a result of this threat, significant damage is suffered and additional cleaning and monitoring measures are taken. Fouling is returned to the sea after cleaning. The related species *I. mediterranea* was not observed in the farms in Raša Bay. As a result of this threat, no damage is suffered, apart from more detailed cleaning of the mussels before sale, no additional measures are taken. Among other threats, occasional intensive predation of mussels by sea bream, various types of fouling and the influence of reduced salinity on the mortality of mussels in the upper part of the pergola due to the inflow of fresh water from the Raša river were recorded. As a result of these threats, more significant damage is suffered, and the measures include increased monitoring of the condition in the farms, washing of installations and documentation of the condition.

Vabriga	*C. oblonga* is present in the mussel production areas - Vabriga from 2020 until today. The intensity of fouling on mussel pergolas and infrastructure depends on the location 30-80%. No significantly increased mussel mortality was observed. As a result of this threat, significant damage is suffered and additional cleaning and monitoring measures are taken. Fouling is returned to the sea after cleaning. The related species *I. medi*terranea was also observed in production area - Vabriga. Its abundance and biomass for now (2022) does not represent a threat, but only a potential threat that needs to be monitored. As a result of this threat, no significant damage is suffered, apart from more detailed cleaning of mussels before sale, no additional measures are taken.

Despite the harmful effects of IAS on the ecosystem, there is also the possibility of their commercial use. We cite an example of an invasive species of blue crab, *Callinectes sapidus*, which recently appeared in the Adriatic, and which, due to its availability, some restaurateurs today offer as a delicacy on the menus of their catering establishments (https://more.slobodnadalmacija.hr/om/ribolov/plavi-rak- threat-to-our-biological-diversity-or-delicacy-1095695). Of course, the hunting and harvesting of IAS species (e.g. jellyfish) requires adaptation of fishing tools and appropriate legal regulations.

In the case of the tunicate *C. oblonga*, there is currently no commercial interest (food, use of biomass), but considering that one of the solutions for its suppression is the prevention of further spread, it is necessary to properly dispose of the waste and returns after cleaning (organized purchase?) and in case cutting mussel pergolas and depositing them on the seabed, it is mandatory to use biodegradable nets.

The presentation of the problem of invasive species in mariculture was made during the 14th trade fair for professional, sport and recreational fishing and mariculture CROFISH 2022 (November 25-27, 2022, Poreč; https://www.more.hr/blog/pocinje-trodnevni -crofish/), as part of the exhibition space (Project – MuMiFaST, IRB, CIM Rovinj) and the lecture "Mitigation of the impact of anthropogenic activities using mussels and technological development of the food supply system - MuMiFaST (BlueBio, HrZZ; Prof. Dr.Sc. Bojan Hamer; ; https://www.crofish.eu/hr/o-sajmu/program-dogadjanja/)" in direct contact with shellfish farmers, employees of county authorities, scientists and visitors, a presentation of recent threats and the possibility of solving problems with the purchase of shellfish after tourist season and the creation of additional value, for example, by the production of "mussel flour" (Figure 11).

Figure 11. The recent threat (*I. mediterranea*) and the invasive species *C. oblonga* present in shellfish farms in the production area of Region of Istria, and the laboratory production of "mussel meal" for the purpose of enriching commercial fish food and conducting experiments on fish (sea bream *Sparus aurata*) for improving the quality of fish growth by feeding with natural food.

Prerequisites for the development of aquaculture are ecological and economic sustainability. The EU pays special attention to the ecological sustainability of aquaculture development, which is generally regulated by Regulation 2000/60/EC of the European Parliament and of the Council on the establishment of a framework for Community action in the field of water policy ("Water Framework Directive" - WFD) and Regulation 2008/56/EC of the Parliament and the Council on the establishment of a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive - MSFD). Aquaculture is extremely dependent on the good condition of the aquatic environment, so in addition to the overall assessment of the condition of the aquatic environment, it is necessary to evaluate possible impacts on its quality.

Food safety: most of these regulations relate to food hygiene during its production, however, when it comes to the production of live bivalves, snails, tunicates and echinoderms, this hygiene package also affects the planning and establishment of the cultivation of these organisms, especially bivalves. For sustainable shellfish cultivation, it is also necessary to ensure continuous monitoring of established parameters in order to minimize the risks to human health. Monitoring refers to product traceability, microbiological quality, the presence of plankton that produces toxins and biotoxins, and the presence of chemical pollutants in relation to Commission Regulation (EC) no. 466/2001.

Collecting data on fisheries and aquaculture is a prerequisite for the successful management of ZRP. The Council Regulation (EC 322/97) on EU statistics provides a reference framework for statistics in the field of fisheries. It particularly requires compliance with the principles of impartiality, reliability, relevance, cost-effectiveness, statistical confidentiality and transparency. Regulation of the European Parliament and the Council (EC 762/2008) on the submission of statistical data on aquaculture by member states and repealing Council Regulation (EC) no. 788/96, the obligations of the member states for the collection and delivery of statistical data on aquaculture were determined.

The National Strategic Plan for the Development of Aquaculture (2014-2020) establishes the goals and priorities of aquaculture development for the period 2014-2020. years. By the end of 2020, the total production in aquaculture is expected to increase to around 45,000 tons, while respecting the principles of economic, social and ecological sustainability. The general goals are to strengthen the social and business-political environment for the development of aquaculture, to increase the national consumption of aquaculture products, as well as to increase employment in aquaculture while contributing to the development of local communities.

The National Strategic Plan for the Development of Aquaculture (2014-2020) as additional priorities for achieving goals foresees the zoning of river basins and sea areas for the cultivation of aquatic organisms, ensuring the appropriate quantity and quality of water for cultivation, determining and implementing protocols aimed at preventing and controlling diseases and benefits of aquatic animals in farming, certification, branding, ecological farming, development of the domestic market, marketing strategies and promotion of aquaculture products, including improving communication with

consumers, diversification of production and introduction of new species in farming, application of ecologically acceptable technologies, protection and compensation for damages from predators, enabling the cultivation of other aquatic organisms, except for fish and shellfish, securing the organisms in cultivation, establishing producer organizations, continuous general education and information of participants in aquaculture while strengthening the role of advisory services, improving the data collection system and improving safety at work. (Regulations on special rules for the organization and implementation of official controls carried out in production areas and areas for re-laying live shellfish NN 82/14).

2.1.2 Design and creating a protocol on how to proceed in the case that the area of interest is affected by the mentioned threats

When devising a protocol on actions to be taken in the event that shellfish farms are affected by the threats in question, for example the recent appearance of the invasive alien species *Clavelina oblonga* Herdman, 1880 in the mussel production areas of the Region of Istria (Majnarić et al., 2022; Hamer et al., 2022), we took into account tje local and public bodies and institutions, taking into account primarily the interests of shellfish farmers. The protocol includes the logical transfer of related information to decision makers regarding reporting, recording and documenting the threat, caused damage, additional costs for the purpose of mitigating the farmers, proposing measures, subsidizing and/or compensation by competent institutions and available funds.

Table 7. Shellfish farmers - unofficial representatives of mussel production areas in the Region of Istria.

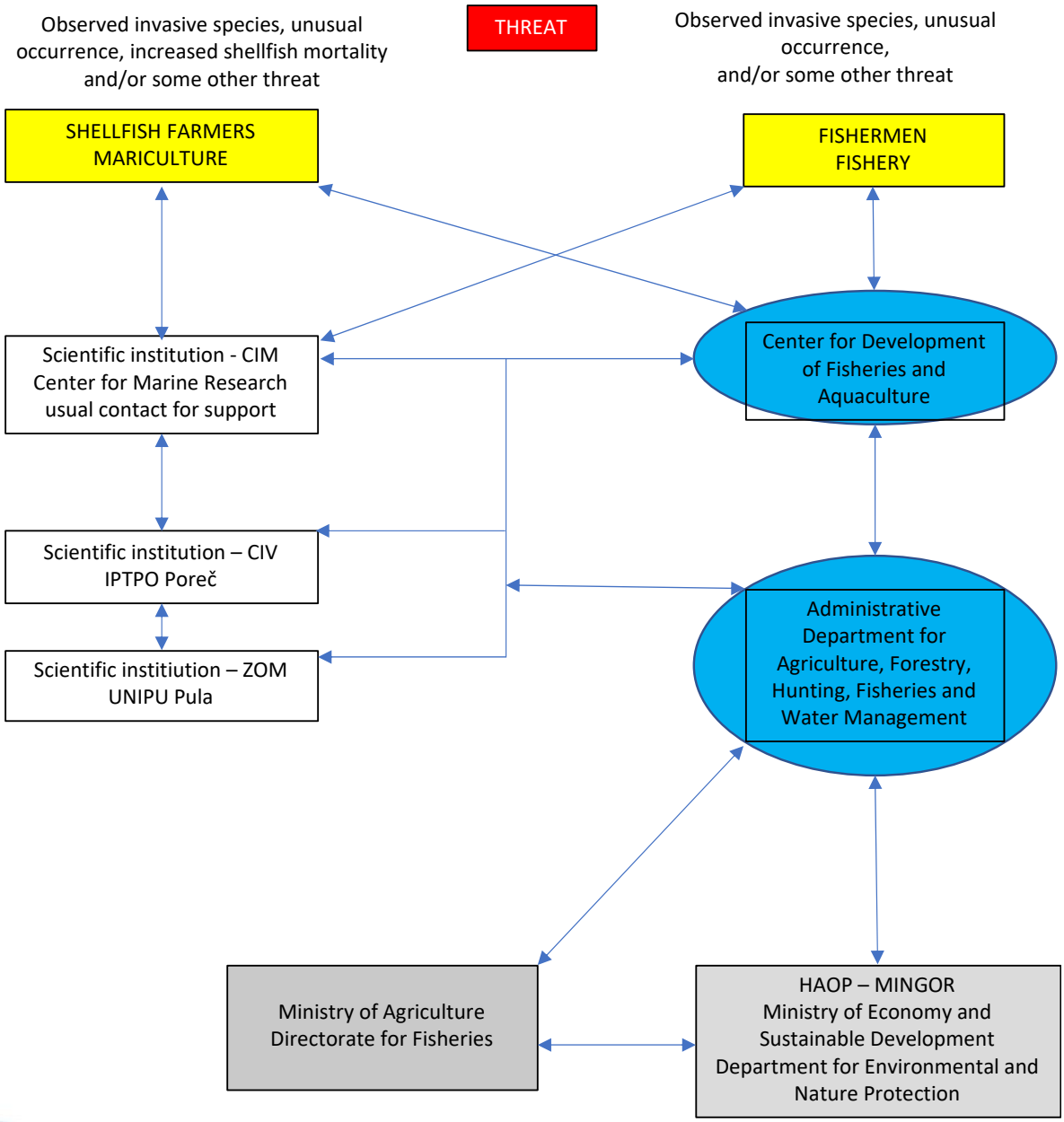
REPRESENTATIVE OF PRODUCTION AREAS	ADRESS	CONTACT
Lim Bay, Istrida d.o.o.	Bruna Valentija 61, 52440 Poreč	Emil Sošić, owner Tel: 091 1200 111 E-mail: emil_sosic@net.hr
Budava, Cincin	Brgod 61, 52224 Trget	Ivan Zupičić, owner Tel: 098 9333 086 E-mail: cincin.zupicic@gmail.com
Savudrijska vala, SARGUS zadruga za proizvodnju i izlov ribe i školjkaša	Vladimira Nazora 6, Umag	Claudio Cozlovich, leader of comunity Tel: 091 2060 564 E-mail: sargus6@gmail.com
Medulin Bay, R.A.K.	Kandlerova 32, 52100 Pula	Aldo Kočevar, owner Tel: 099 3516 945 E-mail: rak.obrt@pu.t-com.hr
Raša Bay, Obrt Dagnja	Kapelica 154, 52220 Labin	Dragan Peić, owner Tel: 091 5144 8833 E-mail: dagnja@hotmail.com
Vabriga, Nivio	Republika 5, Vabriga, 52465 Tar	Nivio Stojnić, owner Tel: 091 5144 8833 E-mail: dagnja@hotmail.com

Table 8. List of cooperating institutions and contacts of the Protocol on actions in the case that the area of interest in the Region of Istria is affected by the mentioned threats in aquaculture.

