REPORT ON THE COLLECTION OF ALTERNATIVE DATA ON MUSSEL CULTIVATION IN THE KRKA ESTUARY

Final Version of December 2022

Deliverable Number D.4.2.2

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	4.2
Activity Title	Common Scheme for the Management of Fishery Activities at Local Level
Partner in Charge	Public institution development agency of Šibenik-Knin County
URL	https://www.italy-croatia.eu/web/argos
Status	Final Version
Distribution	Public
Date	December 2022
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CONTENT:

1. Summary

Interreg program under cross-border cooperation programs between Italy and Croatia for 2014-2020 found the Argos project (Joint management of sustainable fisheries and aquaculture activities as financial support for protecting marine resources in the Adriatic Sea). The project's main objective is to achieve sustainable joint management of fishery resources.

The public institution of the Šibenik-Knin County Development Agency (from now on ŠKC DA) as a project partner PP9 is through the work package 4 (WP4) "Knowledge-based decision-making process" included in activity 4.2. This activity aims to achieve a "Common Fisheries Management Policy Protocol at the local level." The result of this action is the preparation Report entitled "Report on the collection of alternative data on mussel cultivation in the Krka estuary" (from now on referred to as the Report). Therefore, the main objective of the Argos project is, within the activities of 4.2, to establish a well-defined protocol for collecting data at the local level, which will be the basis for the development of more effective local aquaculture management measures.

Within this project activity 4.2, in agreement with the external associate Hippocampus j.d.o.o., ŠKC DA has decided to collect data on the local shellfish farming sector related to the localities of the river Krka estuary (from now on referred to as the Estuary).

The focus of farming research in this area is determined based on a particular issue:

1) The need for a realistic representation of the existing situation in the local shellfish farming sector positioned in the Estuary;

2) Decline of the production in the area for the last five years according to available national data on the production and sale of shellfish;

3) The need to develop a data collection strategy and establish monitoring in the local area of bivalve mollusc farming areas as a tool for better understanding current trends within the shellfish sector, and thus better access to the solution of shellfish farming and the general development of aquaculture in the area of Šibenik-Knin County (from now on ŠKC);

4) Weak integration of aquaculture with the local community;

5) Degree of involvement of shellfish farmers in the development of infrastructure projects related to aquaculture currently in implementation;

6) The compliance of aquaculture with the protection of the Estuary.

Due to the unique geomorphological, environmental, and oceanographic systems, shellfish in the Estuary have a one-year breeding cycle. High-quality cultivating perspective, which local authorities have recognised. Thus traditional mussel cultivation on this site has been taking place for over 30 years.

Local institutions provide full support to farmers through various adaptations of spatial plans, location permits changes, and the development of aquaculture projects, making the area fully adapted to the aquaculture activities up to the maximum capacity of potential production volumes of 3.310 t on the entire site of 234.756 m². The project of the Aquaculture Centre is currently in the progress of implementation and construction, it will be the infrastructure that will support shellfish cultivation, and the services provided to farmers will cover the activities of the depuration, cleaning, sorting, and packaging of shellfish. However, despite the natural advantages of the area, tradition, and the necessary supporting infrastructure, according to official national data, the production volume of shellfish is decreasing.

Institute for oceanography and fisheries in Split (from now on referred to as the IOF) - PP13 which leads the work package 4, suggests an approach to resolving the issues in the aquaculture sector primarily by collecting data at a local level, with a farmer's survey method. Therefore we interviewed nine out of eleven farmers (two are currently inactive). Data collected were primarily on production methods, production capacities, socioeconomic data, and local opportunities, which are very important for current and future projects carried out by ŠKC concerning aquaculture.

Local community connects with the aquaculture activity by selling shellfish on the market, domestic traders and caterers. Also, in the last two years, farmers are taking part in the events organised by the County Tourist Board and the City of Šibenik called "Mussel&Debit love them selfs" and also in the ŠKC's project "Taste Šibenik-Knin County". These actions are the promotion of shellfish production and mussels as a product. It is a slight shift towards marketing promotion of local shellfish production. Still, more severe and significant steps are necessary to promote the quality of the mussels from the Estuary broader than the local community. These steps should enable the cultivation of shells to achieve an essential increase in market value that would undoubtedly stimulate the growth in the production of individual farmers.

Their desire to engage in management processes at national and local levels is evident through communication with farmers. Alternative sources of information they possess are undoubtedly necessary to determine the direction and strategy of this part of the aquaculture sector. The Report will also propose measures and means to establish further data collection and surveillance systems. The proposed criteria can help the authorities better manage the aquaculture sector based on systematic research and data collection and thereby directly help farmers achieve improved and competitive shellfish production.

Finally, even though the Estuary landscape is protected, it is under various pressures like anthropological pollution from the surrounding settlements, cities, and aquaculture (primarily from fish farms).

Therefore, it is essential that the pollution control parameters are systematically monitored and farming equipment and installation biologically adapted to environmental conditions. Also, the waste should be reduced from fish farms. All these parameters would contribute to environmentally sustainable aquaculture, enabling maximum development of this sector in the local area.

2. Introduction

The sea has always been an inspiration for life in our region, and the times we live in a show that it can also be an economically important aspect of our local, and therefore national, economic success. The time we are referring to is the year of writing this Report, 2022 when the Food and Agriculture Organisation (FAO) published the "State of World Fishing and Aquaculture" and announced that by 2030, aquaculture production of animal origin should increase by 14%. With that growth, world aquaculture moves towards a "blue transformation".

Humanity faces increasing problems due to the lack of food, and hunger reigns in certain parts of the world. More precisely, according to FAO data, 811 million people are starving, and the fact that more and more people are being born does not solve this problem. The same data also shows that 3 billion people in certain countries cannot afford a healthy diet, so in that case, the health of a large group of people is at risk.

In 2020, global seafood production (through fisheries and aquaculture) reached its peak of 214 million tons, of which 178 million tons relate to marine animal farming and 36 million tons to algae cultivation.

According to the UN 2030 agenda, the "blue transformation" has three basic postulates:

1. Expand and increase aquaculture production to meet the increasing demands for seafood and healthy nutrients;

2. The effective management of fisheries to maintain a stable state of marine resources and the fleet;

3. Improved supply chains in a context of a circular economy which, through sustainability, promotes positive social, environmental, and economic opportunities.

Citizens worldwide are increasingly considering consuming various seafood, which they recognise as a healthy diet due to healthy proteins, micronutrients, and essential omega-3 acids. As a result, fish consumption worldwide is growing twice as fast as the global population growth itself. For example, in Croatia, according to the European Market Observatory for Fisheries and Aquaculture Products (EUMOFA) 2019, fish consumption grew by 9% compared to 2018. It amounted to 20.8 kg per capita, slightly more than the world average of 20.2 in 2020 (source FAO). People consume fish in bulk by approx 69%, and at the European level - 68% (Source: Eurostat and FAO, 2019).

It is also the year of small-family producers, fishermen, and farmers, which FAO has declared as the International Year of Small-Scale Coastal Fisheries and Aquaculture. Regarding the shellfish sector in Croatia, small family farmers make natural wealth available to everyone who has decided to follow a healthy trend. Although fresh seafood has an advantage in consumption over farmed seafood (according to the Eurobarometer, 2021),

the vast majority of citizens declared that they do not care if the product is caught or farmed. For them, the quality of the product itself is more important.

To primarily accomplish a quality product in aquaculture, farmers need to have intelligent management of aquaculture resources and sustainable cultivation suitable for expanding and intensifying production. Sound governance principles are also based on the constant collection and analysis of the data needed to harmonize the decisions, regulations, and strategies for aquaculture with the situation in the field. From that principle comes the need to involve farmers in collaborative management processes, which is the "bottom-up" approach.

This research aims to define the following:

1) methods of effective collection of alternative local data;

2) methods of data collection at the national, regional, and local level on mussel farming in the Estuary;

3) the current state of mussel farming in the local area.

Report also aims to bring the "bottom-up" approach and data collection at the local level closer to the institutions responsible for monitoring and decision-making in aquaculture. It would enable the direct involvement of farmers in the aquaculture management process. The idea that emerges through the research and preparation process of this Report is that on the operational management level of natural resources, close cooperation and communication with mussel farmers can convey quality. It is up to the institutions to incorporate collected data into management processes and regulations for the mutual benefit of farmers and authorities.

With the results of the Report's research, we will be able to propose measures for further systematic data collection and survey needs (local monitoring) in the cultivation of shellfish for higher quality and more efficient mussel production, all together to manage a more advanced aquaculture sector.

3. General situation of the aquaculture sector of Šibenik -Knin County to the condition of the sector/market in Croatia, the EU, and the world

On a global scale, aquaculture is the fastest-growing food production industry, with an annual growth rate of 6-8%, and production has already reached 63.6 million tons. Although the production of marine organisms in the world is growing, in the EU, it has stagnated in recent years, but it is significant and amounts to 1.3 million tons per year. Due to the stagnation of seafood cultivation in the EU, the import of these products has increased. Consumption of around 12 million tons of fish food and shellfish, 60%, is imported from other parts of the world.

Although fishery is still the main economic activity that supplies the population of the Republic of Croatia with fish, this trend is rapidly changing. Aquaculture along the Croatian coast is becoming an essential source of nutrition for marine organisms both for the domestic market and the closest foreign market (primarily Italy). The share of aquaculture in total fishing production for the last two years is 15%. The Ministry of Agriculture (from now on referred to as the MoA) announced that in 2021. the amount of marine organisms produced is 22,885 t of marine organisms.

Statistics from 2015 show that species cultivated in the Republic of Croatia (from now on referred RC) were: marine fish at about 50%, freshwater fish at 30%, and shellfish at about 20%.

According to the current statistics published by the Directorate of Fisheries for 2021, fish farming continues to lead with around 81% of production, freshwater fish farming occupies 15%, and shellfish farming amounts to only 4% of the entire aquaculture production.

Among the white fish farmed in the RC, the most important species are still sea bass and sea bream (MoA - 2021 - 16,558 t). Sea bass and sea bream are also the most common species grown in ŠKC. These species are produced by five farmers in three different locations in the County, in Rogoznica, Tribunj, and at the Estuary of the Krka River.

The cultivation of blue fish, more precisely bluefin tuna, in the RC reached about 25% of the entire fish cultivation (MoA - 2021 - 4,372 t), but the value of tuna as a market product is more than 50% higher than the value of other organisms. Company Pelagos produces tuna in the territory of the municipality of Murter.

So, according to official data, shellfish farming in the RC in 2021 amounted to a minimum of 4% of total aquaculture production, despite locations with great potentials, such as the Lim Channel, Novigrad Sea, Mali Ston, and the Krka estuary. Although ŠKC has excellent potential for producing shellfish because the Estuary is naturally rich in nutrients due to the inflow of fresh water, most of the farmers who currently use the concessions are relatively poorly utilising the capacity of the approved quantities for cultivation. Of the total national production of shellfish, mussels, and oysters in 2021 amounts to 860 t, only 5% is grown in ŠKC (according to official data of the Directorate of Fisheries). Production is limited mainly to the mussel, a less valued species than other shellfish, for example, the oysters, which

some farmers have only begun to grow in a targeted and serious manner in the last few years, while others grow spontaneously.

The seeds of both species are collected and planted for further cultivation exclusively from natural sources within the Estuary.

4. Methods of creating the Report on data collection within activities 4.2. "Joint protocol for the management of aquaculture activities at the local level"

The methodology is the science of the forms and research methods used to achieve the objective and systematic scientific knowledge (Radeka, 2018).

We used an internally designed methodology in the Report to:

1) analyse the production, socioeconomic aspect, and current local conditions in mussel farming;

2) identify risks that occur during data collection and analysis;

3) propose measures for a further survey of mussel farming.

Choosing the method, we used the guidelines defined by the leader of this activity, IOF. Namely, they created document D4.2, "Common scheme for the management of the aquaculture activities at the local level", which defined the framework of data collection and creation of surveys for respondents.

The methods used in compiling the surveys were a combination of quantitative and qualitative. Using quantitative methods, we tried to prove the goals and purpose of this research using specific statistical data. With qualitative questions, we primarily tried to find out the attitudes and opinions of growers about current local conditions and projects, as well as experience related to the problems that appear in shellfish farming. From the mentioned methods came the compilation of survey questions which are:

a) open type - to which the respondent answers in their own words - they have more excellent scientific value but require solid education and literacy;

b) closed type - under a certain number of answers, the respondent is offered to choose the one answer that expresses their opinion or a particular situation - such questions have less scientific value because they are imposed and require extensive knowledge of the issue from the compiler of the survey;

c) combined question type - which offers simple affirmative and negative answers to the questions asked.

The most significant difficulty when applying this research method is the truthfulness and validity of the data. Therefore, it is necessary to win the trust of the respondents. For this reason, we primarily required the majority of respondents to fill out the survey face-to-face, and in doing so, we carefully explained the purpose and goal of the Argos project, as well as the 4.2. activities. We left it up to the respondent to decide whether the survey would be anonymous because, with anonymity, we wanted to offer the respondents a certain comfort and security that their data would not be misused. It was also necessary that filling out the questionnaire lasted at most 20 minutes due to a drop in interest, attention, and concentration. Nevertheless, we extensively collected all relevant data within that time limit.

The survey method represents organised, pre-prepared survey research, i.e., collecting attitudes, opinions, and data through surveys or questionnaires sent to a specific group to reach certain conclusions about the investigated phenomenon (Radeka, 2018).

