Technical update report

subject: TECHNICAL UPDATE ON *DELIVERABLE* N. 2 – MONITORING AND ACTION PLAN FOR *Callinectes sapidus* RATHBUN 1896

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activities: Technical report: specific monitoring protocol and relative action plan towards the IAS *Callinectes sapidus,* aimed at the "evaluation of the threats to biodiversity caused by the IAS and relative action plan for the protection of biodiversity", inside BEST project - *Addressing joint Agro- and Aqua-Biodiversity pressures Enhancing SuSTainable Rural Development.*

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Premise

The present report aims at realizing a management plan concerning the invasive species *Callinectes sapidus,* also known as blue crab. This plan is composed by two sections: a monitoring plan, whose goal is to characterize the spatial and quantitative patterns of the distribution of the species on the territory, and a relative action plan. The latter will be strictly related to the monitoring plan, proposing different management strategies depending on the different outcomes.

Chapter 1. Introduction

Protecting biodiversity is one of the main and most ambitious goals of our times, requiring a strong cooperation among institutions and local managers. Many anthropic factors represent a great menace in this regard, including the introduction of Invasive Alien Species (IAS), which is considered one of the main threats to biodiversity around the world.

1.1 The Invasive Alien Species

According to Kolar & Lodge (2001), ecologically speaking a species is defined as invasive when able to quickly spread from the introduction point throughout the territory, becoming abundant and eventually dominant in this new area. This is possible thanks to the following characteristics (Life ASAP Project):

1. Resistance to parasites and diseases
2. Adaptation to different environmental conditions, including highly anthropized ones
3. Higher competitiveness in exploiting the resources, compared to the native species (sometimes producing allelopathic substances)
4. Quick growth
5. Short life cycle
6. High reproductive potential
7. High diffusion capabilities, eventual asexual reproduction
8. Adaptation of the life cycle depending on the invaded environments
9. Consociation with human activities
10. Resistance to predators/competitors in the new area

From a regulatory point of view, IAS are defined as those species threating biodiversity and related ecosystem services (CDB 2000, 2002), with negative impacts on economic activities and human health. It is thus important to distinguish between alien species and invasive species, as a new introduced species may not necessarily be related to a menace for local biodiversity.

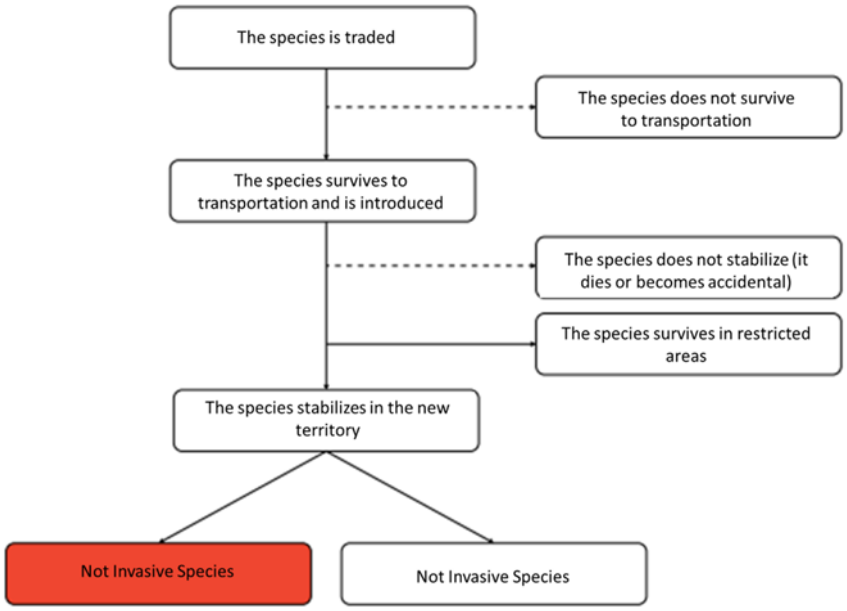

Figure 1: introduction and potential invasion process of an alien species.

According to the tens rule (Williamson, 1996), around 10% of introduced species survive to the transportation, and 10% of these species stabilize in the new environment. Again, a 10% of these stabilized species may become invasive, giving an overall 0,001% probability of invasion of a new introduced species. Obviously, this "rule" represents an estimation, but still remains a reference point in the study of biological invasions.

1.2 *Callinectes sapidus* as an Invasive Species in the Apulian territory

The blue crab (*Callinectes sapidus* RATHBUN, 1896) is a brachyuran decapod from the Atlantic Ocean, introduced in Europe at the beginning of the 20th century. Listed among one the 100 worst invasive species in the Mediterranean thanks to high adaptation capabilities, it can alter the ecosystem mainly competing with other native crab species and cause a negative economic impact to the local fishing activities. The growing number of sightings testifies a quick growth in terms of abundance and distribution all across the Mediterranean Sea. This makes *C. sapidus* an Invasive Alien Species, for which specific and integrated management plans are still not available.