INSTITUTION	ADRESS	CONTACT
Center for Marine Research (CIM), Ruđer Bošković Institute https://www.irb.hr/Zavodi/Centar-za-istrazivanje-mora	Giordana Paliage 5, 52210 Rovinj	dr. sc. Martin A. Pfannkuchen, head Tel: 052 804 700 E-mail: predstojnik@cim.irb.hr dr. sc. Andrej Jaklin Tel: 052 804 732 E-mail: jaklin@cim.irb.hr dr. sc. Tjaša Kogovšek Tel: 052 804 743 E-mail: tkogovs@irb.hr dr. sc. Bojan Hamer Tel: 052 804 714 E-mail: bhamer@irb.hr
Institute for Agriculture and Tourism, Center for Invasive Species (CIS) http://civ.iptpo.hr/	Karla Huguesa 8, 52440 Poreč	Tel: +385 52 408 304 E-mail: civ@iptpo.hr dr. sc. Danijela Poljuha E-mail: danijela@iptpo.hr dr. sc. Barbara Sladonja E-mail: barbara@iptpo.hr
Department of Marine Biology and Oceanology, Faculty of Natural Sciences in Pula, Juraj Dobrila University of Pula https://fpz.unipu.hr/fpz	Zagrebačka 30, 52100 Pula	Neven Iveša, dipl.ing.bio Tel: E-mail: neven.ivesa@unipu.hr dr. sc. Paolo Paliaga Tel: E-mail: paolo.paliaga@unipu.hr
Center for the Development of Fisheries and Aquaculture of the Istrian County - Centro per lo sviluppo della pesca e dell'acquacoltura della Regione istriana	Luigia Montia 2, 52210 Rovinj	Tel: E-mail:
Administrative departments for agriculture, forestry, hunting, fishing and water management, https://www.istra-istria.hr/hr/ustrojstvo/zupanijski-ustroj/upravna-tijela/upravni-odjel-za-poljoprivredu-sumarstvo-lovstvo-ribarstvo-i-vodno-gospodarstvo/	Matka Brajše Rašana 2/1, 52000 Pazin	dr. sc. Ezio Pinzan, head Tel: 052 351-649 E-mail: poljoprivreda@istra-istria.hr Tel: E-mail:
Region of Istria, https://www.istra-istria.hr/	Dršćevka 3, 52 000 Pazin	Tel: E-mail:
Department for foreign species, Institute for Environmental and Nature Protection,	Radnička cesta 80/7, 10 000 Zagreb	Petra Kutleša, department head Tel: 01/5502-973 E-mail: petra.kutlesa@mingor.hr

Ministry of Economy and Sustainable Development https://www.haop.hr/		
Directorate of Fisheries, Ministery of Agriculture https://poljoprivreda.gov.hr/		Tel: E-mail:

Figure 12. Schematic representation of the Protocol - how to proceed in the case that the area of interest of the Region of Istria is affected by threats in aquaculture.



2.1.3 CONCLUSIONS

- On the basis of the collected recent data for designing and creating a protocol - how to proceed in the CASEt that the area of interest of the Region of Istria (aquaculture) is affected by the mentioned threats, we can conclude that:
- shellfish farms and production areas are most affected by: a) intensive fouling of the mussels by invasive alien species ascidian tunicate *Clavelina oblonga*; b) predation of shellfish by fish - sea bream *Sparus aurata*; c) weak - lack of mussel fry for growth and d) mortality of shellfish, especially the oyster *Ostrea edulis* during summer's high sea temperatures;

- lack of mussel fry for production can be linked to climate change and/or predation of bivalve larvae during the planktonic phase of development, for example, in the Lim Bay, the appearance of an invasive species of sea walnut *Mnemiopsis leidyi*, which feeds on zooplankton organisms, including shellfish and fish;

- data on threats in shellfish farms are few and/or non-existent, because there is no systematic monitoring of them by competent and/or scientific institutions and existing monitoring;

- data on the actual total and production of individual farms are unavailable and unreliable, e.g. Croatia in figures 2021, DZS (https://podaci.dzs.hr/media/fagflfgk/croinfig_2021.pdf);

- shellfish farmers avoid presenting problems on their own or in other production areas to the public, because they are afraid of linking negative information and possible adverse effects on the sale and distribution of their products. There are certainly exceptions, but then information is presented in a targeted manner (e.g. Mr. Emil Sošić, Istrida d.o.o., Lim Bay, The Last shellfish farmer in the Lim Channel, 18 September 2022, https://magazin.hrt.hr/price-iz -croatia/last-shellfish-in-the-Lim-channel-9629824). According to the farmers, this is due to the fact that until now "there was no benefit from newspaper articles and presenting the problem", but also because of the general thinking of the wider community "Until we don't have information - the problem does not exist!". Based on my own experience with trying to raise the problem of *C. oblo*nga fouling in shellfish farms in the Istrian County to a higher level, after it was agreed to publish information (CMR Facebook) and an article was prepared for publication in Glas Istre, everything was withdrawn because some farmers were concerned about the expediency of public disclosure of such information;

- The Administrative Department for Agriculture, Forestry, Hunting, Fishing and Water Management of the Istrian County, through this task within the ARGOS project and beyond, strives to achieve organized support and recording of problems and threats in the Region of Istria.

- Due to various national monitoring and supervision of some of the farms located in the areas of transitional waters (e.g. Lim Bay), no one has any information on what was the actual maximum temperature or minimum salinity value in the shellfish production location - Navi;

- According to the Marine Strategy Framework Directive (MSFD) there is an obligation to monitor invasive alien species (Descriptor D2), but there is no information about the occurrence of IAS

species in shellfish production areas and damage caused. It can be assumed that the problem is in available resources or time-space monitoring scale of that descriptor in general.

2.1.4 RECOMMENDATIONS

1. Try to organize constant supervision and monitoring of the conditions in the shellfish production areas through the newly established regional body, for example the Center for the Development of Fisheries and Mariculture;

2. Financially support, co-finance applied and scientific projects of institutions and bodies in the area of Region of the Istria related to research and development of fisheries and mariculture, monitoring of environmental conditions, monitoring of hazards, unusual occurrences and mitigation of shellfish farmers;

3. Subsidize or make available to growers the necessary devices for carrying out fouling removal measures (e.g. high-pressure washers and diesel power generators for field work); The mentioned high-pressure washers with diesel generators could also be used in the case of intervention-cleaning of the coast from incidental pollution, for example fuel oil pollution of the coastal area of the municipality of Ližnjan (November 13, 2022).

4. In cooperation with farmers, to see which real measures would help them with the mentioned threats and ensure their continued survival on the market;

5. Within shellfish farmers obligations to fulfil REPORT IN AQUACULTURE - SHELLFISH ("očevidnik" periodic data input by farmers), insert a column for reporting invasive alien species and other recorded threats, which would be a simple and valuable source of data at the regional and national level.

6. Definitely, one of the welcome measures is the provision of incentives or compensation depending on the damage caused, i.e. subsidizing and/or compensation by competent institutions and available funds. Based on the example of the recent appearance of the foreign invasive species *Clavelina oblonga*, the problem has existed for 6 years in the territory of the Istrian County, the Administrative Department for Agriculture, Forestry, Hunting, Fisheries and Water Management of the Region of Istria showed an understanding of the situation and co-financed the determination of the types of threats and conducted research on possible natural control measures. In accordance with the Implementation Program of the Ministry of Agriculture for the period from 2021 to 2024 (Annex 1) based on the Act on the System of Strategic Planning and Development Management of the Republic of Croatia (NN 123/2017); 7. Fisheries - Measure: State subsidies in fisheries: "In order to enable sustainable development, various support models are intended for the fisheries sector, both through national funds and through EU funds. State support in fisheries has prescribed strict conditions, criteria, method of allocation and obligation to report. The Republic of Croatia has recognized certain forms of state aid that it believes should be implemented in order to enable the competitive business of fisheries entrepreneurs on the common EU market, but also to reduce certain irregularities. Considering the importance of fishing, aquaculture and fish processing with a large number of users, it is necessary to provide funds for those measures that can be implemented as state support. In accordance with the above, the Ministry of Agriculture, in the part of state subsidies in the fisheries sector, implements subsidies of small value (for the sector of commercial fishing at sea, shellfish and trout farming and

FLAGs) and subsidies within the framework of the collective exemption for damage to the catch caused by dolphins. Additionally, in the coming years, it is planned to send 3 more requests for notification, or approval, to the EC".

2.2 Point 2. Recent threats due to invasive species and unusual occurrences in coastal and offshore waters, i.e. fishing zones of the Region of Istria

Aquatic foods represent about 17 percent of animal protein in human diet globally, and provide employment for an estimated 58.5 million people in primary production alone (FAO; 2022). In 2020, production of aquatic animals was more than 60 percent higher than the average in the 1990s, reaching an all-time record of 214 million tonnes according to the last UN FAO report. The majority, 178 million tonnes, comprise aquatic animals of which the amount destined for human consumption equals 20.2kg per capita. In Croatia, the total fish catch was continuously increasing since the early 2000s and reached a yearly maximum peak in 2014 with more than 71,000 tonnes of total yearly catch (Figure 12). After that, the total annual capture steadily decreased to 53k tonnes and jumped up to 60,283 tonnes in 2020 (FAO fishstat). Of this, the majority of the catch represented small pelagic fish, in particular pilchard. The declining trend in annual fish catch in Croatia is concomitant with the significant increase in the number of fishermen, which more than doubled in 2014 (from 3,535 in 2013 to 7,733 in 2014) due to the shift from the small-scale to commercial fishing and despite the average monthly income being below the average salary in the Republic of Croatia (Mikuš et al., 2014). Despite the low contribution of Croatian fisheries to the Gross Domestic Product (GDP) with a share of 0.2-0.7% (Mikuš et al., 2018), the sector represents a considerable economic and social impact; mostly, it represents an important source of employment in the coast areas and islands where fishing is one of the few activities that provide the source of income throughout the year.