4.1. The structure of compiled surveys for interviewing shellfish farmers

We structured the survey according to IOF's proposals, which suggested collecting data on production, technology, and socioeconomic conditions. The intention was to ask questions about current and future local conditions and the local projects in aquaculture for which the opinion of farmers, as the main actors in the aquaculture sector, is relevant. The survey example is in attachment 1.

We divided the survey into several meaningful units:

a) general data;

b) production;

c) economic and social data;

d) innovations;

e) subjective perception of local circumstances.

Through the production and socioeconomic part of the survey, we asked quantitative questions, mainly of a closed type, from which we expected data that we would process statistically and which would give us an insight into the state of cultivation in 2021. Therefore, we will analyse the obtained data through statistical data.

Innovations and the subjective view of local conditions are combined questions and closed-type questions because the purpose of these questions was to collect only primary data on specific essential topics for the local aquaculture community. Communication with farmers should be open and investigative to determine the plan and direction of aquaculture development and projects within the sector. Data processing of shellfish farming is mainly at the national level. Although strategy development and project planning are adopted at the regional level based on the expressed needs of the local farming sector, it is necessary to understand both levels' administrative obligations.

5. Administrative procedures, legal framework and data collection in shellfish farming

5.1. Administrative procedures, legal framework and data collection at the national level of the Republic of Croatia

National and regional levels of management are responsible for conducting procedures for establishing operational units, administrative tasks and monitoring in aquaculture.

Department of Agriculture; The Directorate of Fisheries → regulates shellfish farming according *to the Aquaculture Act (Official Gazette 130/17, 111/18, 144/20)* and through other laws and ordinances:

Ordinance on the Register of Permits for the Use of Foreign and Locally Absent Species in Aquaculture,

Register of entry and transfer and List of closed aquaculture facilities (Official Gazette 10/18),

Ordinance on permits for aquaculture (Official Gazette 17/18),

Ordinance on professional training for the performance of aquaculture activities (Official Gazette 56/18),

Ordinance on criteria for determining areas for aquaculture in the maritime domain (Official Gazette 106/18),

Ordinance on the collection of statistical data on aquaculture (Official Gazette 137/21),

Ordinance on approval for aquaculture activities on family farms (Official Gazette 15/19) i

Law on Sea Fisheries (OG 62/17, 130/17, 14/19).

The Directorate of Fisheries is a vital institution for managing affairs related to aquaculture and preparing national strategic documents in aquaculture. As mentioned earlier, the administrative unit responsible for all these matters is the Service for Aquaculture, with headquarters in Zadar. The Service's priorities are professional training for the performance of aquaculture activities, the approval of the performance of farming activities, and the issuance of permits for aquaculture.

The obligation to submit data of members of the fishing fleet, farmers and processors is prescribed by the *Ordinance on the content, form and method of submission of socioeconomic data in fisheries (Official Gazette 79/20)*.

The Directorate of Fisheries has had an IT system in the form of a database and web application called Geoinformation System of Fisheries (now on referred GSF) since 2006. Data on fishing effort, fleet and economic effects of fishing are entered, updated and reviewed in the GSF system according to specific EU regulations.

However, the most exciting topic for preparing this Report is the data collected in the system related to aquaculture.

The Directorate of Fisheries introduced the mariculture database in 2007. Since then, many modifications and updates have taken place in that GSF module, primarily related to changes in the legislative framework.

According to the new Ordinance, the change applies to filling in and sending data entered in the PGR new module "Aquaculture".

From 2022 collected forms for the submission of statistical data on aquaculture (from now on, the logbook) along with documents for the submission of statistical data on the number of employees in aquaculture farmers are obliged to send monthly.

Logbook forms are filled out for each location within the permit and separately for each approved species in farming. The logbook part on the number of employees is filled out by the license holder and refers to all persons involved in production.

To collect data from the *Act on Aquaculture*, Art. 25, and all following *the Council Regulations (EC)* and *(EU) 2021/1167* and *2017/1004* after the approval of the European Commission, the RC issues *Annual Monitoring Plans for data collection in fisheries and aquaculture* and publishes the results on its website.

The Ordinance on collecting statistical data came out in 2021 and is currently in effect.

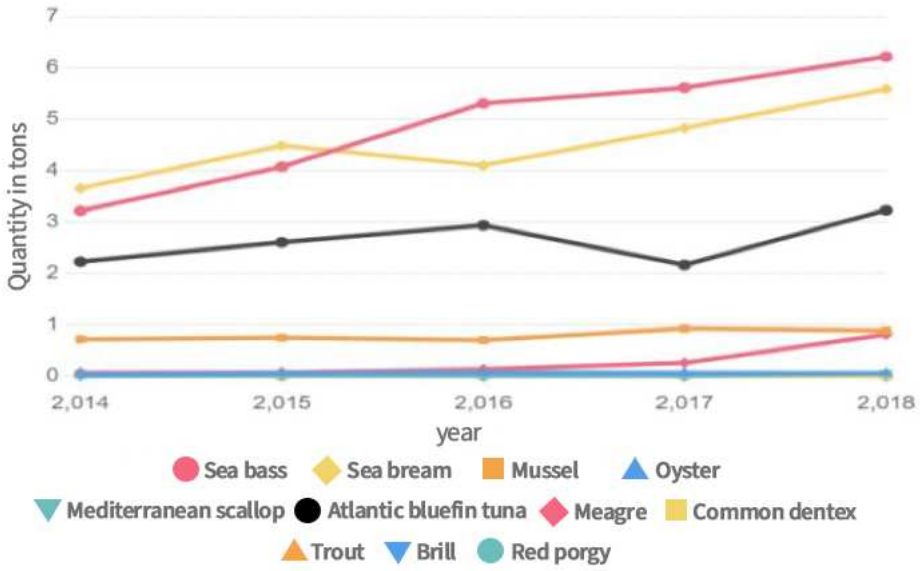
Data collection under the provisions of the *Common Fisheries Policy* is carried out by the competent institution Ministry of Agriculture, i.e. the Directorate of Fisheries. However, the competent authority for collecting biological data as a scientific associate within the framework of the *Annual Data Collection Plan* (according to the *Laws on Fisheries and Aquaculture*) is IOF.

The website for publishing collected data is established.

PROGRAMME FOR FISHERIES DATA COLLECTION IN CROATIA

Figure 1. Logo of the internet portal Podaci.ribarstvo.hr

All Biological Data Reports, socioeconomic and other studies published on this website are related mainly to commercial fishing. The 2019 *Production Reports* for 2014-2018 can be found for aquaculture, and regional production can only be obtained upon request submitted



to the Directorate of Fisheries.

Figure 2. Presentation of mariculture production in the Republic of Croatia (in tons) for the period 2014 - 2018 (source : Podaci.ribarstvo.hr)

As a member of the EU, Croatia is obliged to submit data on fisheries and aquaculture to competent institutions within aquaculture, and the RC offers necessary and timely reports to EUROSTAT (European Statistics) and DCF (Data Collection Framework).

According to *EU regulation 2017/1004*, economic data is collected annually, according to the national classification of companies engaged in marine aquaculture activities. The methods and quality of data collection are defined by *EU regulation 1380/2013. Data* are collected through the database from the register or through surveys. In addition, data from the Croatian Financial Agency (FINA) are used to verify data in certain situations (Grubišić, 2022).

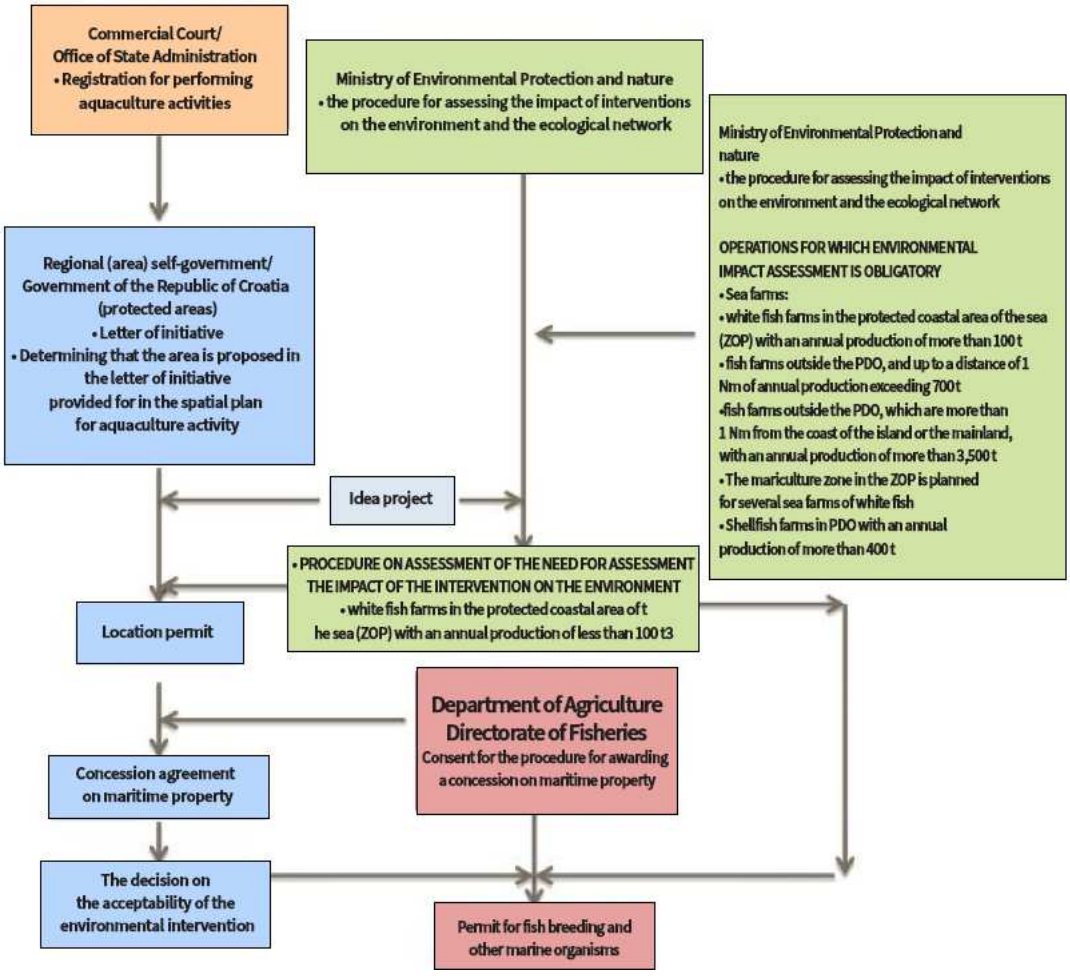


Figure 3. Procedure for issuing an aquaculture license (Directorate of fisheries, 2014)

5.2. Administrative procedures, legal framework and data collection on shellfish farming at the local level of Šibenik-Knin County

ŠKC has a marine water area that covers 2620 km². More precisely, the marine water area occupies almost half of the size of the entire County. Therefore, considering that world aquaculture has reached a high standard technologically and operationally, it would be strategically significant for this locality if aquaculture became a priority economic branch in which it is necessary to constantly invest through infrastructure, technology and knowledge of shareholders within the sector.

ŠKC determined the Estuary area for aquaculture activity in 1979, when significant systematic scientific research into shellfish and potential shellfish farming, primarily mussel farming, began due to the exceptional quality of abiotic factors. Based on a series of scientific studies over ten years, local governance concluded that the Šibenik area is among the best for controlled shellfish cultivation.

That fact refers to the values of the condition index, the number of seeds collected, the growth of mussels and the percentage of survival compared to other localities on the eastern coast of the Adriatic (IRB, 2004). Later (in 1985), IRB researched the cultivation of oysters, so the farmers successfully established the technology of their cultivation as well.

The foundation for the success of aquaculture as a local economic asset is the choice of location and its protection, with all mandatory environmental measures assessed through an adequate study. The direct action of creating an aqua-cultural locality is a spatial plan. Aquaculture interventions in the area of the Estuary zone are based on three spatial regulations - the Spatial Plan of Šibenik-Knin County, the Spatial Plan of the City of Šibenik and the General Urban Plan of the City of Šibenik, the adoption of which is based on the *Law on Spatial Planning*.

The category of significant landscape additionally protects the shellfish farming area of the Estuary according to Council Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora. Estuary is located within the Natura 2000 ecological network.

In preserving the landscape environment, it is necessary not to change the environment's elements and maintain the natural state. Precisely because of this, the spatial plan for this area is adapted to farming shellfish, autochthonous and non-native marine species without damaging the raw values. Furthermore, the spatial plan, among the general goals of the County's spatial development and planning, states the selective effect of mariculture following other users of the space, so based on these goals, localities suitable for the cultivation of fish, crabs and shellfish are determined (URBING, 2002).

ŠKC adopted the last significant changes of the spatial plan in 2017 and the City of Šibenik in 2020. As a result, the capacity of the cultivation area in the Estuary zone was increased, with the initiation of the process of changing the location permit according to the new *Conceptual Project for issuing location permits for the establishment of shellfish cultivation fields and fish in the area of the Krka River* (Klamfa, 2020 - from now on the Conceptual Project). In addition to the Conceptual Project mentioned above, ŠKC was obliged to satisfy administrative regulations. Therefore, before the new location permit came into force, it was necessary to make a procedure called an *Assessment on the need to assess the impact of the process on the environment*, a document for which the Ministry of Environmental Protection and Energy is responsible. For this purpose, a study was made on *Changes and additions to the aquaculture operations in the Estuary zone*. The basis of this Elaborate is the Environmental *Impact Study from 2004* (from now on referred to as the Study) which the Ruđer Bošković Institute then prepared. The Study is the base document on which the competent Ministry of Environmental Protection, Spatial Planning and Construction issued a decision allowing aquaculture activities in the area of the Estuary of the river Krka (2006).