The main goals of this plan are hence the production of a containment plan for the blue crab inside Lesina and Varano lagoons, in the northern part of the Gargano peninsula. The present plan provides for the realization of a first monitoring plan to estimate the abundance of the species in these lagoons, through a stratified monitoring protocol taking in account the difference of salinity inside the lagoon, and by placing specific trapping areas close to the channels (in order to catch ovigerous females during their reproductive migration). Containment actions will focus on the fishing

and physical removal of the captured individuals, which will be disposed of or be sold as a commercial fishing resource, through the cooperation with local fishermen and stakeholders.

Lesina and Varano lagoons are semi-confined areas where *C. sapidus* is present and abundant. This, in addition of being inside the National Park of Gargano and constituting part of Natura 2000 network, makes them suitable areas where to perform this pilot protocol. In any case, the blue crab is not the only exotic species inside these lagoons, because of their proximity to many human activities, making them high-risk areas from this point of view.

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Table 1: Characterization of invasiveness of *Callinectes sapidus*.

Invasiveness characteristics	Evaluation
Velocity of diffusion	Highly dispersive
Tendency of prevalence	Dominant
Level of threat to biodiversity	Competitive
Regional distribution	Widely distributed

Chapter 2. Characteristics of the species

2.1 Morphological description

TAXONOMY

Phylum: Arthropoda
Class: Malacostraca
Order*:* Decapoda
Family: Portunidae
Genus: *Callinectes*
Species: *Callinectes sapidus*

Figure 2: taxonomical framework of the blue crab with pictures: female (sx) and male (dx) of *Callinectes sapidus.* We can see the difference in colour of the claws, blue in the male and orange in the female.

The blue crab (*Callinectes sapidus* RATHBUN, 1896) is a crustacean decapod from the family of portunidae. Adults can reach 15 cm in length and 23 cm of width. The shell shows nine acuminate teeth on the front, the last longer than the others. The chelipeds are robust, longer than the pereopods, shorter and flattened. The merus of the claws shows 4 spines. The last pair of pereopods are even more flattened, as an adaptation to swimming. The colour of the shell goes from grey to blueish green on the back, with a brighter abdomen. In the male, the claws are metallic blue, while the female shows orange patterns. In the male the abdomen shows segments from 3 to 5 fused together, shaped like a T. Before the moult, the last pair of pereopods starts showing some pink spots, turning to red as the moult gets closer. In the picture the morphological features of the blue crab are shown, which can be used by technicians and citizens to distinguish the crab from other species (with particular attention to other species of portunids)

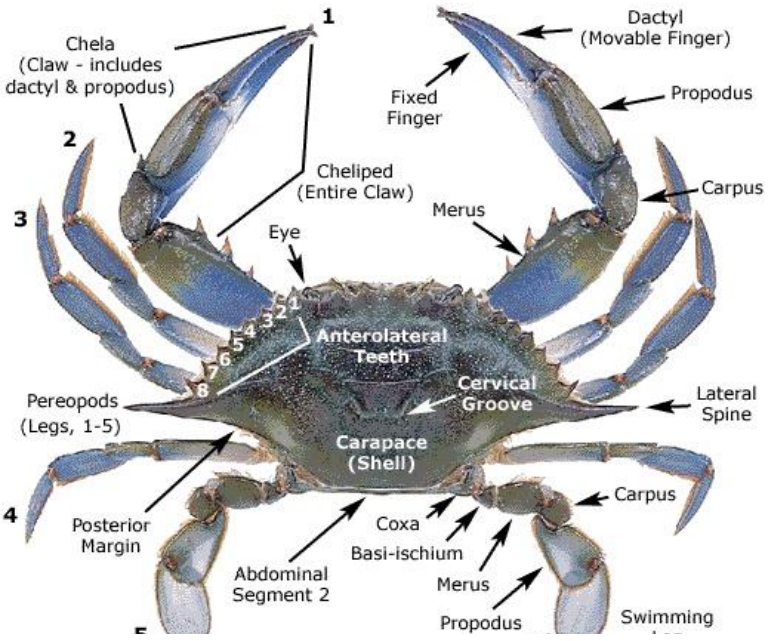

Figure 3: schematic representation of the main morphological features of *Callinectes sapidus*