Source: FAO stat

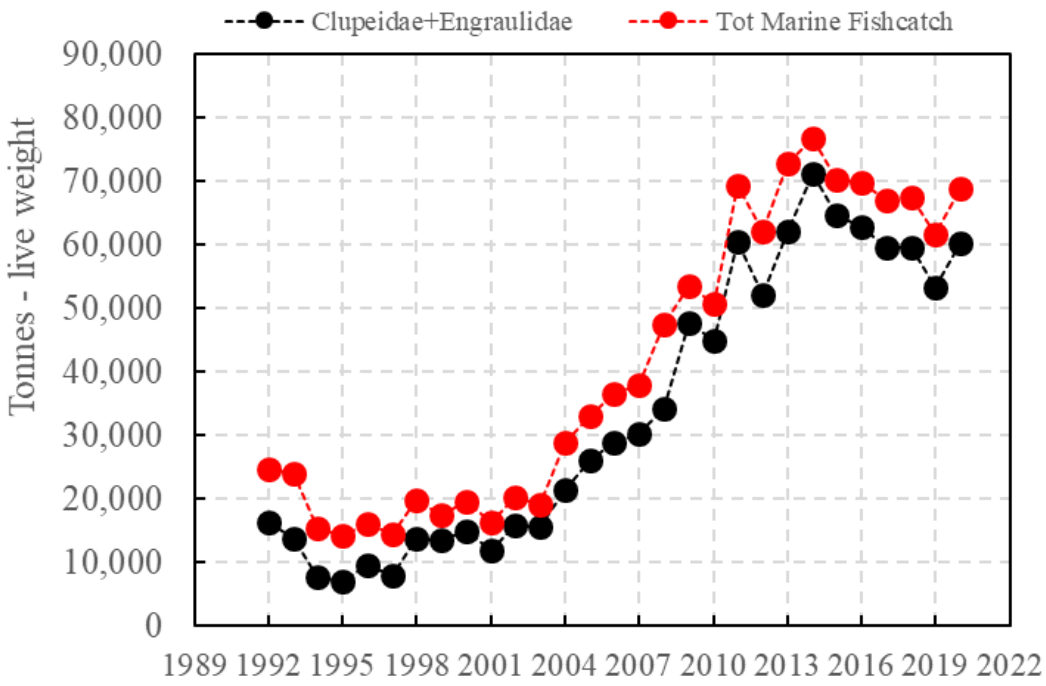


Figure 13. Total Fish catch and contribution of small pelagic fish species (Families Clupeidae and Engraulidae)

According to the last FAO report, the fishery resources continue to decline globally due to various reasons (e.g. overfishing, pollution, etc). Among the rising nuisance for fisheries in some coastal areas worldwide, are jellyfish blooms that are increasing in frequency, intensity and duration (e.g. Brotz, et al., 2012). In the northern Adriatic, such trend has been confirmed for several species over the last decades (Kogovšek et al., 2010; Kogovšek et al., 2018) and were synchronous with drastic changes in the marine pelagic ecosystem recorded in the beginning of 2000s (Mozetič et al., 2012). The devastating effects of the intense jellyfish blooming events over the last decades on the region's economy have been previously evaluated. Palmieri and colleagues (Palmieri et al., 2014) estimated that jellyfish blooms cause an economic loss of up to 8.2 million € per year due to reduction in fish catches for northern Adriatic trawling fleet only, in addition to 460 000€ per year of fuel costs due to displacement of fishing operations and over 89 000 man-hours per year spent by fishermen repairing the damaged equipment. On the other hand, the massive outbursts of the barrel jellyfish (Rhizostoma pulmo) in the early 2000s in the Gulf of Trieste did not reveal a significant impact on the entire Slovenian economy presumably due to the small contribution of the fishing industry to Slovenian GDP; however, the local fishery faced losses due to reduction of fish catch, value added, gross income and sector-related employment (Nastav et al., 2013). The species interfering with the fishing operations were reported by fishermen to all be the native species: the moon jellyfish (*Aurelia* sp.), the compass jellyfish (*Chrysaora hysoscella*), the fired-egg jellyfish (*Cothyloriza tuberculata*), the mauve stinger (*Pelagia noctliluca*), and the barrel jellyfish (*Rhizostoma pulmo*). The studies were conducted before the (re)introduction of the highly invasive ctenophore Mnemiopsis leidyi in 2016 (Malej et al., 2017), whose economic consequences of its impact on the local sea-based operations has yet to be determined. Yet, a recent study shows a clear pattern of avoidance of small pelagic fish (Engraulis encrasicolus) of the areas of massive ctenophore aggregations along the west Istrian coast (Budiša et al., 2021) in addition to competition for food. In contrast, no predation on ichthyoplankton by the ctenophores has been detected by the authors. However, gut content analysis revealed that at least three medusae species in the Mediterranean Sea, the moon jellyfish, the mauve stinger and the barrel jellyfish, consumed fish eggs (Gueroun et al., 2020; Tilves et al., 2016, Leoni et al., 2021). Despite ichthyoplankton may not be jellyfish main food source, it may represent a pressure on already depleted fish stocks. In addition to predation, competition for food act as additional pressure on small pelagic fish.

Gelatinous makroplankton aggregations may have severe impact on pelagic food web structure and functioning and by interaction with fishing activities, tourism and human health present nuisance for coastal-based operations or even cause significant economic loss in some coastal sectors (in fisheries e.g. Palmieri et al., 2014; tourism e.g. Germandi et al., 2015; power plant operations e.g. Chae et al., 2008). Nevertheless, recently it has becoming increasingly clear that jellyfish may also be a valuable resource to humans (Malej et al., 2014). The benefits of medusae as a marine resource are traditionally recognised in Asian cultures. For example, medusae has been traditionally consumed by Chinese for

more than thousand years and are considered as delicacy. In recent decades, consumption of jellyfish has increased and with increasing demand, mostly from Far East countries (China, Japan, Korea), fisheries and aquaculture of edible jellyfish have increased (FAO database accessed in 2021). Several fishing operations that were hampered by recurring jellyfish blooms worldwide, have adopted for, exclusively or additionally in seasons with jellyfish occurrence, fishing medusae (Brotz et al., 2017). In addition to the commodity as a human food, medusae are a valuable source of different compounds. Jellyfish gelatin polypeptides are used as antioxidants, collagens from jellyfish may replace bovine collagens in biomedical and nutraceutical applications, the scyphomedusae venoms possess different pharmacological properties including antitumor activity, jellyfish qniumucin may have disease-modifying effects on osteoarthritis (Malej et al., 2014 and the references therein). Some pilot studies tested jellyfish biomass as potential fertilizer (Fukushi et al., 2004; Seo et al., 2014), nano- and micro-particles adhering filters (Patwa et al., 2015) and even a jellyfish-based plastic material was constructed (Steinberger et al., 2019). Unfortunately, global trends of medusae blooms and causes of population fluctuations still require further rigorous research to clarify trends and enable estimating/predicting jellyfish “stock” material that is essential when implementing a new commercial species.

In the northern Adriatic Sea, the barrel jellyfish is the biggest resident medusa species and its blooms have intensified in frequency and duration over the last decades (Kogovšek et al., 2010). Massive medusae swarms hampering fishing activities in the region have previously been reported (Nastav et al., 2013; Palmieri et al., 2014). In addition, recent studies reviled potential of this edible species in a variety of applications (e.g. Morandini, 2022). Therefore, we selected the barrel jellyfish as case species to investigate the impact of massive aggregations of gelatinous makroplankton on fisheries along the north-eastern Adriatic. In the first step, we perform exhaustive literature search to gather all the available published information on the species biology, distribution and abundance, and coupled it with our data collected over several decades. Next, we investigated the potential impact of jellyfish swarms on artisanal and commercial fishery and t<developed tools fishermen may use to report the jellyfish-caused nuisance/health problems/ economic loss. Finally, we describe the existing protocol of fish catch report and propose an improvement of reporting protocol.

2.2.1 Collection of relevant data on threats, occurrences and invasive species in the area of affected fishing zones

Methodology

Exhaustive literature search was performed to gather all the available published information on the species biology, distribution, seasonal dynamic and abundance in the Adriatic Sea. We coupled the information to fill in missing gaps in our own observations collected over the last two decades. In addition, 120 measures of bell diameter and 120 of wet mass was extracted from our database. For interpretation of the results, we performed a comprehensive literature search and extracted the information on the distribution, abundance and seasonality of the barrel jellyfish.

The geographical range of the barrel jellyfish was determined according to the reports from the citizen science activity launched by CIM IRB in June 2022, the reports from local fishermen and researchers' field observations during CIM IRB ongoing research activities. The received information was validated by an expert and information on species, geographical location and, when possible, an estimation of size and abundance was extracted. In particular, we encouraged local fishermen to regularly send us their observations through a communication group established on the WhatsApp platform. For further analysis, the reports on the barrel jellyfish were extracted and a distribution map containing all georeferenced locations of the species was constructed using a free software Ocean Data View.

The information on the direct impact of medusae blooms on local fishing operations was collected through an anonymous questionnaire in which fishermen reported on the type of the fishing gear they are using, the fishing area, and the species of gelatinous species they are interacting with the most. In addition, the respondents reported on health issues experienced due to jellyfish venoms and gave their personal opinion on the extent on the increase in jellyfish population(s). Finally, we investigated their willingness to include jellyfish as a new commercial species.

Results

Barrel jellyfish (*Rhizostoma pulmo*) - life cycle, reproduction and feeding

The barrel jellyfish is a Scyphomedusa native to the Mediterranean Sea. Medusa bell diameter can reach 50cm and can attain more than 10 kg. Besides its size, this whitish opaque medusa is distinguishable by a purple bell margin and oral arms endings. As common to the Scyphomedusae, barrel jellyfish has a bipartite life cycle, in which a benthic polyp asexually reproduces (in the process called strobilation) to release several free-swimming ephyrae that grow and develop into sexually reproducing medusae. Larva (planulae) release by medusae settles to attach onto a substrate, and metamorphose into a polyp. Polyps are perennial and reproduce asexually to form new polyps (clones), while medusae disintegrate after spawning (estimated medusa life-span is up to around one year). The polyps of this species have never been found in nature and the scarce experiments that exist were performed under laboratory conditions. These experiments revealed that strobilation is enhanced at

higher temperatures (21 and 28°C compared to 14°C), while survival rate of polyps was significantly higher at lower temperature (14°C compared to 21 and 28°C) (Purcell et al., 2012). This result is concomitant with our field observations of ephyrae and metaephyrae in August while young medusae (with bell diameter of less than 10cm) were collected from August to October (Kogovšek, unpublished data). On the other hand, the sexually mature medusae were collected during winter and spring.

Due to its peculiar life cycle, understanding factors driving outburst of population are hard to understand. Several factors may be responsible; however, a recent study analysing more than 7000 records across the Mediterranean Sea uncovered a strong connection of spring temperature with blooms intensity and duration, with warmer springs favouring an earlier start (c. 3 months) and a longer duration (from 5 to 7 months) of jellyfish season (Leoni et al. 2021). On the other hand, the same study revealed that high productivity of the sea was significant only in some regions. Large aggregations of medusae have drastic impact on the pelagic food web. In a Mediterranean lagoon small medusae were predominately feeding on copepods and may consume 5% of the copepods daily standing stock, while medusae larger than 15cm ingested predominately ciliates and fish eggs (Leoni et al., 2022). Thus, the barrel jellyfish may represent not only a predation pressure on, but also a strong competition for food with small pelagic fish to which copepods represent significant source of daily carbon demand (Borme et al., 2009; Borme et al., 2022).