The new document Conceptual project is the effort of the County to enable the aquaculture farmers to increase the cultivation areas to the maximum allowed capacities of the farms. With the increase, the County has minimal changes in farming fields because they have moved outside the given set coordinates over time.

Therefore, all efforts and preparation of related documentation are aligned with the new spatial plan.

The total capacity of all farms in the area of the Krka River, according to the Ministry of Environmental Protection decision from 2007, was 3000 t/y of shellfish. Such capacity is conditionally determined with environmental protection measures and a program for monitoring the state of the environment, breeding installations - floating parks, cages and facilities that must be placed within the farming zone.

Changing the capacity in 2020 with the new *Conceptual decision* and amendments to the existing Study, the ability of shellfish cultivation has been increased to 3,310 t/year, i.e. 310 tons more than before.

With the planned intervention, the total area for farming shellfish is 234,756 m², which refers to 54 farming fields (Oikon, 2019). Considering that before

the new location permit was issued, the scope of cultivation areas was 180,000 m², the new cultivation areas are larger by 54,756 m².

The proposed zones for shellfish farming are located on the right and left shores of the sea-submerged Estuary from the junction Martinska/Crnica to the entrance to Lake Prokljansko in a width of at least 30 m from the line to the shore, 10 meters towards the middle of the sea passage. Maritime traffic along the central line of the Estuary is most intense in the summer when foreign and domestic yachts and ships sail through our waters. Traffic within the cultivation zone is limited by waterways and a driving speed of 5 knots.

5.3. The course of development of production capacities, research and data collection in the Krka estuary

Scientific research on the possibility of growing mussels *(Mytilus galloprovincialis)* was started in 1979 in the Estuary primarily due to the knowledge that many of these shells are collected in the natural habitat. The research results also showed that the Estuary area has large mussel production, up to 20 kg/m³ (Teskeredžić, 1979).

Since 1980, the Aquaculture Research and Development Laboratory at the Ruđer Bošković Institute has been established on Martinska opposite Šibenik, whose headquarters is the Centre for Marine Research in Zagreb, and research is expanding in the following directions:

- hydrologi□al studies of sea quality;

- resear□h into the life stages of mussels to determine their □ommer□ial □ultivation;

- resear□h on the a□□eptan□e of mussel spats on solid substrates;

- the capacity of the researched localities to ensure a sufficient amount of seeds for the needs of controlled mussel farming;

- control of the growth, survival and condition index of mussels, and related to this is the determination of the suitability of the Estuary for successful and rapid growth to market values (IRB, 2004).

In 1984, the IRB investigated the possibilities of growing other shellfish on the same site, commercially valuable pectindae (*Pectinidae*) and scallops (*Pecten jacobaeus L.*), specimens of which could be found on the shell-sandy bottom at depths between 7 and 22 m (IRB, 2004). Then it was established that there are real possibilities for growing both species, which was confirmed by intensive scientific research of Drago Marguš and Emin Teskeredžić. Both scientists contributed significantly to scientific research in aquaculture with their intensive work in the Estuary.

The first controlled cultivation in the Estuary zone approved 26 localities on a total area of 90,495 m². According to the Study, the possibility of cultivation at that time was 1,500 t. The Study proposed to increase the cultivation capacity to a double size of 180,000 m² with an increase in production to 3,000 t. According to the Study, 300-400 tons of mussels and 10,000 pieces of oysters were grown then. This production was recorded in the period from 1997 to 2003. According to the study *Development of aquaculture in the area of the Šibenik-Knin County*, *management of the water area of the Krka River* (Teskeredžić, 1998), clear guidelines for setting up cultivating grounds were determined to have the highest yield of

shellfish. However, when the County awarded concessions to the farmers, they didn't respect experts' research regarding the biology and related shellfish cultivation technology. Fields were set up at the request of potential farmers, and their cultivation took place in bays, which hindered primary production on the bottom of the coast. An unprofessional approach resulted in poor-quality mussel cultivation.

At that time, the first survey was conducted with farmers, and it turned out that they produce only 261 tons of mussels and 20,000 pieces of oysters, or 17% of the total capacity, to be exact. According to the Study, only one farmer had an adequately set up farm. In this survey, they stated that they use 30% of the capacity of the farming fields, while the profession suggested 14% use for cultivating every field area. At that time, one company with 90 t grew 50% of the total farming capacity of shellfish, while other growers produced 10-20%. Also, farmers were using a very primitive and toxic production technology, Styrofoam with a coated cement mat, so that it would not tear (IRB, 2004).

In the work "Three Decades of Shellfish Farming in the Estuary of the Krka River" from 2009, Marguš learns how, despite a long tradition, Croatian shellfish farming is still not well developed and uncompetitive with the EU market. For this work, another survey was conducted with farmers in 2008, the results of which are as follows:

Concessions for the cultivation of shellfish in the Estuary of the Krka River were awarded to 14 concessionaires, of which 8 are artisans with a total area of 92,356 m² (51.1%). Potential production of 950 t (47.5%), 4 of them are professional fishermen with a total area of 55,510 m² (30.7%) and potential production of 700 t (35%), and two are registered as companies with a total scope of 32,973 m² (18.2%) and possible production of 350 t (17 .5%).

It was determined that 507.5 t of mussels were grown in Ušće, of which 342 t were the market size and 165.6 t were mussel seeds, and 15.000 oysters. In 2008, 25.4% of the possible total production and only 17.1% of market-size mussels were grown on 38 farming fields, with a total area of 180,839 m² and potential shellfish cultivation of 2,000 tons.

The number of employed people in mussel farming was 17. Farms were established based on the experience of previous farmers. However, most farmers have secondary education, so they do not know enough about the biology and ecology of shellfish, new technologies and farming techniques in Europe (Marguš, 2009).

After these two surveys and the collection of alternative data from shellfish growers, there is no public information that similar surveys were conducted at the local level from 2009 until this Report's preparation.

Figure 5. The Ćoran family has been farming mussels traditionally in the Estuary for more than 30 years

5.4. Current production capacity in the Krka estuary

The Conceptual Project mentioned earlier determined the increase of the total farming area for shellfish to 234,756.00 m². Overall with the cultivation area defined for fish farms at the same Estuary total area for growing marine organisms is now 254,810.00 m², which is close to the maximum aquaculture area determined by the Study of 255,000 m². According to the new conceptual solution, the zone for growing shellfish consists of 54 fields.

The Study stated that one field with an area of 3,180 m² could produce 50 tons of shellfish. However, new calculations in Conceptual Project showed that the unit area must be larger due to the configuration of the coastal zone and the bottom of the Estuary of the Krka River. On the other hand, the spatial plan determines the maximum capacity of the cultivation area, which is 3,691.13 t/year, and the permitted current production is 3,310 t/year. Therefore, mussel farming fields are divided into groups with maximum allowed production based on the maximum capacity of each area.

Each field is shown concerning the basic one. The permitted production is divided into four groups, depending on the size of the cultivation field:

● Group I - cultivation fields with a maximum capacity of 30 to 40 t/year, permitted the production of 35 t/year

● Group II - cultivation fields with a maximum capacity of 40 to 70 t/year, permitted the production of 50 t/year

● Group III - cultivation fields with a maximum capacity of 70 to 100 t/year, permitted the production of 75 t/year

● Group IV - cultivation fields with maximum capacity >100 t/year, permitted production 100 t/year

Figure 6. One of the production fields in the Estuary

6. Shellfish farming technology used in the Krka estuary

Considering the number and richness of species that abound in the Estuary, according to the Study, the cultivation of many shellfish is predicted *(Mytilus galloprovincialis, Ostrea edulis, Pecten jacobaeus, Chlamys varia, Aequipecten*

opercularis, Chlamys flexuosa). In the Report, we focused on mussel *(Mytilus galloprovincialis) farming. Although* most farmers in their aquaculture licenses have two species registered that can purposefully grow mussels and oysters, most (not all) only grow oysters spontaneously.

The planned cultivation of shellfish takes place in floating parks in horizontal lines and forms the so-called long-line farming.

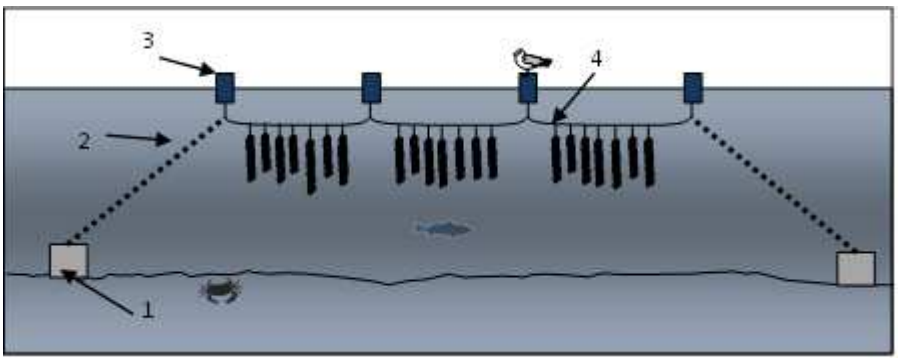


Figure 7. Schematic representation of farming lines most often used in mussel farming; 1. anchor blocks, 2. anchor pins , 3. buoys, 4. growing line with socks

The location of the cultivation fields was primarily determined according to the following:

- provisions of valid spatial plans,

- the requirements of the port authority (waterway, signalling),
- other users of the space, e.g. rowing club,
- to protect the landscape environment.

According to Conceptual Project, we distinguish the cultivation area, consisting of all the installations, including the anchor system, and the production area, where the mussel farming takes place. Due to the sudden change in the Estuary's depth, the production field's size is reduced, but the anchor system must still be placed within the prescribed limits of the concession. Production and cultivation areas cannot be the same in the natural environment. Therefore, a new location permit for each field is determined, considering all the guidelines of spatial plans, studies, and the actual depth and configuration of the bottom at specific locations.

The farming equipment is placed according to the coordinates and dimensions defined in the location permit.

Floating parks must be marked with appropriate signage following the regulations issued by the competent port authorities.

The installed equipment must be environmentally friendly so as not to cause changes in the environment.

The entire mussel farming field must be at least 15 m away from the land and placed where the depth reaches a minimum of 8 meters.

The main line can be 100 m long and 1 m wide with a protective belt of 3 m on each side. The total area of one breeding line can therefore be 742m². Given that most farmers use four cultivating lines, the whole area, in that case, would be 3180 m², with a total length of one line of 106 m and a width of 30 m.

Determination of the installation of the anchor system is planned to the maximum load of the system itself, as well as the oceanographic properties of that field. The anchoring system consists of a block (usually concrete) of a certain weight according to the acceptable budget. This submerged rope connects the lines to the anchoring system and steel fasteners to withstand marine environmental conditions.

Work on the farm can only be done from a floating object, ship or floating platform that can be placed next to each cultivating unit. The vessel must be registered for the performance of the economic activity of aquaculture. The floating platform can have a maximum size of 50 m² and a load capacity of 1350-2000 kg. According to the *Law on Navigation and Ports of Inland Waters (Official Gazette 152/14),* it must have a certificate from the competent ship register.

Mussel juvenile collecting is carried out by placing collectors on load-bearing ropes.

Figure 8. Preparation for the installation of the collector for the reception of mussel larvae

7. Basic ecological, chemical and physical properties of the Krka estuary

Due to its funnel shape, the mouth of the river Krka forms an estuary. Given that estuary are usually divided into three areas: the lower part where sea water enters, the middle part where the exchange of fresh and saltwater is most pronounced and the upper part closer to the entry of fresh water into the estuary, so is the Estuary divided into two significant landscapes, first the Krka Lower Stream and the Luka Channel, and the second is ecological network Natura 2000 Ušće Krka HR30007171. Upstream from this area is the Krka National Park (IZOR, 2019).

The Estuary stretches from Skradinski Buk to the exit through Šibenik 's St. Ante's channel and is 23.5 km long. The Estuary's depths differ depending on the flow, so they can be from 1 m to 42 m at the same exit from the Channel. The bottom relief of the Estuary goes from shallower to deeper, i.e. from Skradinski Buk to Šibenik channel, and it changes with each bay.

The inflow of freshwater changes due to seasonal external influences on the karsts of the Krka and Čikola rivers. The influx of the Krka is more dominant than other tributaries because the area of its basin is 2,610 km^2. Therefore, currents are strong in the surface and bottom layers (IRB, 2004).

Among other tributaries, the basin of the Guduća stream also has an influence, which brings many solid particles that most often settle on Lake Prokljan (IRB, 2004).

The average annual flow of the Krka River amounts to 49 m^3/s, bringing relatively small amounts of sediment blown away by waves and currents. The ratio between the particles returning to the Estuary and those leaving it is called the return gradient (IZOR, 2019). Due to the strong stratification, the retention time of these particles is short, and no unfavourable conditions are created in the environment. As a result, the Krka River does not carry sediment to a large extent; therefore, the water through the Estuary is mostly clear, and according to some studies, the eutrophic layer is up to 20 m (Viličić, 2003).

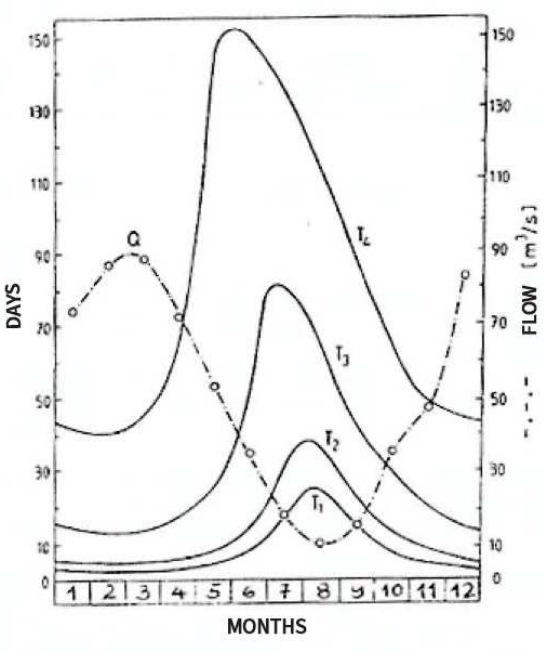


Figure 9. Average monthly flow of Krka (m³ / s) (source: IRB, 2004)
T1 - time of passage of fresh water through Prokljan (days)
T2 - time of passage of fresh water through Ušće (days)
From T3 to T4 time of passage of sea water through the Estuary

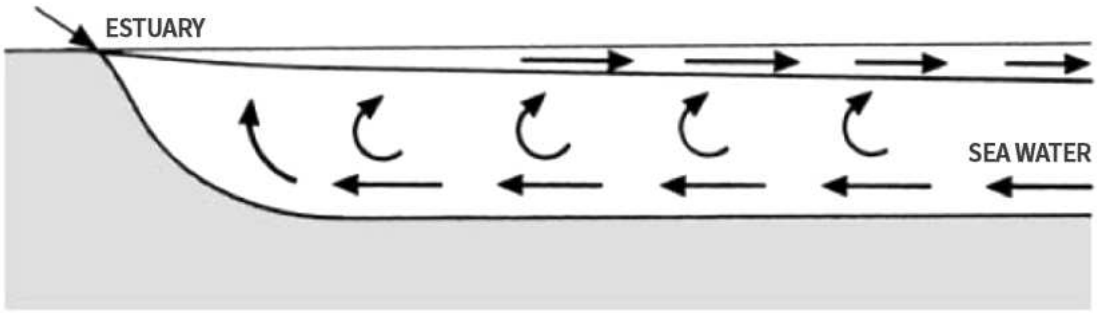
Through the Estuary, river and sea water alternate in different layers. Layer of halocline is a suitable habitat, breeding ground and nursery ground for many marine organisms due to its stratification and appearance of a wedge of fresh water. In addition to the discontinuity of salinity, there is a sudden temperature change, so a layer of high temperatures appears under the surface during the summer.

The change of water layers in the Estuary occurs 2-3 times a year with the tides, which range approximately 40 cm depending on the area along the Estuary.

In estuaries, mixing two basic types of water, sea and fresh, creates the so-called transition water - brackish water (Sal = 0.5 < transition water). Because fresh water is lighter than sea salt, a two-layer flow and a mixed layer of brackish water are created by mixing these two layers. The brackish water is thus located under the halocline layer, so when it passes through the Estuary, it thins out and becomes salty, and it is certainly very rich in nutrients. The layer of fresh water and its flow through the Estuary depends on the amount of seasonal

precipitation, and it leaves the Estuary in the surface layer. Along the bottom, in the opposite direction from St. Ante's Channel through the Estuary towards the Krka river, seawater enters, which is retained in the lower layers and penetrates the Estuary up to 25 km, all the way to the waterfalls of Skradinski Buk (Buljan et al., 1978).

The dynamics of the outflow of fresh water and the inflow of seawater depend on the horizontal pressure gradient, which in turn arises due to the difference in the density of fresh



and saltwater that exchange through the Estuary..

Picture 10. Schematic representation of estuary circulation (source Izor, 2019)

Given that the stratification of the water in the Estuary is influenced by oceanographic, hydro-logical properties and the synoptic situation, changes in these systems cause specificity in microbiological characteristics. Therefore, the microbiological situation in the water largely depends on the inflow of fresh water and the anthropological influence on the area. The Estuary is close to the urban settlements of Šibenik, Drniš, Knin and Skradin, as well as smaller towns such as Zaton, Raslina, Bilica.

Within the framework of supervisory and operational monitoring funded by Croatian Waters and based on the study " Determining the Zero State in the Port of Šibenik " conducted in 2013 and financed by the Ministry of Maritime Affairs, Transport and Infrastructure, 135 micro phytoplankton were determined; 69 diatoms, 54 dinoflagellates, 6 coccolithophorids, 2 silicoflagellates, and one type of euglenophyte. As the number of phytoplankton communities and their abundance depends on the environmental parameters, their quantity in the Estuary is variable depending on the season. It is greatest during the spring and autumn fluctuations of nutrient salts in the water column due to the greater availability of light needed for photosynthesis. The lowest abundance occurs during the summer stratification of the water when the surface layer is hot, and the deeper layer is colder, thus preventing the mixing of nutrients and the creation of new supplies of food for shellfish. The highest density of phytoplankton, freshwater and marine species is found in the upper layer of the halocline, and their number decreases sharply with depth (IRB, 2004). Phytoplankton from fresh water, which comes from the so-called Visovac lake, when it passes through the Estuary and touches seawater at the upper limit of the halocline, decomposes and creates

practical and nutritious organic matter for shellfish, as well as pheophytin, which is formed as a product of chlorophyll decomposition (Viličić et al., 2016).

Farming in this area is suitable due to all the biological, physical and chemical properties listed above because shellfish, as benthic and filtering organisms, have abundant food and a rich habitat for growth. Through water filtration, mussels consume plankton and detritus, and the filtration ratio depends on their size and weight (IRB, 2004). In the previously mentioned research in 2013, 56 species of bivalves were recorded in the Estuary, 22 sessile and 33 mobile on the seabed. The most numerous mussel species are *Mytilus galloprovincialis,* also called Mediterranean mussel, which are defined as a euryhaline and eurythermic species and are distributed throughout the Estuary, usually up to 5 m deep. The mussel feeds on the phytoplankton of various sizes from 6 µm to 200 µm, and its growth depends on the nutritional value of specific amounts and types of algae.

The reproductive cycle of the mussel takes place during two periods of time in one year; primary in spring and secondary in autumn. The natural production of mussel larvae in deeper, more stable layers (salinity > 30 PSU) in spring (April) at a depth of 3 m is higher than 5,000 individuals per 125 cm 2 (COAST, 2009).

Of the other species that are found in the Estuary on solid substrates, the European flat oyster *Ostrea edulis* is the most abundant, and the most numerous species of floating and muddy ones were the grooved carpet shell *Tapes decussatus* , the warty venus *Venus verrucosa* and the lagoon cockle *Cerastoderma glaucum*.

Among the protected shellfish species, the date shell *Lithophaga lithophaga* and the noble pen shell *Pinna nobilis* were found.

8. The sensitivity of the coastal area of the Krka estuary and the potential danger of pollution of shellfish farming zones and the protected landscape of that area

An estuary, according to Pritchard (1967), is a semi-enclosed coastal area that has a free connection with the open sea and in which the sea water is diluted with fresh water from the land. Because of the complex processes in estuaries, they are sensitive habitats because they are usually located next to cities where they are threatened by pollution.

Estuaries are economically significant due to the possibility of aquaculture activities. However, fish and shellfish farming and human factors of pollution, such as agriculture, waste and sewage water, industry, shipyards, ports, ship traffic and other construction projects near the estuary, threaten biological communities in the sea and on land daily.

In addition to river tributaries, wastewater is also part of the tributaries to the estuary and is the primary source of bacteriological pollution. Due to its physicochemical properties, wastewater spreads over the surface of the sea at pretty large distances from the source of pollution, depending on surface currents and wind (IOF, 2019). Wastewater is connected to the larger urban settlements of Šibenik, Skradin, Knin and Drniš and the smaller places Raslina, Bilice, Zaton.

According to the data provided by Vodovod i odvodnja d.o.o of Šibenik-Knin County, the parts of the city that are closest to the agricultural fields (Crnica, Dolac, Mandalina) are connected to the public drainage system of the city of Šibenik, which has an outlet behind the island of Zlarin. Surrounding settlements (Bilice, Raslina and Zaton) have discharged into black or septic tanks. In contrast, the town of Skradin has a wastewater treatment plant with II degrees of purification, and the annual discharge of treated wastewater is about 70-80 thousand m³. The water permit and the *Ordinance on wastewater limit values* set the parameters that monitor the water quality that the Skradin device meets.

The majority of the population in the County lives in the city of Šibenik, which location is in the lower part of the Estuary. Therefore, an ideal situation for the farming environment is that pollution by wastewater has been reduced to a minimum by constructing a collector, a project implemented by Vodovod i odvodnja d.o.o., Šibenik.

Table 1. Total annual precipitation in the area of ŠKC according to DHMZ

Years	Total amount of precipitation (mm)
2017.	733.6
2018.	878.9
2019.	908.3
2020.	628.5
2021.	748.7

Due to the specific environmental conditions in the Estuary, the quality of juvenile mussels depends mainly on the seasonal inflow of fresh water in a given year. However, its decline can also be caused by a sudden freshwater catchment, which also significantly affects the composition of phytoplankton and increases the circulation of the surface waters of the Estuary. Furthermore, precipitation is more frequent in the colder part of the year, so an enormous amount of fresh water collects in the river and flows towards the Estuary.

In the city area of Batižela, located at the entrance to Estuary, the city of Šibenik is planning the Urban Regeneration of the Industrial Zone. Under that name, a *Development Strategy Proposal* was issued in April 2020, and the associated action plan and implementation priority. It is an area of more than 200,000 square meters where zones for tourism and hotels, residential buildings, parks and green areas, and socially valuable facilities are planned. The project is currently in the second phase, in which a team of consultants has been selected to assist in revising *the Development Strategy Proposal*, making the necessary analyses and preparing tender documents for the selection of a potential investor.

The European Bank for Reconstruction and Development joined in supporting the project. However, the project's impact on the environment, especially on the aquaculture installations in the Estuary, has not yet been determined.

Figure 11 . Batižela area (source: the City of Šibenik website)

8.1. Sanitary control of shellfish production in Šibenik - Knin County

Farms within the Estuary are under constant official monitoring, which defines shellfishs as food safe for consumption. However, due to the increasing pressure of pollution from the environment that threatens the farming zone of the Estuary - the growth of tourism, planned infrastructure projects in the immediate environment and wastewater - it is necessary to plan purification of the shellfish before further marketing and consumption by consumers. Shellfish, as filters, accumulate particles from the environment in the organism. That is why they can be toxic to humans if their origin comes from a polluted environment. The causes of pollution can be toxins, viruses and bacteria, metals, herbicides, and insecticides.

Bacterial contamination of shellfish comes from *Clostridium botulinum* type E and F, *Vibrio parahaemolyticus*, *Salmonella* spp., *Escherichia coli*, *Streptococcus faecalis*, *Proteus* spp., *Clostridium perfringens*, and the number of faecal coliforms. Many bacteria multiply in shellfish meat even during storage at temperatures of 0 and -5 °C (Pseudomonas and Achromobacter, Dobrota, 1970).

Viral contamination of shellfish is also possible with bacteriologically "clean shellfish", so diseases such as gastroenteritis and hepatitis can occur when shellfish are consumed, mainly from port areas.

The chemical-toxicological integrity of shellfish also refers to their possible contamination with heavy metals (Pb, Cd, Hg, methyl-Hg, As as well as Fe, Zn, Cu), PCBs, and biotoxins (PSB-Paralytic shellfish poison; NSP-Neuroparalyticshellfish poison).; DSP-Diarretic shellfish poison), radioactive isotopes, herbicides, insecticides, etc. (Lovrinov, 2007).

Monitoring within the Estuary is carried out by the Veterinary Directorate, and data is collected on the entire farming area of the Estuary, which is divided into six zones (Šibenik I, Šibenik II, Šibenik III, Šibenik IV, Zaton, Strmica). Annual plans for monitoring the quality of sea shellfish in production areas and re-laying areas are based on *Ordinance on special*

rules for the organization and implementation of official controls carried out in production areas and areas for re-laying live shellfish (Official Gazette 82/14). According to the current *Sea and Shellfish Quality Monitoring Plan in Production Areas and Live Shellfish Restocking Areas for the Krka River Estuary (P-11-URK)* from 2019. measurements are taking the place of various factors in seawater, sediment and shellfish (reference species for monitoring is mussel, *Mytilus galloprovincialis*).

Regarding previous mentioned legal framework, sampling in Estuary is carried out at a total of eight stations (from figure 12.), and the parameters are determined as shown in table 2.