Distribution in the (east) Adriatic Sea, seasonal and interannual fluctuations in abundance

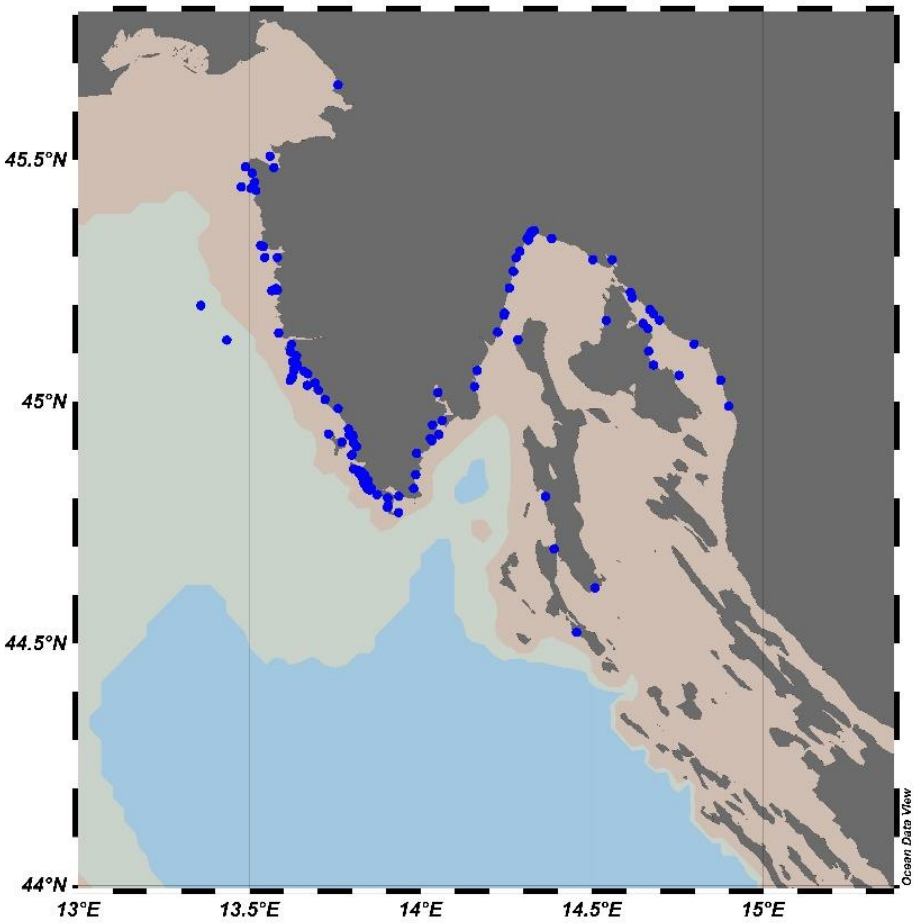


Figure 14. Geographical range of the barrel jellyfish observations during the RBI CMR citizen science activity (4th of June – 31st of August)

In total, there were 812 validated reports received between 4th of June and 31st of August 2022. All reports were from the eastern Adriatic, from Croatia, Slovenia and Montenegro. Of total, 9% were reports of local fishermen and represented >90% of the total offshore reports. Citizens reported on 8 gelatinous species: compass jellyfish (*Chrysaora hysoscella* 41%), fried egg jellyfish (*Cotylorhiza tuberculata* 20%), barrel jellyfish (*Rhizostoma pulmo* 17%), walnut jellyfish (*Mnemiopsis leidyi* 9%) and moon jellyfish, other ctenophores (*Leucothea multicornis*), and the two hydromedusae *Olindias muelleri* and *Aequorea* sp. (together 9%). Less than 2% records reported of no jellyfish and with the similar extent the citizens reported on jellyfish stings. The reports reflected the seasonality of the gelatinous species.

The barrel jellyfish was the third most reported gelatinous species (17%). The species was observed in the Gulf of Trieste, along the west Istrian coast and Kvarner, with the southernmost observation located on Mali Lošinj (Figure 14). There were no reports from the central and south Adriatic Sea during the mentioned period. The observations obtained from the citizen science activity are concomitant with results published by Pestorić and colleagues (Pestorić et al., 2021). According to them, the barrel

jellyfish dominated the gelatinous plankton community in the Gulf of Trieste and the rest of the northern Adriatic, where it was present year-round during the period between 2000 and 2019. In contrast, presence of this species was recorded only during summer and autumn months along the coast of the central and south Adriatic Sea (Figure 15).

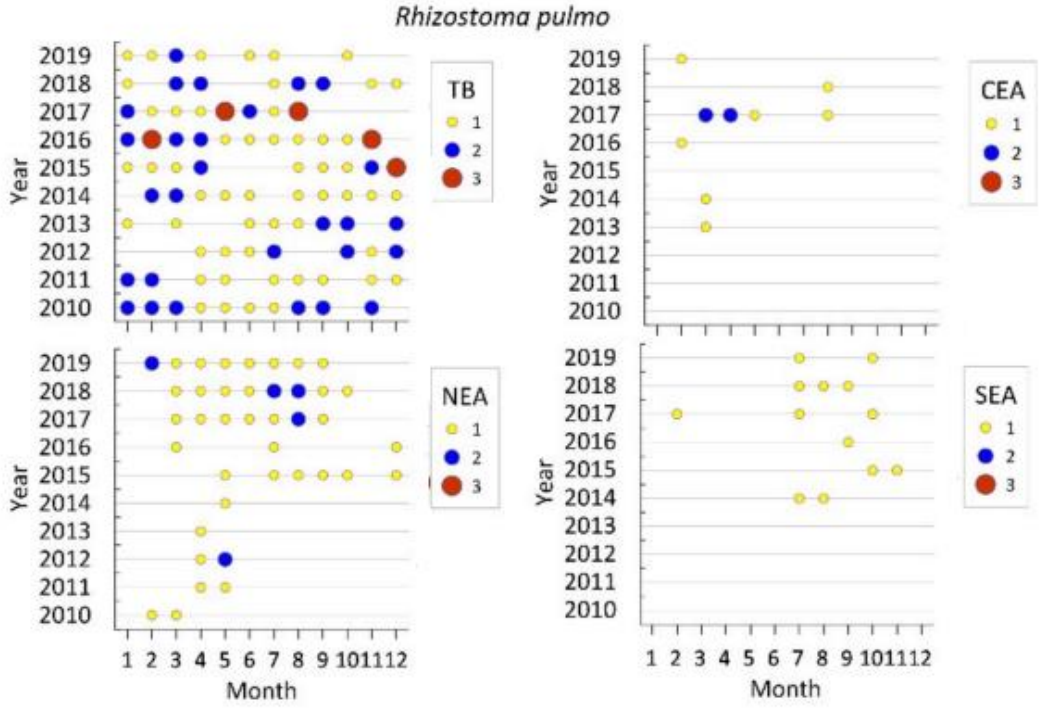


Figure 15. Interannual seasonal variability of the barrel jellyfish along the east coast of the 4 regions: TB – Gulf of Trieste, NEA – Northeast Adriatic Sea; CEA – Central eastern Adriatic; SEA – southeaster Adriatic Sea (Figure extracted from Pestorić et al., 2021 and modified).

According to the authors (Pestorić et al., 2021), the northern part of the Adriatic Sea is the only region in the eastern Adriatic Sea where blooms were recorded. The high abundance during summer was attributed to high numbers of early pelagic forms, i.e. ephyrae and juvenile medusas, while the swarms of large individuals were reported during colder part of the year. Indeed, Nastav and colleagues (Nastav et al., 2013) analysed by-catch of Slovenian trawlers during extensive medusae blooming in 2004 and 2005 and reported highest abundances of the barely jellyfish as by-catch in months from December to April with the maximum abundance of 99.7 – 265x103 ind/km3 in January 2004. For the years 2020 and 2021, we have gaps in the dataset for most of the months (Kogovšek, data not published). However, the large aggregations along the coast of the northern Adriatic Sea were noted by fishermen and researchers, and also reported in the media and on social media. The barrel jellyfish was particularly abundant (equivalent to category 3 in Figure 14) at least in March 2020 and from March to May in 2021, and less abundant in June 2021 (category 1). In 2022 (Kogovšek, data not

published), medusae were reported in all months (January to November) with extensive aggregations from January to May (category 3) and a drastic decrease in abundance in the following months (category 1).

During our citizen science activity during the period between June and August 2022, only single specimens were observed and swarms of medusa were never reported. From the photo and video documentation, we could deduce that the medusa body size was within the uppermost size class and often showed signs of decomposing. These reports are in accordance with the medusa seasonal dynamic reconstructed from the size and wet mass measured on 120 individuals over several years (Kogovšek, data not published; Fig.16). Early pelagic stages (ephyrae, metaephyrae and juvenile medusae) were observed during the warmer months. After that, the medusae size and mass were continuously increasing until late spring when sudden collapse of pelagic population can be observed. Although being numerous during summer months (Fig. 15), their biomass (in terms of wet mass) is negligible compared to biomass of large sized medusae accumulated in extensive swarms during winter and spring (from November to May). We can thus deduce, that during the years of high abundances, the barrel jellyfish may represent a threat for fishing activities from November to May. Unfortunately, the factors responsible for outburst of medusa population(s) are still poorly understood, therefore predictions of blooming years are not possible at the moment. In addition, published data indicate, that the swarms of gelatinous makroplankton is more frequent, prolonged and intensive in the northern Adriatic Sea compared to the central and south Adriatic regions where dense jellyfish aggregations are recorded as sporadic and localised events (Pestorić et al., 2021). Indeed, the severe negative impact of jellyfish blooms on fisheries in the Adriatic region has been identified and reported only for the norther Adriatic Sea (e.g. Nastav et al., 2013; Palmieri et al., 2014).

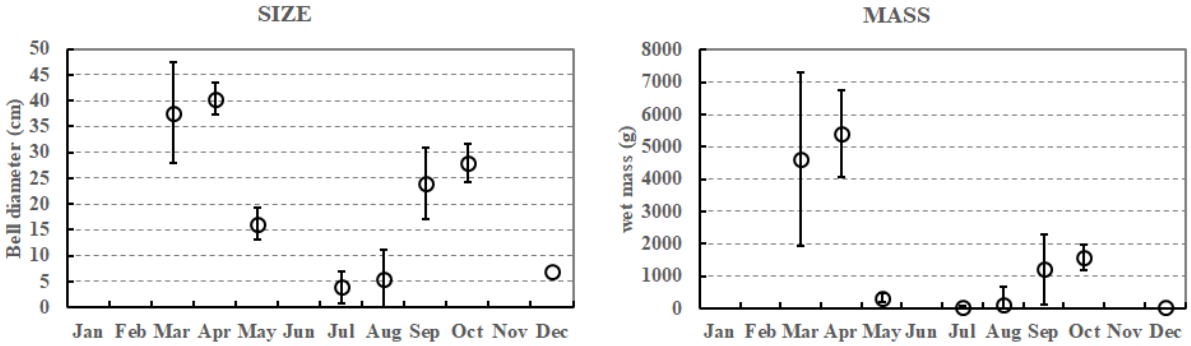


Figure 16. Size (left) and wet mass (right) distribution of barrel jellyfish in different months of the year (average ± standard deviation)

Interaction of jellyfish with fishing operations

Fishermen reports on jellyfish sightings through our communication network

A communication network was established between CIM IRB and a group of fishermen performing the fishing activities along the Istrian coast and Kvarner, for a two-way information transfer. The fishermen

were sending information and photo/video material of jellyfish sightings, while the researchers involved in this activity provided to fishermen information on jellyfish distribution on a weekly base in the form of distribution maps. In addition, fishermen received near-real time information on jellyfish sightings from their colleagues included in the communication network. After three months, a questionnaire was distributed in order to investigate the benefit of such activities to the fishermen, but also to understand the extent of impact their reporting may have on the work performance. Analysing the results, we concluded that all participants agreed that the they benefited from the communication network in two ways; 1.) from the near-real time reports of the colleague fishermen on jellyfish sightings or on the bycatch and 2.) based on distribution maps of gelatinous makroplankton for a certain period, they avoided performing operations in the most impacted areas or even stopped the operation for a certain period. All participants wrote that reporting did affect their work, though only for a short period of time not hampering the entire fishing operation. Overall, there were no suggestions for improvement and they all recommended to continue the collaboration.

We received 9% of the total number of reports from the local fishermen that represented >90% of total offshore reports. Fishermen observed or interacted with 6 different species of gelatinous plankton: the compass jellyfish (*Chrysaora hysoscella*) represented 29.2%, the fried-egg jellyfish (*Cotylorhiza tuberculata*) 27.8%, the barrel jellyfish (*Rhizostoma pulmo*) 16.7%, ctenophores 15.3%, and the moon jellyfish (*Aurelia* sp.) 4.2% of total reports. In 7% of cases they did not observe any gelatinous species. We received no reports on jellyfish stings. Except for the moon jellyfish, all of the reported species were caught in the net (individuals of a single or, rarely, of two species), affecting the fishing operations in some cases (Figure 17).