Figure 12. Map showing measuring stations as part of the regular monitoring plan (M – measuring station for monitoring microbiological parameters and B – measuring station for monitoring biotoxins) (Source: OIKON, 2019)

Table 2. List of stations and parameters that are determined according to the Sea and Shellfish Quality Monitoring Plan in production areas and areas for re-laying of live shellfish for the Krka River Estuary area (Source: OIKON, 2019)

Station	Sample	Parameter	Frequency
M1	Shellfish tissue	Microbiological quality of shellfish *(E. coli)*	Per month
M1	Shellfish tissue	Benzopyrene, benzoanthracene, benzofluoranthene, chrysene	Half -yearly (April and October)
M1	Shellfish tissue	Metals (Cd, Hg, Pb)	Half -yearly (April and October)
M2	Shellfish tissue	Microbiological quality of shellfish *(E. coli)*	Per month
M3	Shellfish tissue	Microbiological quality of shellfish *(E.coli)*	Per month
M4	Shellfish tissue	Microbiological quality of shellfish *(E. coli)*	Per month
M5	Shellfish tissue	Microbiological quality of shellfish *(E. coli)*	Per month
M6	Shellfish tissue	Microbiological quality of shellfish *(E. coli)*	Per month

M6	Shellfish tissue	Benzopyrene, benzoanthracene, benzofluoranthene, chrysene	Half -yearly (April and October)
M6	Shellfish tissue	Metals (Cd, Hg, Pb)	Half -yearly (April and October)
B1	Shellfish tissue	Biotoxins	Per week
B1	Sea water	Phytoplankton	12-3 months 2 weeks 4-11 months every week
B2	Shellfish tissue	Biotoxins	Per week
B2	Sea water	Phytoplankton	12-3 months 2 weeks 4-11 months every week

Ordinance on veterinary health conditions for fishing, cultivation, purification and marketing of live bivalve molluscs (Official Gazette 70/97), which determines the quality of the sea according to the presence of *Escherichia coli bacteria,* is in force.

The Ministry of Agriculture also issued a new *Ordinance on microbiological classification and special rules for the hygiene of live shellfish in production areas and restocking areas in 2022.* In this document, the rules of procedure are described in detail. However, monitoring results show that the health standards for live shellfish, echinoderms tunicates and snails intended for human consumption still need to be met.

Date of sampling	Zone	Production area	Result
08.12.2020	P-11-URK-01	Krka estuary - Šibenik I	16000
14.12.2020	P-11-URK-01	Krka estuary - Šibenik I	490
05.01.2021	P-11-URK-01	Krka estuary - Šibenik I	490
03.11.2021	P-11-URK-01	Krka estuary - Šibenik I	1300
07.12.2021	P-11-URK-01	Krka estuary - Šibenik I	790
08.12.2020	P-11-URK-02	Krka estuary - Šibenik II	1100
04.06.2019	P-11-URK-04	Krka estuary - Šibenik IV	790
04.08.2020	P-11-URK-04	Krka estuary - Šibenik IV	790

Table 3. Results of official sampling in the estuary of the Krka River

According to the latest data provided by the Veterinary Directorate on August 1, 2022, we requested to write this Report on non-compliant results of *E. coli* recorded in the meat of live bivalves and intershell fluid. During the last 3 years, more precisely from January 1, 2019, to 31 On July 2022, in the zones of the production area of the Estuary, according to *Plans for monitoring the quality of sea and shellfish in the production areas and areas for the re-laying of live shellfish*, it was recorded that there was no exceedance of the limit of biotoxins determined *by Regulation (EC) no. 852/04*.

Under legal regulations, shellfishs, which are located in zones that, according to the Sea and *Shellfish Quality Monitoring Plans in production areas and areas for the re-laying of live shellfishs,* are suitable for production and are classified in sea quality class A. They can be distributed on the market only after processing in dispatch centres. Shells are cleaned of fouling, sorted, packed and labelled in dispatch centres. In ŠKC, almost every farmer has a dispatch centre.

8.2. Aquaculture Center project

According to the Development Plan of Šibenik-Knin County 2021 - 2027, 82% of the total aquaculture farming in the County refers to shellfish farming. Furthermore, aquaculture is mentioned as a potential for entrepreneurial investment in the highlighted plan. Therefore, it is also planned to invest in the mariculture sector by financing the necessary infrastructure, improving processing technology and encouraging innovation.

ŠKC recognized the importance of shellfish farming and developed a long-time, expected infrastructural project called the Center for Aquaculture (from now on referred to as the Center). The Center is still under construction and should start operating in the first few months of 2023.

The project of the Center in ŠKC will be built and equipped for:

1) acceptance of shellfishs;

2) washing and cleaning;

3) sorting;

4) depuration;

5) packaging and labelling of shellfishs;

6) storage and loading for transport to the market.

The Center is predicted to be resourceful and technologically equipped. The implementation of activities aimed at strengthening cooperation between growers and general stakeholders from the aquaculture sector with the community and academic or research sector. The planned activities will positively affect the professionalization and then the competitiveness of micro, small and medium enterprises in the entire area of the Adriatic NUTS II region (text from the Šibenik-Knin County Development Plan for the period 2021-2027).

The total value of the project is HRK 10,000,000.00. The project is financed by the European Maritime and Fisheries Fund. The project holder is the Development and Innovation Center AluTech, an institution for encouraging entrepreneurship, research and development. This project is essential for srashell farmers in ŠKC primarily for the sake of the healthiness of their products. With the better value of purified shellfish on the market and meeting the standards of the control system, farmers will ensure settled and organized business development of their small farms.

According to the research for the Report, all shellfish farmers are well aware of the Center project and believe that it will contribute to the improvement of their business through the activities that will be carried out within the Center.

However, despite all the efforts of local and national authorities to establish a quality basis for the more focused management of the aquaculture sector, most farmers are still looking for more than the institution's efforts. The lack of plans, strategies and communication with the farmers is manifested in the disorganization of the sector at the local level. Namely, shellfish farmers are locally associated through the Chamber of Craftsmen of ŠKC within the Guild of Mariculture. However, officially this applies only to crafts, so they use this form of association for joint meetings rarely and when necessary. The county branch of the Croatian Chamber of Commerce also supports the sector.

9. Results and discussion of the results of the conducted survey of shellfish farmers from the Krka estuary

Due to the many factors that affect shellfish farming, the actual state of the sector in Estuary is best described by a SWOT analysis:

STRENGHTS:	**WEAKNESSES:**
- Natural, convenient location - Estuary of the Krka river - rich in natural larvae suitable for growing mussels and oysters - Three decades of farming tradition - Government support for the progress of aquaculture - High demand for seafood products during the tourist season in the Republic of Croatia - Proximity to potential domestic markets outside the ŠKC region - Building of the shipping and purification Center for Aquaculture	- Proximity to municipal wastewater, marinas and the inflow of fresh water into the estuary of the Krka River - Insufficiently developed aspects of work in terms of safety - Insufficiently developed infrastructure for aquaculture (storage areas, manipulative coastal strip, shellfish processing) - Underdeveloped market chain, insufficiently developed marketing aspect - Gray and black market - Weak organization within the sector in the local area of ŠKC
POSSIBILITIES:	**THREATS:**
- Introduction of new technologies and cultivation methods - Introduction of cultivation of new species - Expanding to markets outside Croatia - Interest of foreign investors - Construction of infrastructure on land necessary for storage, processing, hatching, etc. - Expansion and re-purposing of the spatial plan for mariculture	- Pollution near cultivation sites caused by: - Waste water from surrounding settlements - Negative anthropological impact on the environment - By developing tourism infrastructure projects on land that penetrate deeper into the Krka estuary - Limitation of production - Import of cheap and low-quality products

9.1. Structure of respondents

The authors of the Report proposed surveys to be anonymous due to farmers' trust and obtaining better quality data. IOF and members approve that kind of survey system of the AAC board.

According to the submitted national data, eleven Estuary farmers are engaged in shellfish farming. In addition, eight farmers carry out their economic activity under craft, one of them is a professional fisherman, and three concessionaires operate as a limited liability company.

Unfortunately, one farmer died during the project, so out of respect for his family, we did not collect data on production within his trade for the year 2021. Also, one company refused to cooperate, but they have not been active for years in terms of farming, harvesting and other actions to ensure mussels' quality production capacity.

A total of nine farmers (seven crafts and two companies) were surveyed, and the following data were collected:

- General information,
- data on shellfish production,
- economic and social data,
- innovations,
- knowledge about current opportunities within the local aquaculture sector.

One company owns concessions whose total farming fields occupy almost 50% of the surface of the full cultivation area capacity. Other concessionaires carry out mussel farming in areas that occupy 10 - 15% of the total cultivation area (pic. 13).

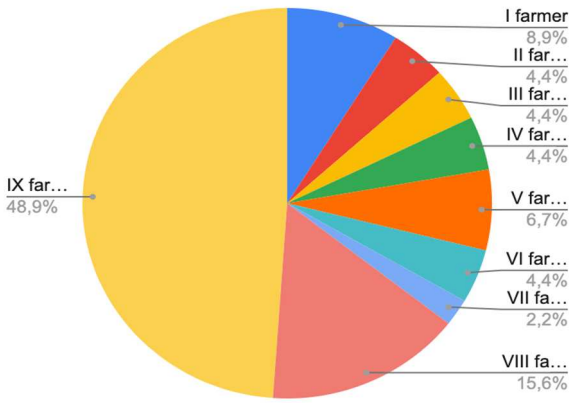


Figure 13. Size of farming areas by respondents

Table 4. Comparison of collected alternative data in the area of the Estuary in different periods

Year of data collection	Number of farmers	Number of farming locations	Production area	Potential production in tons	Realized production of mussels in tons	Production
2000	21	26	90,495 m²	1,536.76	261	50% of the capacity of one company, the other 10-20% of the production capacity
2009	14	38	180 839 m²	2000 t	507.5 (342 consumption and 165.6 seeds)	
2021	11	54	234,756 m²	2975 t	310 (197 consumption and 113 seeds)	One company holds 50% of the farming sites (22)

Table 4 shows that for 21 years, the number of farmers decreased while the spatial plans were adjusted to increase cultivation areas and farming capacity. So in 2021, the potential maximum cultivation capacity was available to farmers. However, despite the possibilities, production is declining according to the collected alternative data from the past years.

9.2. The technology used by the respondents in mussel production

Farming systems that consist of equipment and devices are set according to the coordinates, dimensions and the exact position of the specific concession concerning the appropriate location permits (Klamfa, 2020).

Most farmers use the traditional, long-line method for shellfish farming.

Long-line farming of shellfish in the Estuary differentiates two ways of setting up the mussel farm:

1) A simple system is used by placing multiple cultivating lines 100 meters long that are reflected on the surface using plastic buoys, each being placed approximately 7 meters apart from the other. The lines are independent of each other and are connected to the supporting rope. The carrying rope is used to set up the collector for shellfish larvae and mesh socks (pergolar) with planted the collected spats for further cultivation.

2) According to the Study, this system represents the optimal size of the cultivation field, consisting of four basic production units and four lines. That way placed farm is 106 meters long, 30 meters wide, and occupies an area of 3180 m². Each of the four production lines is supported on the surface by plastic buoys 1 m long (15 pieces) connected at their ends with load-bearing ropes. Carrying ropes are used to set up collectors for the reception of mussel larvae, i.e. setting up mesh socks (pergolas) with planted seeds in the other stage of the farming cycle. It is a modified system 1., in the form of increased production. (Klamfa, 2020).

Farmers using these two systems generally carry out similar production processes.

Both systems contain the following elements:

● lines with buoys that keep the equipment on the surface. The length of the line depends on the type of farming and the number of buoys (usually placed at a distance of 7 meters). At the end of each line, there are parts of the anchoring system ;

● an anchor system consisting of blocks that are determined according to the calculations of the profession, ropes, chains, and metal connectors;

● mesh socks(pergolas) in which mussels seeds are placed and farmed until market-sized shells. Mussels are generally planted with a density of 2.5 to 3 kg per long meter of socks and are placed on a line at a distance of 0.5 m. Cultivation after transplanting to market size takes about nine months. A final stocking density of 15-18 kg/m inside the mesh socks is desirable so that the mussels grow undisturbed to a size of 60-70 mm and a weight of 20-25 g.;

● collectors for receiving mussels larvae are usually prepared in March before spring or in September before the autumn reproduction of the parent stocks of mussels. They consist

of thicker ropes (diameter approx. 40 mm, length 2 m). Collectors are placed at a distance of 0.5 m, and when the small mussels reach 30-40 mm, the shellfish are further divided into mesh socks. It is possible to grow 10-12 tons of shellfish at the end of the growing cycle by meeting the conditions of the given spatial plan per field. More significant amounts are generally better accepted in the spring. Total farming time from the acceptance of mussel spat to the consumption of shellfish in the environmental conditions of the Estuary takes a total of about 15 months.

Through interviews, most farmers stated that during the freshwater inflow season, they manually lower net socks, which are tied with a thin line for the main line. Socks are lowered to a depth below 3-5 m, depending on their current estimation of freshwater inflow depth.

3) The shellfish production system is adapted to a specific cultivation field defined by the Study, measuring 106x30 m. It also consists of four cultivation lines at intervals determined by the Study. However, instead of collectors, lines and socks, a net is placed lengthwise in the direction of the production line. The floating of the production line is ensured through a sealed PEHD pipe, also put longitudinally in the order of providing the production line. (Klamfa, 2020)

Respondents who use this innovative technology claim that it proved to be excellent for increasing the surface area for the reception of juvenile shellfish and for the further growth and development of the individuals themselves. However, the problem arises with the seasonal inflow of fresh water, where there is total mortality of shells on the production lines due to the impossibility of lowering or raising the system into deeper layers to certain depths to which the layer of fresh water would not reach.

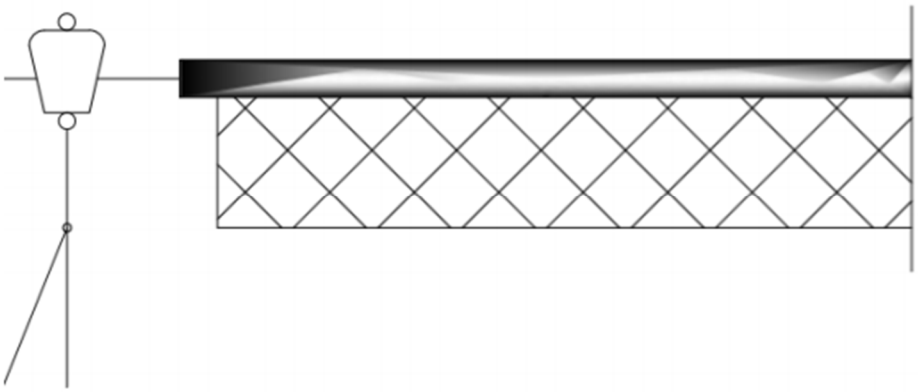


Figure 14. View of the PEHD pipe system with a network (Source: Klamfa, 2020)

9.3. Data on mussel production in the Krka estuary

According to the Study, the growth and survival of shellfish depend on these factors:

- mussel seed qualities,
- amount of available food (phytoplankton),
- physic-chemical characteristics of the growing area,
- temperature regime,
- amount of oxygen,
- salinity drew by water currents,
- density of farmed mussels,
- fouling organisms,
- diseases,
- attention during work.

In addition to the listed characteristics, the organization of work on the farm is essential. Primarily, this refers to the installation of the collector at the correct time during the year, observation of the growth of mussels, extraction and transplanting at a specific shell size. Sorting is crucial in mussel farming so that shells of similar size are placed in the same socks and removed when the mussel grows to market size. When it's time to extract market-size shellfish, they must pass through the dispatch centre for a health check, after which they are weighed, packed and marked with an origin stamp whose content is determined according to the relevant legal regulations.

Besides inflow, potential dangers can also be equipment damage after certain rough weather events, attacks by predatory species (mostly sea bream), fouling that prevents the average circulation of phytoplankton and the human factor of alienation of property or various pollution. Within the research for the Report under the concept of production, we asked respondents to enter specific values in their surveys lists:

● **Total mussel production in 2021** - refers to the rough estimate of the number of mussels (seeds and market-size shellfish) that contained the respondent's production lines in the reference year 2021. According to the obtained data, the two respondents reached even 90% and 72% of the potential production determined by the Study. However, a farmer with 50% of the total farming capacity gets only 14% of his possible production. According to this respondent, the cause of the reduced production probably originates from the high mortality that occurs during the inflow of fresh water in the cultivating zones where PEHD pipes have been installed, which we described as technology system type 3 (chapter 9.2). This farmer uses such technology on 17 of the 22 fields on which he owns concessions in the Estuary. According to the respondent, the mortality in the fields where this technology is located is 100% due to the impossibility of lowering the installed pipes. Other farmers fulfil their production potential in values between 30 - 50%, except for a few that fall below these values.

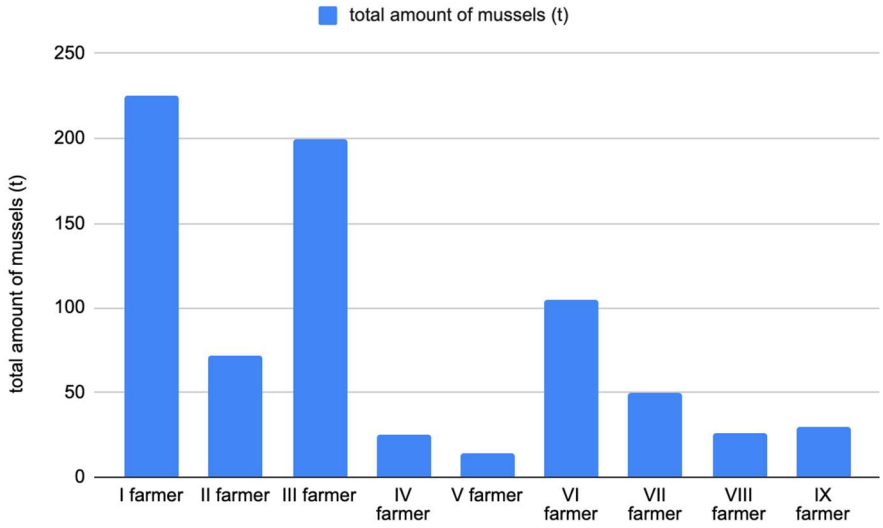


Figure 15. Estimated total amount of mussels according to respondents

Picture number 16 shows the relationship between planted seeds and market-size mussels. According to respondents, market-size mussels were sold primarily in the summer season, and most seeds were planted in spring 2021, so it is assumed that the planted quantities remain on the production lines until they reach market size (in approximately 9 months).

The graph shows that the respondents have an amount of planted mussel seeds equal to or less than the market-size mussels that are ready for sale. According to some farmers, such a situation occurred due to the abundant mortality caused by the influx of freshwater that year, predators, fouling, and the negative impact of the epidemiological situation due to the Covid-19 pandemic, under which the sale of shellfish in 2020 and 2021 declined significantly.

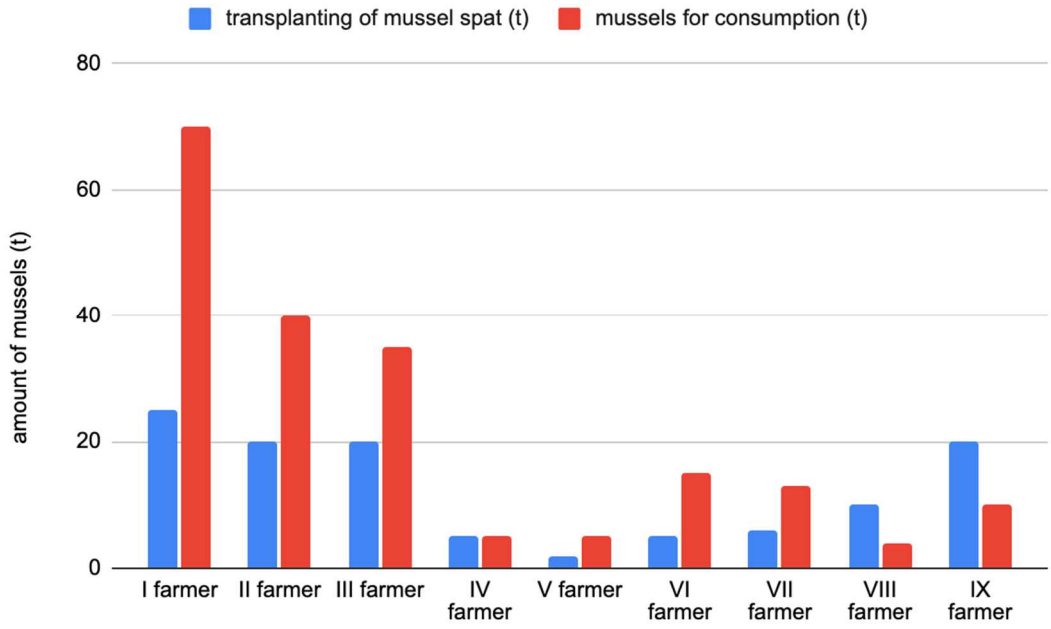


Figure 16. Comparison of planted seeds and market size shellfish according to respondents

According to the completed surveys, respondents believe that the mortality of shellfish is affected by the following factors:

- most of the respondents believe that fouling affects the shell production itself by about 10%;
- seven respondents believe that predators damage 30% of their production, while 2 of them believe that the mortality of 70% originates from invasive predatory attacks on farming installations;
- most respondents believe that the inflow of fresh water causes mortality of up to 30-50% on their farming fields, while the others lower the socks on lines. Therefore this phenomenon does not affect their mussel production as much.

9.4. Economic and social data on mussel production

The economic aspect of shellfish farming and its successful statistics largely depend on the biological characteristics of the mussel itself, primarily the nutrition, which mainly depends on the natural population of phytoplankton and their abundance. Therefore, the growth of shellfish corresponds to the amount and type of algae in their environment, i.e. their amino acid composition. The quantity of phytoplankton, on the other hand, depends on the season. According to research from the Study, the value of the weight of the wet edible part of mussels does not show regular seasonal changes, as was found in other bivalves (e.g. *Chlamys varia*), considering the amount of available food. The highest values of the

weight of the moist edible part of shellfish were recorded during winter and the lowest during autumn. Recorded values correspond to the period immediately before or after spawning.

In any case, the chemical composition of the edible part of the mussel partially (depending on the season) coincides with the average values of the edible part of shellfish prescribed by some authors, which contain 81% water, 13% protein, 1.5% fat, 1.6% ash (minerals) and about 1-3% of glycogen.

Most of our respondents plan their production concerning the expected sales in the summer when, due to the increased number of foreign visitors, mussels are sold at higher prices in catering facilities or at lower costs by direct sales to customers. However, a smaller number of farmers (4) sell mussels throughout the year, and they have this possibility because of the distribution of their products to retail chains.

None of the farmers exports their products outside Croatia (figure 17).

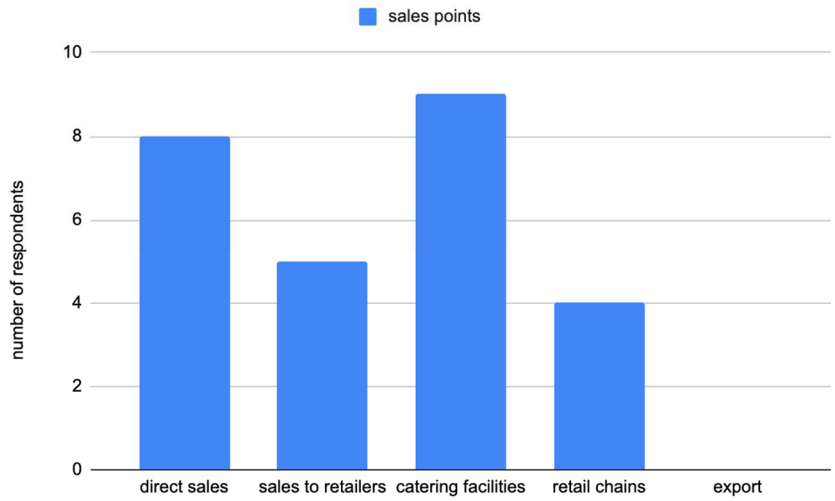


Figure 17. Mussels sale places by respondents

The costs of growing energy and water production per unit of time are negligible and, according to the Study, they amount to:

● electricity approx. 30 kW/h per ton of shellfish production,

● diesel fuel approx. 2 l per ton of shellfish production,

● gasoline approx. 7 l per ton of shellfish production,

● technological and hygienic-sanitary water consumption approx. 1000 l per ton of shellfish grown.

This calculation does not apply to farmers who own machinery for the mechanical processing of shells but are in the minority.

According to the Study, it is suggested that a minimum of two full-time employees and two seasonal workers per 65-70 t capacity of the production area work on the farm. The majority of farmers now operate according to these ratios.

According to our surveys, only men participate in the shellfish farming production process, mostly with at least a high school education process, mostly with at least a high school education.

CULTIVATION AREA		MUSSEL	
COUNTY	YEAR	MUSSEL PRODUCTION (kg)	MUSSEL SALE VALUE (kn)
ŠIBENSKO-KNINSKA	2017	109.267,00	1.057.193,09
ŠIBENSKO-KNINSKA	2018	85.231,50	919.812,60
ŠIBENSKO-KNINSKA	2019	92.260,00	1.007.891,30
ŠIBENSKO-KNINSKA	2020	37.182,50	424.385,50
ŠIBENSKO-KNINSKA	2021*	41.392,00	457.572,21

Data for 2012. are preliminary

Table 5. Official data on mussel production for ŠKC from 2017 to 2021. (Source: Directorate of Fisheries)

National data on shellfish production and sales value are generated through the collected data that farmers send from registered data logbooks.

According to the instructions for filling out the logbook, collected data are from farming technologies, size/length of production installations and sales. The sales section is entered separately for mussels, the quantity and value of shellfish during the reporting year and the values are entered in kilograms. The instructions state that the farmers determine the amount before any shell harvesting, the value after harvesting and before sales. The values are expressed in Croatian kuna without value-added tax (VAT).

Losses recorded in the register referred to natural mortality, predators and other factors.

The remaining shellfish farmers should also enter the log book based on a free estimated amount.

Through this research, we collected data on the sale of shellfish in 2021, shown in Figure 18. The total value of the sale of mussels in 2021, according to respondents, was HRK 1,699,092.5. In the second part of the survey, all respondents agreed that there is a grey and black market for shellfish in the local area, and controls on the cultivation and sale of shellfish are irregular. Therefore, it is difficult for farmers to work and sell shellfish products because, in their opinion, the shellfish market needs to be more organised, so in that business aspect, they need support from the national and local levels.