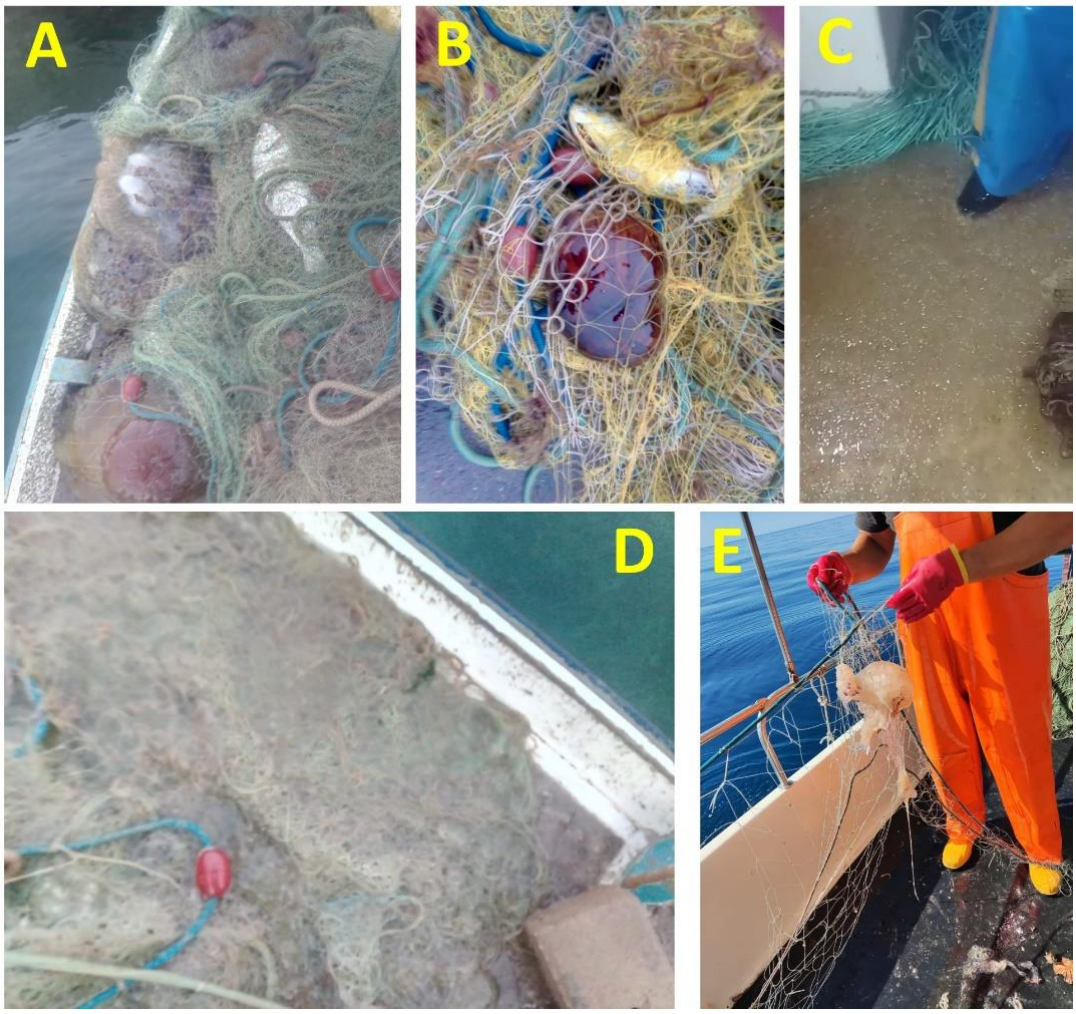


Figure 17. Jellyfish caught in fishing nets A – the fried-egg jellyfish; B – the compass jellyfish; C – Salpa fusiformis; D – the walnut jellyfish; and E – the barrel jellyfish; A, B, D & E from the east coast while C was taken on the west coast of the northern Adriatic Sea; photo kindly shared the affected fishermen.

Current state of reports on fishing operations under the legislative

Currently in the republic of Croatia, both, the catch from the commercial offshore and artisanal fishing operations has to be repoted under the legislative "PRAVILNIK O OBLIKU, SADRŽAJU I NAČINU VOĐENJA I DOSTAVE PODATAKA O ULOVU U GOSPODARSKOM RIBOLOVU NA MORU" (NN 38/2018) issued by the Ministry of Agriculture of Republic of Croatia in 2018. The reports are in the form of logbook filled in and reported for each fishing event, and of a monthly report. Both, commercial and artisanal fishermen, have to fill in a logbook for each fishing event and delivered it to the Directorate of Fisheries (Uprava Ribarstva), which issued the fishing permit, within 48 hours of landing. The information of the catch is inserted for each commercial species separately according to the FAO codes but only if the catch is of 5 kilograms or more, while for those species whose catch is below 5 kilograms, data is entered under the category "other catches" (with some exceptions). If they have fishing effort

and no catch, they have to submit the information with the first next log book when they have a recorded catch. Discarded catch by species has to be recorded as well as the interaction with protected/endangered species. In addition to the information about the catch, also fishing zone (sub-zone) according to GFCM/FAO classification has to be added. The information on daily catch is summarized for each month of the year in a monthly report and submitted to the Ministry before the 15th of the following month.

In total, there are 13 417 species items on the FAO list, however, a list of 114 items has been adopted in the Republic of Croatia. Among them, there are no species of gelatinous makroplankton on the reports list(s) as they are not considered as targeted species. Since each entry in the report sheet is through a selection from a drop-down menu, no information on any other organism can be included. Therefore, the reporting of jellyfish as a bycatch (in the paragraph above we refer to it as "discarded catch") is a completely personal decision of a fisherman. In informal discussions, artisanal fishermen complained that they have no possibility to report on the jellyfish catch and the possible loss they may suffer. Even if information on jellyfish is reported (i.e. written by hand on printed version of the form), the authorities do not consider the remarks on the existing forms nor accept the form as valid. In addition, they complained that they have to submit report for the months they refused to fish due to the persisting jellyfish aggregations along the west Istrian coast, without stating the reason for it.

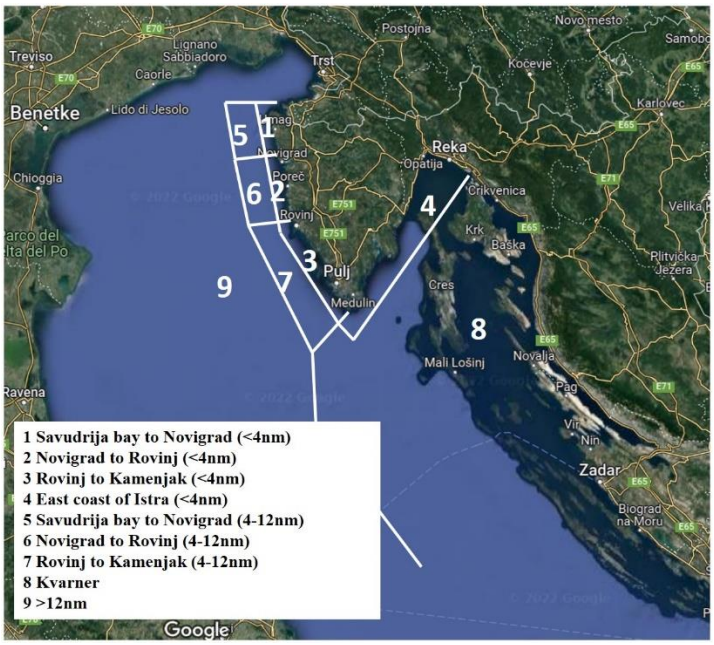
Interaction of jellyfish with fishing activities

In order evaluate the impact of jellyfish blooms on fishing activities, we created a questionnaire and distributed it to the commercial and artisanal fishermen. The 19 questions of the questionnaire were answered by seven active fishermen, who hunt in zones 1 to 7.

Questionnaire

Fishers' perceptions of jellyfish interference with fishing operations (the case of the North-Eastern Adriatic)

1. Please select the general area(s) where you do the most of your fishing



Area(s) number:_____

2. What fishing gears do you use?

3. Of the fishing gears you use, please write the one gear type for which you experience the most problems with jellyfish. If jellyfish never pose a nuisance to you, write NA.

4. What species of jellyfish pose the greatest nuisance to you? (You may check more than one, or none, if jellyfish do not pose any nuisance to you)
    a. None
    b. Barrel jellyfish (*Rhizostoma pulmo*)
    c. Fried-egg jellyfish (*Cotylorhiza tuberculata*)
    d. Moon jellyfish (*Aurelia* sp)
    e. Compass jellyfish (*Chrysaora hysoscella*)
    f. Mauve stinger (*Pelagia noctiluca*)
    g. Crystal jellyfish (*Aequorea forskalea*)
    h. Comb jellyfish (Ctenophorae)
    i. Other
5. In which period of the year the jellyfish pose the greatest nuisance to you? (If more species, link the species to the season)
6. How much of a nuisance are jellyfish to your fishing activity? (0 none – 10 the most)

    1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

7. Do swarms of jellyfish increase your expenses/reduce your revenue? If yes, how?

a. Jellyfish reduce the catch
b. Jellyfish bycatch increases sorting time
c. Jellyfish foul/wreck gear
d. Jellyfish sting captured young fish, which spoils their commercial value
e. Fishing must be relocated to avoid jellyfish swarms;
f. Fishing time must be shortened because of jellyfish swarms
g. Other:_____
h. No, jellyfish do not reduce my revenue from fishing

8. What percentage of your seasonal/yearly (mark) revenue do the cumulative losses from jellyfish represent?
   0%, <5%, 10%, 25%, Other:_____
9. To which entity/office do you report your fish catch?
10. In your reports, do you have the possibility to report on damage/revenue loss? (if yes, specify how)
    a. NO
    b. YES: _____
11. How often are you typically stung by jellyfish or suffer other symptoms related to jellyfish venom while fishing?
    never, daily, weekly, monthly, once every few months
12. If you have been stung by jellyfish while fishing, how painful are the stings? (0 the least to 5 being the most)
    0– 1 – 2 – 3 – 4 – 5
13. Indicate your level of agreement with the following statement:"I see more jellyfish during my fishing now than I did 5 years ago" (1 Strongly disagree; 2 Disagree; 3 Neither agree nor disagree; 4 Agree; 5 Strongly agree.)
    1 – 2 – 3 – 4 – 5
14. To the best of your recollection, what species caused the most nuisance during the last 5 years?
15. Indicate your level of agreement with the following statement:"I see more jellyfish during my fishing now than I did 10 years ago" (1 Strongly disagree; 2 Disagree; 3 Neither agree nor disagree; 4 Agree; 5 Strongly agree.)
    1 – 2 – 3 – 4 – 5
16. To the best of your recollection, what species caused the most nuisance during the last 10 years?
17. If any jellyfish species become commercial I will adapt my fishing activities (and fishing gear) to catch jellyfish. (1 Strongly disagree; 2 Disagree; 3 Neither agree nor disagree; 4 Agree; 5 Strongly agree.)
    1 – 2 – 3 – 4 – 5
18. If easily available on the market, I will include jellyfish in my diet. (1 Strongly disagree; 2 Disagree; 3 Neither agree nor disagree; 4 Agree; 5 Strongly agree.)

1 – 2 – 3 – 4 – 5

19. If you have any additional comments or opinions about any of the above topics or the survey itself, please share them here

_____

Results of the questionnaire

At the moment, seven persons employed in the fishing sector answered the questionnaire. Among them, three are taking part in commercial offshore fisheries (seine nets for pilchards), while 4 are artisanal fishermen using different types of standing nets (regions 1,2,3,5.6,7 on the Figure 18). To all of them jellyfish represent a nuisance, with the barrel jellyfish and ctenophores being the most frequently reported organisms. Among the reported species were also compass jellyfish, moon jellyfish and the fried egg jellyfish. Jellyfish – fisheries interactions were reported for all seasons and the impacted season is strongly related to the seasonality of the reported species. The two most commonly reported species, the barrel jellyfish and the ctenophores were causing nuisance during spring and summer to autumn, respectively. All of them had agreed that jellyfish are more abundant than in the past 5 and 10 years.