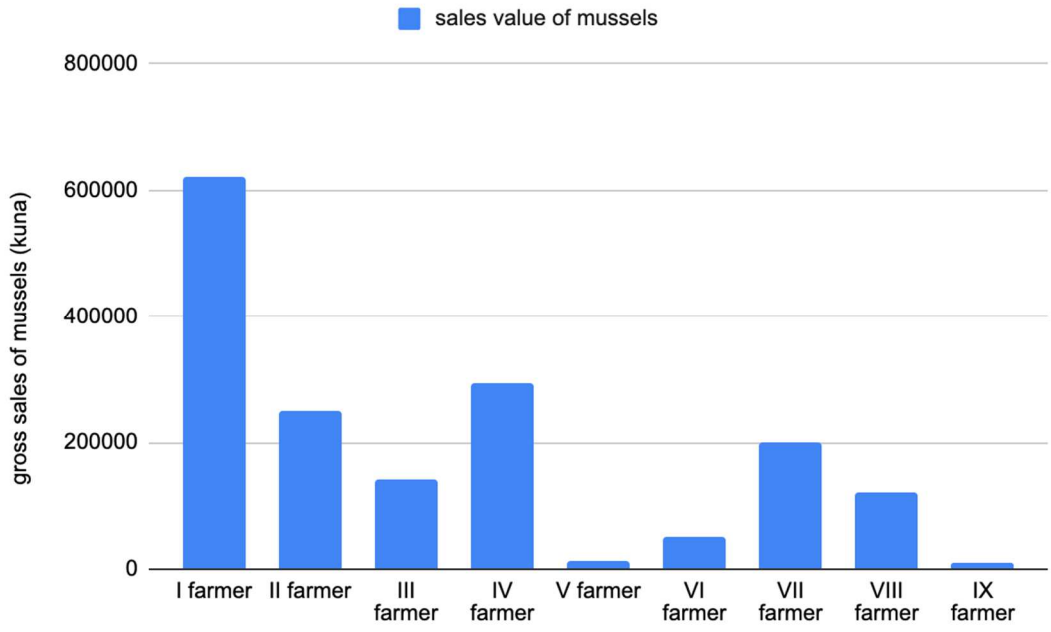


Figure 18. Value of mussel sales by respondents

A comparison of the national sales value data and the data collected through this Report at the local level at first glance shows a significant disparity, which may be the result of various factors:

- different data collection methodologies,

- credibility,
- interest of the respondent,
- understanding the question,
- the fact that the farming business is taken care of by authorized, third persons (e.g. accountants).

Although the EU, according to the first component of the Common Fisheries Policy (CFP), determined the Common Market Organization (CMO) for fishery and aquaculture products back in 2013, the success of such an idea to protect producers in this area has not yet been realized. There are no uniform market standards or an organized market.

The majority of farmers declared through the Report that they would be satisfied to have their products certified and believe that this way, they would confirm and ensure the market quality of their shellfish. Furthermore, by meeting the standards of specific production conditions, the respondents would also contribute to the ecologically sustainable exploitation of the living resources of the sea, which would contribute, at the same time to greater customer confidence and a better prospect of market value.

The current trend of association in the EU is producer organizations. Producers join together for the sake of better market competitiveness but also the sake of broader interests. This interest in the case of shellfish farming would refer to a joint influence on the sector's management in changing regulations, making procurement easier, primarily through financing from EU funds and general mutual support in the active part of the production. The majority of farmers, through our research, declared that they are for establishing the association. However, at the moment, there has yet to be an initiative among them to make the mentioned happen soon.

The organization of the sector is necessary to jointly plan to increase the competitiveness of mussel production in the local area and to create a Protected Designation of Origin (POI) that would add value to shellfish products. Furthermore, the Šibenik mussel is a trademark of the aquaculture of this region, so that branding would give it the necessary mark of diversity based on the competition of the same or similar products on the global market.

10. Participation of respondents in the measures financed by the European Maritime, Fisheries and Aquaculture Fund (EMFAF)

National Aquaculture Development Plan for the period until 2027 (from now on NADP) focuses on four specific objectives:

1) increasing the productivity and resistance of production in aquaculture to climate change;

2) strengthening the competitiveness of the aquaculture sector;

3) strengthening the aquaculture sector, contributing to the restoration of the economy and the improvement of living conditions in rural and coastal areas;

4) encouraging innovation in the aquaculture sector.

All these goals are essential for the regional aquaculture level and should be implemented with a particular direction and organization of the sector towards sustainable development. However, the issue that local shell farmers are facing now is the duration of their concessions. Namely, for most farmers, the period of the Concession Agreement on the maritime property they have with ŠKC expires this year. So the shell farmers in ŠKC need to be able to adapt their operations to applications for tenders of EU funds. The County solved that issue by changing their contracts in December 2022, along with changes on the location permit and other necessary documentation. With this change of arrangement of the Concession Agreement on the maritime property, the farmers got an extension of the concession period for another 5 years.

According to the NADP, one of the most important goals is investing in innovation, so we paid special attention in the survey to the respondent's ability to develop innovative methods for shellfish production. In addition, in the past financial period, within the Operational Program for Maritime Affairs and Fisheries, innovation in aquaculture was encouraged through measure II.1 in EMFAF.

One respondent claims that he has designed an innovative product whose feasibility has yet to be technically or economically tested. Also, the respondents of one company applied for the tender of measure II.1 with their innovative and improved production and product.

Measure II.2/II.3/II.4, related to Productive investments in aquaculture, was also a suitable measure for farmers in the past budget period. This measure covered activities such as production investments and modernization of shellfish farms, diversifying production and farmed species, switching to energy-sustainable aquaculture, adapting farming to climate change, reducing aquaculture's negative impact on the environment, and improving the quality and adding value to aquaculture products. Unfortunately, just two farmers applied for this measure in the past few years.

Through our research, we asked respondents how much they are involved and informed them about the Maritime, Fisheries and Aquaculture Operational Plan. Unfortunately, most of the answers were negative, and only those respondents who have applied for tenders are fully or somewhat knowledgeable about the topic.

Some of the activities financed by EU funds are diversifying farmed species. It is a fascinating topic for Estuary because, in the Study, its author IRB suggests the cultivation of other shellfishs besides mussels and oysters.

Through our survey in the part of the subjective view of local conditions and related to the diversification of shellfish production, many respondents believe that it is possible to have profitable production of shellfish that are not currently targeted or not produced at all in the Estuary, like species: European flat oyster *(Ostrea edulis)*, Mediterranean scallop *(Jacobaeus pecten)* and Mimachlamys varia *(Chlamys varia).* Most farmers are also ready to invest in the experimental cultivation of species that have yet to be produced in the Estuary area. They believe that for some species, it is necessary to establish a hatchery because their seeds were seen in the natural environment a long time ago, e.g. Mediterranean scallops.

11. Proposal of measures and methods of data collection with a *bottom-up* approach

11.1. Data collection as a tool for determining risk factors

As shown in the Report, it is necessary to determine, in addition to previously collected scientific studies on the environment:

- basic parameters of the production area,
- mussel production capacity,
- prescribed legal frameworks,
- pollution hazards that threaten the growing environment.

It is also necessary to define the economic characteristics of the sector through production and the socio-economic circumstances of concessionaires, as well as the farming technology through **official and alternative means of data collection**.

Given that the environment is the main precondition for setting up and carrying out quality shellfish farming, the increase of current production can be accomplished from this basic

request. There it is necessary to collect recent scientific evidence through a survey of the state of the environment as - **local monitoring** over a particular time:

1) determine stations for local monitoring of specific parameters at different depths (1-10 m) in the estuary of the Krka river, near Skradin and in the St. Anthony's channel;

2) monitor and record the following characteristics - water parameters (temperature, salinity, dissolved oxygen, organic matter, biomass and composition of phytoplankton and zooplankton, nutrient salts), biota (shellfish health, traces of metals and biotoxins in shells, fouling) and sediment (redox potential, carbon, nitrogen, phosphorus, type and granulometric composition of sediment, traces of metals).

Recommended is to monitor and record a minimum of:

- basic parameters of seawater (temperature, salinity, dissolved oxygen, phytoplankton) and sediment,

- quality of shellfish (sanitary-bacteriological control, sanitary condition, metals).

Local monitoring is also necessary to observe the impact of **climate change** on shellfish farming, which has not explicitly been researched in this area so far.

Particular attention should be paid to reducing human impact on the growing environment and potential pollution. It is necessary to harmonize the planned infrastructure projects around the Estuary with the farming environment and to reduce the wastewater from the surrounding settlements that continue to affect this sensitive landscape.

Collecting suggested parameters of local monitoring and environmental indicators as scientific evidence makes it possible to identify, assess and categorize business **risks. Protection goals and development measures can then** be proposed for the quality management of the shellfish sector in the Estuary area. Such proposals can also serve the management levels of the government for more specific regulations drafting and measures which are providing financing of the regional aquaculture sector.

Establishing a **local research team** is recommended to ensure that all collected data are reliable, technically correct and documented according to specific scientific criteria. The establishment of such a team is also necessary for the sake of constant education of growers and more effective data collection at the local level (*bottom-up* approach).

11.2. Determination of development measures

This research established that the collected alternative scientific data, through direct communication with shellfish producers, can document valuable indicators of the current situation in this branch of aquaculture in the local area. The most important result of involving farmers in data collection is gaining public trust and a better understanding of production opportunities.

It is essential that by collecting data at the local level, the risks factor are determined. In cooperation with local authorities and farmers as actors, science should identify and characterizes these risks through an evidence-based approach.

The research through this Report showed that the current **risk factors** of managing the shellfish sector in ŠKC are:

- predators,
- fouling,
- freshwater inflow,
- pollution.

They can directly affect on:

- changes in abiotic and biotic environmental factors,
- changes in suspended particles,
- changes in the water column and sediment,
- changes in the oceanographic properties of the Estuary,
- changes in primary production and food availability for shellfish,
- changes in the natural environment,
- changes in the health and hygienic-sanitary conditions of cultivated organisms.

Development measures can be used to construct specific necessary infrastructures and apply new technologies and practices for better management of the area and the farming sector.

Based on the assessed risks, an integrated **strategy and plan** for the development of sustainable aquaculture and the protection of the area can be designed. That strategy and plan could propose a management framework based on defined risk factors, i.e. problems with shellfish farming linked to the specific breeding environment and production activities in the Estuary.

Picture 19. Mussels on mesh socks

12. Conclusion

Within this Report, data were collected on two levels: from available scientific and professional literature, Internet data sources and by surveying farmers.

According to everything presented, the following conclusions were reached:

● At the **national** level, aquaculture data is tracked through administration and regulations. The **local** authorities run the spatial planning for aquaculture and location permits changes. They also regulate other necessary documentation that defines the impact of shellfish production on the environment.

● Out of nine **respondents**, one company owns 50% of the total production area, which is determined as an aquaculture area. The other respondents farm mussels in 10-15% of the total production area.

● According to **official national data**, production has been declining in the last 5 years. Shellfish farming in ŠKC amounts to only 5% of the total national production in 2021, 42.3 t. According to the presented **alternative data** from this Report and the other two surveys (from 2000 to 2021), a decline in production over 2 decades is visible despite the increase in the production area and the number of production fields.

● The best **technology** based on this Report is long lines, traditional shellfish farming with equipment that is biologically safe for the farming environment, reliable and installed according to the profession's rules.

● According to the **total production**, only two companies in 2021 achieved production of 90 and 72%, and the others gained 14-50% of their potential. The company that owns 50% of the total cultivation area achieves a small production because 77% of their production fields use farming technology, where the mortality is 100%, considering the inflow of fresh water.

● Some respondents believe that the cause of their lousy production is **mortality** caused by fouling, predators and the inflow of fresh water.

● Mussels are mainly **sold** in summer, and most shellfish are sold in restaurants.

● Official national and alternative **sales data** collected through this Report differ significantly due to several factors.

● To better manage the local shellfish sector, it is necessary to encourage farmers to organize themselves into **associations** that guarantee better market competitiveness.

● In addition to official and alternative methods of data collection, it is proposed by the author of this Report to establish a **local research team** that would carry out a specific system of the survey of the state of the environment and its impact on production - **local monitoring**. The collected data could be used to determine the **risks** in the farm operations and the mussel production process. According to such determined risks, development **measures, strategies and/or plans** for further sustainable development of the shellfish sector could be proposed.

13. Literature

ARUP, 2020, Development Strategy Proposal; Urban regeneration of an abandoned industrial zone in Šibenik

Alfier D., Čulav B., Marinčić A., 2020, Preliminary project for the issuance of a location permit for the establishment of shellfish and fish farming fields in the area of the Krka River, Šibenik, Klamfa doo

Bavčević L., Glamuzina B., Marguš D., 2009., Integral plans for the development of shellfish farming, COAST

Cvitković et al., 2019, Monitoring of the Krka estuary; Report on the initial assessment of biological and oceanological indicators, Split, IZOR

FAO, 2022., The state of world fisheries and aquaculture; Towards blue transformation

FAO, Eurostat, 2019, Croatia in the world and the EU

GDI doo, 2019, Aquaculture; User manual, Zagreb

Haramina et al., 2017, Resource mapping and sustainable management of the mariculture sector in Šibenik-Knin County, Zagreb, Green Infrastructure

Lončar et al., 2020, Program for fisheries and aquaculture for the programming period 2021-2027. year, Zagreb, VITA PROJEKT doo

Marguš D., 2009. Development of shellfish farming in the mouth of the Krka River; Vision, strategic measures and action plan for the development of shellfish farming in the mouth of the Krka River, Fishing, 67, 153-168

Marguš D., 2009., Three decades of shellfish farming; Three decades of shellfish farming in the estuary of the Krka River, Fishing, 67, 77-85

Ministry of Agriculture, 2022, National Aquaculture Development Plan for the period until 2027, Zagreb

Radeka R., 2018, Constructing a questionnaire for research, Final thesis, Pula: Jurja Dobrila University

Šibenik-Knin County, 2021, Development Plan of the Šibenik-Knin County for the period 2021-2027. year, Šibenik

Šorgić et al., 2019, Elaborate on environmental protection; Modification and supplementation of aquaculture operations in the area of the estuary of the Krka River, Šibenik-Knin County, Zagreb, OIKON

Teskeredžić et al., 2004, Environmental Impact Study for Aquaculture Facilities in the Krka River Estuary Zone, Zagreb, IRB

ANNEX I.