On the scale from 1 to 10, the nuisance was on average estimated to be 7.9 (from 5 to 10). The aggregations of jellyfish are reported to: reduce the fish catch, damage or destroy the fishing gear; the bycatch prolong the sorting of the catch, reduce the time of fishing, reduce the quality of caught fish, cause the replacement of the operations to avoid catching the jellyfish and increases the work effort. The estimated impact, in terms of reducing the cost, was between <5% and 25%, most commonly reported (4 out of 7) that jellyfish are responsible of 25% reduction of the seasonal/yearly income. In addition, we identified that jellyfish impacted fishermen health by stinging (4 out of 7 respondents). All of them, with an average score of 3, would adjust their fishing gears and operations to catch gelatinous plankton if any of the jellyfish become a targeted species. The score is higher (4.3) for artisanal fishermen. However, when the fishermen were asked if they would add jellyfish in their diet, the average agreement was low (2.6).

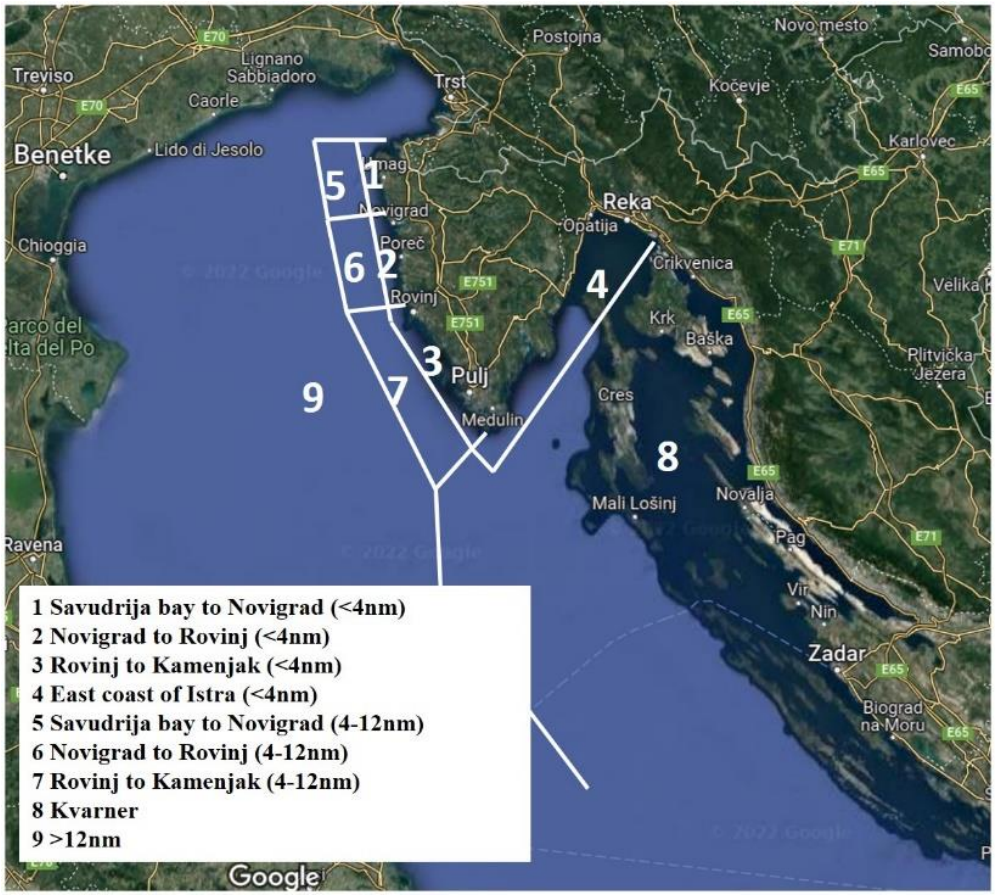


Figure 18. Divisions of the east coast of the east coast of the northern Adriatic Sea into 9 regions, 4 coastal (up to 4 nm off shore), 3 offshore regions (4 to 12 nm off shore), 1 region covered international waters and 1 was attributed to Kvarner area.

2.2.2 Designing and creating a protocol on how to proceed in the case that the area of interest is affected by the mentioned threats

Despite the fact that the negative impact of jellyfish blooms with fishing activities have previously been reported and evaluated in scientific literature and media, and was also confirmed herein through the questionnaire, there is no mechanism available to report the damage/economic loss(es) to the authorities on any scale or form.

Currently, information on fish catch, bycatch, interaction with endangered species, fishing effort, time and location have to be reported in the designed form of the reports and filled in as described in "PRAVILNIK O OBLIKU, SADRŽAJU I NAČINU VOĐENJA I DOSTAVE PODATAKA O ULOVU U GOSPODARSKOM RIBOLOVU NA MORU". The reports are submitted to the Directorate of Fishery and the data is inserted into a national database. The forms of both are precisely structured in the way to include all the before mentioned parameters. The total per specie catch has to be filled separately, choosing from a drop-down menu consisting of adopted FAO list of 114 items which include exclusively commercial species. No other information can be included.

Based on our results, we propose to modify the current reporting protocol as follows:

1. the reporting forms should be modified in order to enable gathering information on previously identified threats on a local or a national scale (e.g. jellyfish present a threat only on a local scale, i.e. the northern Adriatic) and retain the current communication paths between the two end parties, or

2. to include an administrative body of a regional government as a communication intermediary responsible for identification, monitoring and data collection on possible threats at a local level. For this purpose, it is necessary to develop and implement additional reporting tools.

As for this, we propose the Istrian County with its Centre for the Development of Fisheries and Aquaculture as the intermediary, and jellyfish blooms as the threat to fishing activities identified as a characteristic of the northern Adriatic Sea.

2.2.3 Conclusions

1. The barrel jellyfish is a native Scyphozoan species to the Adriatic Sea and recurring blooming events have been recorded only for the northern Adriatic. Therefore, the jellyfish impact on coastal human activities is of a reginal significance.

2. The medusa stage is present in the water column all year-round with largest biomass recorded during winter and spring. Significant interannual fluctuations of medusa abundance and biomass have been identified. Unfortunately, the factors responsible for the outburst of medusa population(s) are still poorly understood and to date unpredictable.

3. Swarms of the barrel jellyfish have been reported from several coastal areas in the Mediterranean Sea. Nevertheless, to our knowledge, it was never identified as an invasive species. Despite this fact, the barrel jellyfish has been identified as a potential threat to the fishing sector in the northern Adriatic Sea, particularly during the years of prolonged and intensive blooms. Indeed, it has been also reported by the local fishermen as the species that most commonly interacted with the fishing activities. Large swarms may reduce the yearly income by up to 25%, by reducing the fish catch, damage or destroy the fishing gear, prolonging the sorting of the catch, reduce the time of fishing, reduce the quality of caught fish, cause the replacement of the operations to avoid catching the jellyfish and increase the work effort. In addition, due to its toxins, it may cause health problems to the fishermen in close contact with these gelatinous organisms. Despite the nuisance identified by the researchers in the past and reported various times in the local and national media, there is no tool set in practice to enable reporting of the impact(s) of the blooms on the fishing operations to the authorities.

4. To date, about 40 species of jellyfish are commercially fished for food purposes (Edelist et al., 2021). However, until 2020 when FAO categories of commercial species were updated to include two items referring to jellyfish, the catch of gelatinous species was mainly listed under “other marine invertebrates”. According to the national reports (summarized in Edelist et al., 2021), there is an increasing trend in world jellyfish catch, particularly from 2016 on, when it reached 900 000t/y. It is important to note, that, according to our investigation, there is a strong interest among local fishermen to adjust their fishing strategies to fish jellyfish if any become targeted species. Yet less intention to change dietary habits was expressed.

5. The barrel jellyfish is the most reported species interacting with fishing activities. However, other species of gelatinous plankton have been, recurrently or sporadic, forming blooms during the last decades and identified within this study to cause nuisance to the local fisheries. Our citizen science approach proved to be an efficient tool to obtain data on seasonality and distribution of gelatinous plankton. Based on the numerous high-quality reports, distribution maps were constructed and communicated to the local fishermen, who adjusted their fishing strategy according to the near-real time reports on observations.

2.2.4 Recommendations

From the information gathered herein, we provide with the following recommendations:

1. **Threat(s) to fishing activities should be identified locally.** For example, through continuous flow of communication between several parties, efficient and simple reporting protocol or through meticulous monitoring programme.

2. In the next step, **collection of data** is essential to understand the type, extent and intensity of the possible threats. This can be achieved with regular **reporting and monitoring programmes**. Within this case study we concluded, that despite the nuisance identified by the researchers in the past and reported various times in the local and national media, there is no tool set in practice to enable the reporting of the impact(s) of the jellyfish blooms on the fishing operations to the authorities. Consequently, no data exist to evaluate the economic losses due to the jellyfish blooms in the region and its impact on the local economy.

3. In addition to **a monitoring system** that provide data on biology and ecology of the invasive species (or any other threat previously identified on a local scale), its distribution and estimation of the extent of its impact on the sector on the long term, **an early warning system**, would enable adaptations of the operations on a shorter time scale. We show here, a case study of an early warning programme based on an efficient and low-cost data collection and data process by involving citizens, to collect data on jellyfish presence and distribution.

4. Based on the meticulously collected information, **measurements of mitigation/prevention may be adopted locally**. One of the proposed mitigation strategies, is **the commercial exploitation of the invasive species**. As we show here, jellyfish show prominent potential in a wide range of uses, including for human consumption. In this context, collecting data on gelatinous plankton on a long term will enable the identification of interannual variability on a basin scale and evaluation of the stock potential for commercial exploitation. Establishing jellyfish fishing activities in the region, would benefit local community in terms of employment and (blue) economy.

3. FINAL CONCLUSION AND RECOMMENDATION

The Region of Istria, as a project partner, participates in the implementation of the ARGOS project - "shARed GOvernance of Sustainable fisheries and aquaculture activities as leverage to protect marine resources in the Adriatic sea" as part of the cross-border cooperation program INTERREG V-A Italy - Croatia. In order to promote a joint integrated approach in the protection of fish and marine resources and to improve the quality conditions of the marine environment and to strengthen the decision-making process based on knowledge as a solid basis for every decision and a common management framework with activities for the general harmonization of the assessment of fisheries and aquaculture data in the area The Adriatic Partnership proposes a National - regional protocol for establishing a common approach and coordinating data collection (Figure 19).

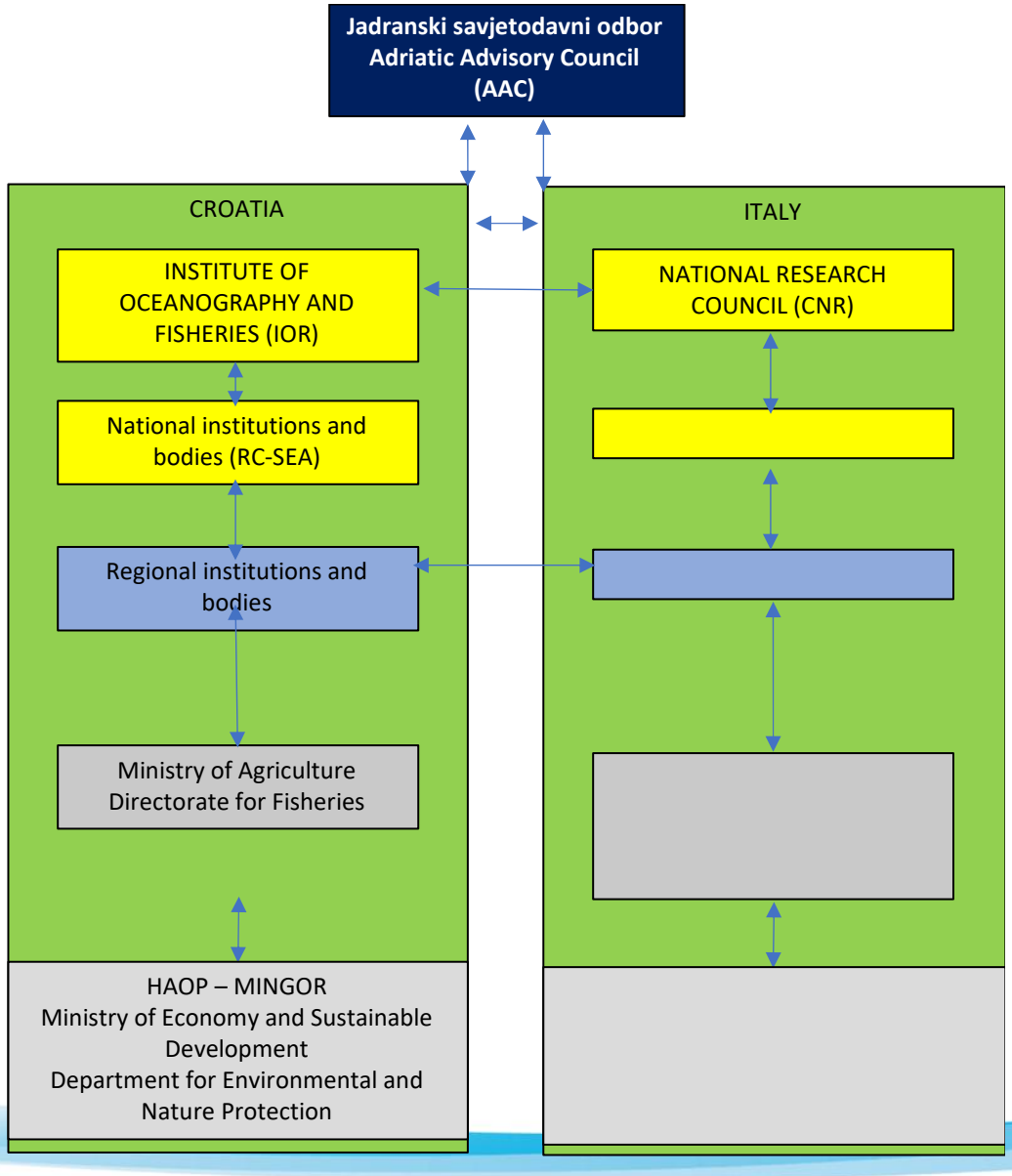


Figure 19. Schematic representation of the proposal of the National-Regional Protocol - how to proceed in case the area of interest is affected by the subject threats (IAS) for the Adriatic, which includes national institutions - coordinators (Croatia - IOR Split and Italy - CNR) and the Adriatic Advisory Committee (AAC), an expert body established at the level regions with representatives of project partners for the purpose of shared management of sustainable fisheries and aquaculture as a means of protecting marine resources.

Recommendation:

Due to the importance of national and regional management of sustainable fisheries and aquaculture as a means of protecting marine resources, it would be useful for the AAC "Adriatic Advisory Council" as an expert regional body with representatives of the ARGOS project to continue working even after the end of the project.

4. LITERATURE

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5. SUPPLEMENTS

Supplement 1.

Implementation program of the Ministry of Agriculture for the period from 2021 to 2024

Izrada Provedbenog plana obveza je svih tijela državne uprave na temelju *Zakona o sustavu strateškog planiranja i upravljanja razvojem Republike Hrvatske* (NN 123/17).

Provedbeni plan Ministarstva poljoprivrede od 2021. do 2024. godine sadržava 69 mjera koje za cilj imaju pružiti odgovore na izazove i razvojne potrebe iz 8 područja što je prikazano u Tablici 1.

Tablica 1: Pregled Područja izazova i razvojnih potreba i Broja mjera Provedbenog plana Ministarstva poljoprivrede RH, KLASA: 400-05/20-01/18, URBROJ: 525-06/0119-20-1 od 16. studenog 2020.

Red. br.	Područje izazova i razvojnih potreba	Broj mjera
1	Poljoprivredno zemljište, biljna proizvodnja i tržište	12
2	Potpore poljoprivredi i ruralnom razvoju	5
3	Stručna podrška razvoju poljoprivrede i ribarstva	5
4	Veterinarstvo i sigurnost hrane	9
5	Šumarstvo, lovstvo i drvna industrija	6
6	Poljoprivredna politika, EU i međunarodna suradnja	4
7	Ribarstvo	9
8	Stočarstvo i kvaliteta hrane	19
Ukupno:		69

7. Ribarstvo

U cilju uspostave ribarstvene politike u skladu sa zahtjevima Europske unije, i obzirom na potrebu jačanja konkurentnosti ribarskog sektora na zajedničkom tržištu EU, kroz program Ribarstvo predviđena su financiranja glavnih aktivnosti kako bi se postigli navedeni ciljevi. Pravna stečevina EU u dijelu ribarstva obuhvaćena je kroz Zajedničku ribarstvenu politiku EU koja sadrži: upravljanje resursima i flotom, nadzor i kontrolu, tržišne mjere, fondove EU i državnu potporu u ribarstvu, Održivo gospodarenje ribljim resursima temeljna je odrednica politike ribarstva koja je uređena odgovarajućim zakonodavnim okvirom. Cilj održivog upravljanja živim bogatstvima jest postići odgovorno i održivo iskorištavanje ribljih resursa na ekološki uravnotežen te gospodarski i društveno opravdan način kroz mjere za zaštitu, očuvanje i obnovu resursa i eko-sustava. Održivo upravljanje i financiranje sektora kroz navedene modele usko je vezano te se nadopunjuje. Mjere očuvanja i upravljanja se moraju zasnivati na najboljim dostupnim znanstvenim spoznajama i osiguravati dugoročnu održivost podjednako ribljih resursa kao i djelatnosti ribarstva te je stoga neophodan učinkovit sustav

prikupljanja podataka o stanju resursa i ribolovnim aktivnostima. Također, održivo gospodarenje ribljim resursima nije moguće bez učinkovitog sustava nadzora i kontrole kroz rad inspekcijskih službi i sustav satelitskog praćenja plovila. Uspostava funkcionalnog i odgovarajućeg sustava satelitskog praćenja plovila (VMS) u sklopu Ribarskog monitoring centra jedna je od značajnijih aktivnosti u procesu prilagodbe u okviru Zajedničke ribarstvene politike EU.

Mjera: Praćenje biološkog bogatstva mora

Republika Hrvatska dužna je sukladno Uredbama EU prikupljati i dostavljati podatke u okviru Nacionalnog programa prikupljanja podataka, a što se odnosi na ekonomske, socijalne i biološke podatke u svim segmentima ribarstva i akvakulture. Biološke podatke za Nacionalni program prikuplja i obrađuje Institut za oceanografiju i ribarstvo s kojim MP svake godine na temelju Zakona potpisuje ugovor sukladno Nacionalnom programu prikupljanja podataka. Kako je ovo mjera unutar Operativnoga programa za pomorstvo i ribarstvo 2014.-2021. godina (OPPiR) dio od planiranih sredstava se refundira od strane EK u omjeru 80% EK, 20% RH. U novome programskom razdoblju 2021.-2027. godina omjer financiranja biti će vjerojatno povećan i iznositi će 85% od strane EK, no Uredba o EMFF-u je u postupku donošenja te će se konačni postotak tek znati nakon donošenja nove Uredbe. S obzirom da su podaci temelj za donošenje mjera naročito u dijelu upravljanja nacionalnim resursima, provedba ove aktivnosti pozitivno će utjecati na okolišno održivo, resursno učinkovito, inovativno, konkurentno i na znanju utemeljeno ribarstvo i akvakulturu.

Mjera: Državne potpore u ribarstvu

Za omogućavanje održivog razvoja, sektoru ribarstva namijenjeni su različiti modeli potpora, kako putem nacionalnih sredstava, tako i putem EU fondova. Državna potpora u ribarstvu ima propisane stroge uvjete, kriterije, način dodjele i obvezu izvještavanja. Republika Hrvatska prepoznala je određene oblike državnih potpora koje smatra da bi trebalo provoditi kako bi se omogućilo konkurentno poslovanje poduzetnika u ribarstvu na zajedničkom tržištu EU, ali i kako bi se smanjile određene nepravilnosti. **S obzirom na značaj ribolova, akvakulture i prerade ribe sa velikim brojem korisnika nužno je osigurati i sredstva za one mjere koje je moguće provoditi kao državna potpora. Sukladno navedenome, Ministarstvo poljoprivrede u dijelu državnih potpora u sektoru ribarstva provodi potpore male vrijednosti (za sektor gospodarskog ribolova na moru, uzgoj školjaka i pastrva te FLAG-ove) i potpore u okviru skupnog izuzeća za štete na ulovu koju čine dupini**. Dodatno, tijekom narednih godina planira se EK uputiti još 3 zahtjeva za notifikaciju, odnosno odobrenje.

Mjera: Operativni program ribarstva

Republika Hrvatska kroz OPPiR 2014.-2020. godina dobila je na raspolaganje ukupno oko 352 mil EUR-a. OPPiR-om predviđeno je 36 mjera te su pokriveni svi segmenti ribarstva od uzgoja i ulova do stavljanja na tržište i prerade proizvoda ribarstva. Također, ovim fondom EU obuhvaćene su i mjere financiranja nadzora i kontrole te prikupljanja podataka. Kao najznačajnija mjera izdvojeno je financiranje ribarskih luka i iskrcajnih mjesta kojima bi se riješio dugogodišnji problem veza i iskrcaja. Ministarstvo poljoprivrede do sada je raspisalo veliki broj Natječaja iz OPPiR-a, za koje će dio plaćanja biti u narednim godinama, a uzimajući u obzir pravilo N+3. Točnije, do sada je raspisan 39 Natječaj za

19 mjera OPPiR-a. Rezultati provedbe su već sada vidljivi, a do kraja provedbe mjera unutar OPPiR-a planira se izgraditi/modernizirati/opremiti ukupno 20 ribarskih luka, 30 uzgajališta ribe i 15 pogona za preradu proizvoda ribarstva i akvakulture.

Supplement 2.

An example of a questionnaire about recent threats in mariculture supplemented with data collected through interviews (Istrida d.o.o., shellfish farm in the Lim Bay).

	**Limski zaljev** Istrida d.o.o., Bruna Valentija 61, Poreč Trgovina na veliko ostalom hranom uključujući ribe, rakove i školjke Vlasnik Emil Sošić Limski zaljev, Utorak, 19.10.2022.

1. **Prikazan tunikat *Clavelina oblonga* primijećen je na uzgojnom području Limskog zaljeva:**
   - Od ljeta 2020., tu i tamo
   - Od 07.2020. do danas 10.2022. godine.
   - U velikom broju 2021. i 2022., npr. u uvali Navi manje 2022, uslijed pranja povrata visoko tlačnom pumpom.

2. **Da li zbog njegove prisutnosti trpite štetu prilikom uzgoja dagnji – kamenica:**
   - Intenzitet njegove pojave na konopima i bovama (infrastruktura, 80%),
   - Intenzitet obraštaja na dagnjama (2 m pergolari, 2020-21., 1.5 m pergolari 2022.) je manji (60-80%, kako koja uvala), nije primijećena povećana smrtnost, iako postoji kompeticija za hranu i resurse,

3. **Da li zbog njegove prisutnosti poduzimate neke mjere:**
   - Stalno praćenje stanja na uzgojnim lokacijama, i prilikom čišćenja dagnji pred prodaju, posvetili smo dodatnu pažnju i vrijeme na stanje obraštaja i prisutnost ove vrste *I. mediterranea*,
   - Na lokacijama sadnje dagnji, prije sadnje sva oprema i infrastruktura je oprana minivošom!
   - Obraštaj se prilikom čišćenja vraća nazad u more.