SURVEY FOR THE ARGOS PROJECT - joint management of fisheries and aquaculture activities as a lever for the protection of marine resources in the Adriatic Sea

GENERAL INFORMATION

OWNER OF THE PRODUCTION SITE (legal entity and/or natural person)
_____

FARMING FIELD CODE AND AREA (according to Aquaculture Permit)
_____
_____

CULTIVATED TYPES OF SHELLFISH AND ALLOWED QUANTITY OF PRODUCTION (according to the Permit for Aquaculture) _____

FARMING TECHNOLOGY FOR MUSSELS (circle one of the offered answers):

a) Line production (the so-called "Longline" system)

b) Production using floating tubes (the so-called "Raft" system)

FARMING TECHNOLOGY FOR OYSTERS (circle one of the offered answers):

a) Line production with cementation of oysters

b) Production in caskets (the so-called "Rack" system)

PRODUCTION

NUMBER OF BREEDING LINES (per field)

_____
_____

TYPE AND QUANTITY OF SHELLS PER GROWING LINE (you can use the calculation - number of pergolas per individual line x approximate weight of each mesh sock)

MUSSELS
_____

OYSTERS
_____

HOW MANY LINES OR PARTS OF LINES PER FIELD DO YOU USE FOR COLLECTION OF SPATS?
_____

PLANTED QUANTITY AND TYPE OF SEEDS IN 2021
_____

QUANTITY AND TYPE OF MARKET SIZE SHELLFISH GROWN IN 2021

_____

QUANTITY AND TYPE OF SHELLFISH HARVESTED IN A SINGLE SEASON (2021):

SUMMER HARVEST _____

SPRING HARVEST _____

AUTUMN HARVEST _____

MORTALITY IN 2021 _____

DO YOU COLLECT ADDITIONAL SHEELFISH SEEDS FROM OTHER HABITATS?
(which are not from the natural habitat of the Krka estuary - mark the answer)

YES NO

If you mark YES, indicate the amount and type of seeds collected from other habitats in 2021.

_____

IS IT POSSIBLE TO INCREASE YOUR PRODUCTION CONSIDERING YOUR CURRENT CAPACITY, TAKING INTO ACCOUNT THE LIMITATION OF THE ALLOCATED CONCESSION? (mark one of the offered answers in percentages)

a) An increase of up to 10% is possible

b) An increase of up to 30% is possible

c) An increase of up to 50% is possible

d) An increase of up to 70% is possible

e) An increase of up to 90% is possible

CONDITIONS NECESSARY FOR INCREASE OF PRODUCTION (mark one or more of the answers offered):

a) Change in technology

b) Investing in new equipment

c) Finding sources of seeds for mussels or oysters from other habitats

d) Construction of hatcheries for oysters

e) Increasing the workforce

f) Finding new markets for the possibility of export

If you marked the answer under a) and/or b), please indicate what technology and/or investment would be needed to increase the production of your farm.

_____
_____
_____

If you have marked the answer under c) and/or d), please indicate, according to your free estimate, what quantities of seeds from other habitats or produced in the hatchery would be needed to increase the production of your farm sufficiently.

MUSSELS_____

OYSTERS_____

ECONOMIC AND SOCIAL DATA

POINTS OF SALES (2021) (mark one or more of the answers offered):

a) Direct sales to customers

b) Sales to traders

c) Direct placement in catering establishments

d) Sales to retail chains

e) Sales for export

IF YOU ARE EXPORTING THE PRODUCTS, PLEASE STATE:

a) The country to which you are exporting

_____

b) Export quantities for 2021 by species

_____

REVENUES - GROSS SALES BY TYPE (2021)

MUSSEL_____

OYSTER _____

NUMBER OF EMPLOYEES
_____

EMPLOYEES BY GENDER:

MALE_____ FEMALE _____

AGE GROUP OF THE EMPLOYEES (mark one or more of the answers offered):

a) 0-20 years b) 20-30 years c) 30-40 years d) 40-50 years e) 50 and beyond

EMPLOYEE EDUCATION (mark one or more of the offered answers):

a) Finished elementary school; a number of workers _____

b) Completed high school; a number of workers _____

c) Higher education; number of workers _____

TOTAL ANNUAL STAFF COSTS (sum of all employees' costs):

_____
_____

SUM OF WORKING HOURS PER EMPLOYEE IN ONE YEAR/PAID WORKING HOURS
_____
_____

FOR THE FOLLOWING GROUP OF COSTS (from a-d), PLEASE WRITE THE APPROXIMATE ANNUAL COSTS:

a) Energy costs
_____

b) Raw material costs
_____

c) Maintenance costs (depreciation of equipment)

_____

d) Other business expenses
_____
_____

BUSINESS SUBSIDIES - SMALL VALUE SUBSIDIES (according to previous years):

2019._____

2020._____

2021._____

TOTAL VALUE OF ASSETS (capital)
_____

INNOVATIONS

HAVE YOU OR YOUR EMPLOYEES/ASSOCIATORS DESIGNED OR IMPROVED PRODUCTION ACCORDING TO SOME OF THE SUGGESTED PARAMETERS:

a) By developing technical, scientific or organizational knowledge on aquaculture farms that reduce the impact on the environment, encourage the sustainable use of resources and facilitate new sustainable methods of use

b) Development and/or introduction of new and/or significantly improved products

c) By developing and/or introducing new or improved procedures and/or new or improved management and organizational systems

d) Examining the technical and/or economic feasibility of innovative products or procedures

SUBJECTIVE VIEW OF LOCAL OPPORTUNITIES

WHAT DO YOU THINK IS THE ADVANTAGE OF FARMING IN THE ESTUARY OF THE KRKA RIVER? (mark one or more of the offered answers)

a) High productivity of the area itself, which causes rapid growth of shellfish

b) Stable amount of mussel spat

c) Stable amount of oyster spat

d) Ensured space for increased production by all levels of government

e) Long-standing tradition

ACCORDING TO YOUR KNOWLEDGE, IS THERE A NEED FOR ADDITIONAL QUANTITIES OF SHELFISH SEEDS WHICH DO NOT COME FROM NATURAL SOURCES BUT CAN BE OBTAINED BY ARTIFICIAL SPAWNING? (mark)

YES NO

If you marked YES, choose the type of shell whose nature you consider insufficient to start production. (mark one or more of the offered answers)

a) European flat oysters

b) Mediterranean scallop

c) Mimachlamys varia

DO YOU THINK THAT THE PROFITABLE PRODUCTION OF SHELLFISH SPECIES THAT ARE CURRENTLY NOT IN THE FOCUS OF FARMERS WITHIN THE KRKA ESTUARY IS POSSIBLE? (mark one or more types)

a) European flat oysters

b) Mediterranean scallop

c) Mimachlamys varia

WOULD YOU TRY THIS TYPE OF EXPERIMENTAL GROWING YOURSELF? (mark)

YES NO

ARE YOU SATISFIED WITH THE SUPPORT OF LOCAL GOVERNMENT LEVELS? (mark)

YES NO

DO YOU THINK THAT THE COUNTY WILL ENSURE BY OBTAINING OF NEW LOCATION PERMITS (by drawing up *the Conceptual Project for the obtaining of location permits for the establishment of shellfish and fish farming fields in the area of the Krka River mouth* and the *Environmental Protection Elaborate for amending and supplementing the aquaculture operations in the Krka River area*) SPACE FOR FURTHER DEVELOPMENT WILL BE ENSURED FOR FURTHER SHELLFISH PRODUCTION IN THE ESTUARY OF KRKA, i.e. INCREASE IN PRODUCTION? (mark)

YES NO

DO YOU THINK THE COASTAL INFRASTRUCTURE WHICH MAKES SHELLFISH PRODUCTION EASIER HAS BEEN DEVELOPED ON THE LOCAL LEVEL? (mark)

YES NO

ARE YOU SATISFIED WITH THE SUPPORT OF THE NATIONAL-LEVEL AUTHORITY? (mark)

YES NO

ARE YOU FAMILIAR WITH THE POSSIBILITIES OF FINANCING FROM EU FUNDS? (mark)

YES NO

HAVE YOU APPLIED FOR A TENDER FOR FINANCING FROM EU FUNDS? (mark)

YES NO

If you marked YES, please indicate which EU fund tenders you have applied for and whether you were approved for financing.

_____

WHAT CHANGES WOULD YOU LIKE TO BE INTRODUCED AT THE LOCAL/NATIONAL LEVEL IN AQUACULTURE? (mark one or more of the offered answers)

a) Better cooperation of the local level of government with farmers

b) Better communication at the national level of government regarding the information on EU funds

c) Establishment of an Aquaculture Center that would focus on shellfish purification

d) Establishment of the Center for Aquaculture, which would focus on increasing shellfish production

e) Establishment of an Aquaculture Center that would focus on processing

f) Establishment of a research Center for aquaculture

g) Establishment of shellfish hatcheries

ARE YOU FAVOR OF ESTABLISHING AN ASSOCIATION/COOPERATIVE OR PRODUCER ORGANIZATION OF LOCAL FARMERS?

YES NO

ARE YOU WILLING TO INVEST IN ADDED PRODUCT VALUE AND/OR PRODUCT CERTIFICATION AND/OR ECOLOGICAL PRODUCTION?

YES NO

ARE YOU FOR THE INTRODUCTION OF NEW CULTIVATION TECHNOLOGIES? (mark)

YES NO

DO YOU CONSIDER THAT THE AQUACULTURE PRODUCTION OF KRKA ESTUARY IS ENVIRONMENTALLY THREATENED DUE TO HUMAN ACTIONS AND IN WHAT WAY? (mark one or more of the offered answers)

a) Surrounding municipal waters

b) Nautical tourism

c) Future construction plans in the land area around the estuary of the Krka river

HOW DOES FOULING OF YOUR EQUIPMENT AFFECT YOUR SHELLFISH PRODUCTION (mark the approximate percentage reduction in production)?

a) 10%

b) 30%

c) 50%

d) 70%

e) 90%

HOW DO PREDATORY FISH SPECIES (e.g. sea bream) AFFECT YOUR SHELLFISH PRODUCTION (mark the approximate percentage reduction in production)?

a) 10%

b) 30%

c) 50%

d) 70%

e) 90%

HOW DOES MORTALITY AFFECT YOUR SHELLFISH PRODUCTION (mark the approximate percentage reduction in production)?

a) 10%

b) 30%

c) 50%

d) 70%

e) 90%

DO YOU THINK THE NAVIGATION THROUGH THE CHANNEL HAS A NEGATIVE INFLUENCE ON YOUR SHELLFISH PRODUCTION? (mark)

YES NO

DO YOU THINK THE LOCAL SHELLFISH MARKET IS ORGANIZED? (mark)

YES NO

DO YOU KNOW THERE IS A GRAY MARKET WITHIN LOCAL AQUACULTURE? (mark)

YES NO

IS THERE A BLACK MARKET WITHIN LOCAL AQUACULTURE (illegal trading)? (mark)

YES NO

DO YOU THINK THE SHELLFISH FROM THE ŠKC AQUARIUM ARE ADEQUATELY PROMOTED ON A LOCAL OR NATIONAL MARKET? (mark)

YES NO

ARE YOU FAMILIAR WITH THE AQUACULTURE CENTER PROJECT (dispatch-purification centre)? (mark)

YES NO

IN YOUR OPINION, DO YOU THINK THE ESTABLISHMENT OF AQUACULTURE CENTER WILL CONTRIBUTE TO THE DEVELOPMENT OF AQUACULTURE IN ŠKC? (mark)

YES NO

If you circled YES, indicate if you agree with any of the following statements - the Center for Aquaculture will contribute to:

a) general increase in shell production.

b) hygienic and sanitary correctness of the produced shells.

c) opening of new markets.

d) increasing manipulative and/or storage space for growers.

e) step to establishing shellfish hatchery.

f) establishment of shellfish processing.

ARE YOU WILLING TO PARTICIPATE IN RESEARCH PROJECTS CARRIED OUT BY PUBLIC INSTITUTIONS BY ASSIGNING A PART OF YOUR NATURAL RESOURCES (concessions) FOR THE NEEDS OF THE PROJECT?* (mark)

YES NO

*projects can be for the development of marketing strategies, experimental production of the new species, research on the reduction of fouling, the establishment of an integrated system of multi-trophic aquaculture, ecological production and the like.

WHAT TYPES OF WASTE DOES YOUR FARM SITE GENERATE? (mark or complete)

a) Plastic (e.g. mesh socks)

b) Large waste

c) Bio-waste (e.g. remains of shells)

d) Some other type of waste (specify) _____

DO YOU DISPOSE OF GENERATED WASTE PROPERLY? (mark)

YES NO PARTIALLY

DOES WASTE DISPOSAL CAUSE LARGE COSTS IN YOUR BUSINESS? (mark)

YES NO

DO YOU NEED FINANCIAL ASSISTANCE FROM NATIONAL OR LOCAL AUTHORITIES FOR WASTE DISPOSAL? (mark)

YES NO

THANK YOU FOR YOUR ATTENTION!