4. **Po Vašem mišljenju koja mjera ili uređaj bi Vam najviše pomogla vezano za smanjivanje štete uzrokovane obraštajem ove invazivne vrste tunikata:**
   - Visokotlačna pumpa na morsku vodu s dizel agregatom na kotačima, tako da se može seliti po uzgajalištima-uzgojnim područjima na području IŽ

5. **Da li ste možda primijetili ovu vrstu plošnjaka *Imogine mediterranea* - predatora koji se hrani između ostalog i dagnjama-kamenicama:**
   - DA 2020 godine, negdje u isto vrijeme zajedno s tunikatom *C. oblonga*,
   - Od 07.2020. do danas 10.2022. godine,
   - 5-9 mjesec 2021. baš ga je bilo puno tijekom intenzivnog obraštaja *C. oblonga*
   - Ovaj vrsta ili možda neka slična poznata je u uzgajalištima dagnji u Sjevernom Jadranu (Istra) kao *Planaria*. Emil se sjeća kad je bio mali Stari uzgajivači su govorili „nedaj bože da se pojavi Planaria crv to je opasno“, u Limskom zaljevu kod barake postoji lokacija blizu izvora slatke vode gdje su uzgajivači smještali pergolare s školjkašima na tretman obraštaja i svega drugog…

6. **Da li zbog njegove prisutnosti trpite štetu prilikom uzgoja dagnji – kamenica:**
   - Intenzitet njegove pojave je ograničen, tu i tamo se nađe u praznoj ljušturi prilikom čišćenja konzumnih dagnji,
   - Ili spadne s pergolara prilikom presađivanja – manipulacije,
   - Jednoga uhvatio radnik prilikom intervjua kako pliva među pergolarima kod barake
   - nije primijećena povećana smrtnost (možda 1%), iako se hrani dagnjom, oslabljenom dagnjom uslijed jakog obraštaja *C. oblonga*,
   - njegova brojnost i biomasa za sada 2022. ne predstavlja ugrozu, već samo potencijalnu prijetnju koju treba pratiti.

7. **Da li zbog njegove prisutnosti poduzimate neke mjere:** DA
   - Praćenja stanja u uzgajalištu
   - Pranje instalacija
   - Eksperimentalna testiranja smrtnosti kamenica i dagnji po dubinama, mjerenje temperature i saliniteta, pranje poša i praćenje novog obraštaja
   - Evidentiranje i dokumentiranje stanja

8. **Po Vašem mišljenju koja mjera ili uređaj bi Vam najviše pomogla vezano za smanjivanje štete uzrokovane obraštajem ove invazivne vrste plošnjaka:**
   - Uređaj za čišćenje, tunelskog tipa za pranje pergolara pod 360 stupnjeva
   - Prezentacija problema i diskusija uzgajivača o svim ugrozama, od obraštaja, invazivnih vrsta do klimatskih promjena tijekom npr. CROFISH sajma ribarstva Poreč
   - Isprobavanje mjera na terenu u uzgajalištima i laboratoriju

9. **Da li ste možda primijetili neku novu prijetnju ili povećanu smrtnost dagnji - kamenica na vašem uzgojnom području npr. neuobičajene visoke temperature mora tijekom ljeta, pozitivne analize na toksine (fitoplankton), bolesti uzrokovane parazitima, bakterijama i/ili virusima:**
   - Veći mortalitet naročito kamenica uslijed visokih temperatura mora
   - Postoji problem sjemena – prihvata mlađi dagnji, zadnjih godina prihvat je puno slabiji, konopi su „zeleni“ (alge), a inače crni od prihvata, mogući uzrok tome je predacija od strane orada ili invazivne vrste rebraši 2021 i 2022 bilo ih je puno, brdo!
   - Predacija je problem i u mojem uzgajalištu, 09.2022. orada pojela konzumnu dagnju, po ostacima kamenica na konopima (ugriz) vidljivo je da su to bili primjerci >3 kg.
   - Limski zaljev je posebni rezervat u moru. Problem suživota uzgojnih područja s sve intenzivnijim turizmom, ulaskom brodova u Limski zaljev, povremeno nakon kiša ili incidenata, (koliformne bakterije) nužno je napraviti purifikaciju dagnji,
   - DA, uzgojno područje je pod stalnim redovitim godišnjim inspekcijskim nadzorom na tri točke (Veterinarski institut Rijeka, Veterinarski centar Poreč – uzorkovanje). Podaci su nedostupni uzgajivačima, vlasnik podataka Ministarstvo. 1 kg *E. coli* (svaka 4 tjedna), 3 kg biotoksini (svaki prvi ponedjeljak u mjesecu)
   - Uzgajivači u Istri osim uzgoja vrše i funkciju otpremnih centara.
   - Od 01.01.2023. ako 2x uzastopne ne odgovaraju koliformne bakterije – zona B, reklasifikacija uzgojnog područja?

10. Da li zbog tih pojava trpite štetu prilikom uzgoja dagnji – kamenica: DA

11. Da li zbog tih pojava poduzimate neke mjere: DA
    - Praćenja stanja u uzgajalištu, pranje instalacija, dokumentiranje stanja
    - Eksperimentalna testiranja smrtnosti kamenica i dagnji po dubinama, mjerenje temperature i saliniteta, pranje poša i praćenje novog obraštaja

12. Da li bi bili voljni sudjelovati - surađivati s IRB CIM Rovinj (B. Hamer) u besplatnom praćenju temperature - saliniteta morske vode te drugih parametara po dogovoru na lokalitetu od vašeg izbora na vašem uzgojnom području putem postavljanja data loggera i praćenja vitalnosti **dagnji-kamenica**?
    - DA, Praćenje smrtnosti i rasta kamenica novim tehnikama (vješanje) vs poše,
    - Pošto dosadašnjim praćenjem nije utvrđen plaštenjak *C. oblonga* van uzgojnih područja, provjeriti stanje u uzgajalištu kod Poreča Čivran koje jedino nije uvala-zaljev 100 m od obale vs uvala Saline gdje je obraštaj i plošnjak bio intenzivno prisutan tijekom 2021/22.

Supplement 3.

An example of cooperation and actions in the case of unusual occurrences - problems in shellfish farming areas in the Region of Istria.

Uzgajalište školjkaša Istrida d.o.o. vl. Emil Sošić	**Znanstvena institucija - Javna institucija** Institut Ruđer Bošković, Centar za istraživanje mora Rovinj
1. Radnik primijetio problem u uzgajalištu: - intenzivan obraštaj koji guši dagnje i opterećuje infrastrukturu 2. Potreba za stručnim mišljenjem i znanstvenim podacima o ugrozi (voditelj) 3. Kontaktiranje i traženje potpore-mišljenja lokalne znanstvene institucije o pojavi nove ugroze (vlasnik)	
	4. Upit prima sekretarica koja o tome obavještavaju predstojnika Zavoda 4.1. Predstojnik Zavoda nakon obzirom na vrstu problema (biologija, kemija, fizika, ekotoksikologija) prosljeđuje informaciju stručnjaku za to područje (obraštaj - to je područje biologije mora)
4.1.1. Nakon kontakta telefonom slijedi dostava slika i opis stanja (voditelj)	
U slučaju plaćanja usluge, uzgajalište-naručitelj usluge šalje zahtjev i traži od Institucije ponudu	Za uzgajališta s kojima postoji suradnja, Institucija ne naplaćuje uslugu, te se to obavlja besplatno
	4.2. Stručnjak – znanstvenik razmatra vrstu ugroze, te kontaktira uzgajivača i dogovara terenski uviđaj
5. Terenski uviđaj (voditelj, radnik, znanstvenici) - Pregled uzgajališta, - Foto i video dokumentiranje, - Mjerenje osnovnih oceanografskih podataka	
	6. Analiza na terenu (znanstvenik-stručnjak) - Ukoliko se već radi o poznatoj ugrozi, uzročnik problema se brzo identificira. U ovom slučaju dagnje na pergolarima su obrasle invazivnom vrstom plaštenjaka Clavelina oblonga, čija je pojava prethodno već zabilježena u uzgajalištima u Savudrijskoj vali.
7. Uzorkovanje obraštaja - jedinki invazivne vrste plaštenjaka za proučavanje u laboratoriju (znanstvenik)	
	8. Osmišljavanje ekološko prihvatljive mjere za suzbijanje obraštaja, a da se ne našteti školjkašima biolozi - ekotoksikolozi - oceanografi (znanstvenici u višim zvanjima) - Design laboratorijskog pokusa izlaganja plaštenjaka nižim salinitetima (100, 75, 50 30%) morske vode kroz 14 dana uz dodatnih 14 dana oporavka na 100% morskoj vodi
	9. Postavljanje pokusa (14 izlaganja +14 dana oporavak) - dnevno praćenje promjena na organizmima, hranjenje planktonom, provjera saliniteta, fotodokumentiranje, vaganje, uzimanje hrane… (tehničari, stručni suradnici, doktorandi)
	10. Obrada rezultata (znanstvenici-stručnjaci) - izrada tablica i slika - pisanje izvještaja o mogućim mjerama suzbijanja intenzivnog obraštaja školjkaša u pogođenom uzgajalištu
	11. dostava izvještaja odgovornoj osobi uzgajališta (sekretarica)
12. Primjena predloženog suzbijanja obraštaja *in situ* u uzgajalištu (radnik, voditelj uzgajališta)	
13. Nakon provedenog tretmana davanje povratne informacije o uspješnosti načina suzbijanja obraštaja (voditelj, vlasnik)	
	14. Traženje suglasnosti uzgajivača za objavu rješenja predmetnog problema putem javnih medija (znanstvenici)
15. Davanje suglasnosti DA-NE (Vlasnik)	16. Objava na facebook i web stranicama Zavoda i/ili institucije 17. Objava u lokalnim novinama (Glas Istre) 17.1. Dostava teksta i slika novinaru 17.2. Autorizacija članka (znanstvenik) 18. Objava znanstveno-stručnog članka u međunarodnom časopisu iz područja akvakulture (Aquaculture Reports) 18.1. Slanje kompletnog članaka na engl. jeziku uredništvu časopisa, koje razmatra prikladnost članka za časopis da ili ne 18.2. U slučaju da, članak ide na vanjsku recenziju 18.3. Korekcije članaka u skladu s komentarima recenzenata 18.4. Prihvaćanje članak 18.5. Prijenos autorskih prava na časopis 18.6. Online objava članka (https://www.sciencedirect.com/science/article/pii/S2352513422003982)

	18.7. Tiskanje volumena časopisa s predmetnim člankom (Majnarić N., D. Pavičić-Hamer, A. Jaklin i B. Hamer, 2022. Susceptibility of invasive tunicates *Clavelina oblonga* to reduced seawater salinities. Aquaculture Reports, 27:101402; https://doi.org/10.1016/j.aqrep.2022.101402)

1. Introduction

These guidelines aim at providing in one document all the useful information for a steady, effective and efficient project implementation based on Programme Manual indications.
The document contains instructions previously provided by the managing Authority at Lead Partner Seminars or in other manuals, factsheets and documents, with the intention to offer a hands-on guide with very practical and structured information. It is organised in the following chapters:

2. Activities agenda and checklist for each WP
3. Reporting on output indicators
4. Templates for deliverables collection
5. Guidelines on progress reporting
6. Guidelines on sound management
7. References to Programme Manual

When necessary, the present guidelines are updated and the new version is made available to project partners