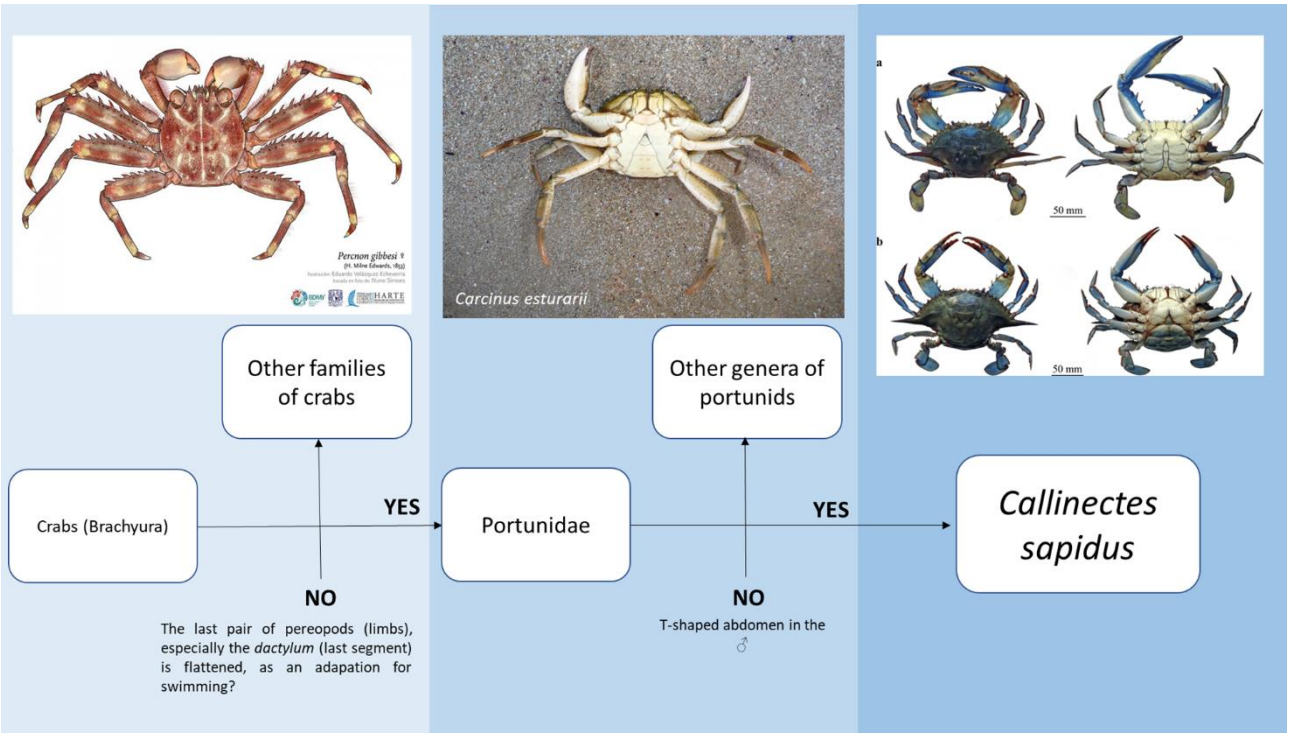

Figure 3. Key to the identification of *Callinectes sapidus* (credis: www.gulfbase.org; George Chernilevsky (*Wikimedia commons*); MuVe Venezia; Vasconcelos *et al*., 2019).

2.2 Ecological features

The blue crab is omnivorous, eating invertebrates, fishes and algae as well. It is preyed upon other fishes and bird, especially during its early life stages. Also, the blue crabs may be eaten by other individuals of the same species and by humans as well, being a fishing resource.

C. sapidus is a coastal species living in muddy or sandy bottoms close to estuarine areas, thanks to its tolerance to different levels of salinity up to 117‰. It bears difference in temperatures from 3 to 35°C, and with a concentration of dissolved oxygen up to 0,08 mg/l, making the blue crab a very adaptable species. its distribution is determined by many factors, including seasonality, age and sex. Adults tend to be ubiquitarians in the estuarine areas, with a distribution of males in low-salinity areas and females in high-salinity areas. During autumn/winter, when temperatures are lower, blue crabs migrate towards deeper zones, where they dig a burrow in the bottom.

The species host some cirriped parasites like *Loxothylacus texanus* and *Octolasmis muelleri*, which gets attached to its gills, or worms like *Carcinonemertes carcinophila.*

2.3 Reproduction and development

The blue crab is a highly fertile species, and the female can lay up to 8 million eggs per time. They reproduce only once in their life, after their final moult, when their shell is still soft, and males can transfer their sperm. The male will

then protect the female, as long as the shell gets hard again. Reproduction occurs in late summer, and egg deposition starts from 2 to 9 months after mating (from late autumn to early summer), hence comprising a broad period with its peak during the summer season.

Just before the deposition, when the female carries its eggs, it takes the name of “sponge” or “berry”, a stage that lasts about 14-17 days. Shortly before the hatching, females migrate to higher-salinity zones (requiring the larvae concentrations of about 20‰), going towards the open sea.

C. sapidus larvae have 7 moult stages as zoeas (sometimes 8) and a post-larval stage as megalopes. Total larval stage lasts 30-50 days, before completing the post-larval stage in 6-58 days. Eggs hatching occurs during high-tide phases and in deep water areas, and individuals come back to estuarine areas at the stage of megalope. Blue crabs tend to live about 4 years.

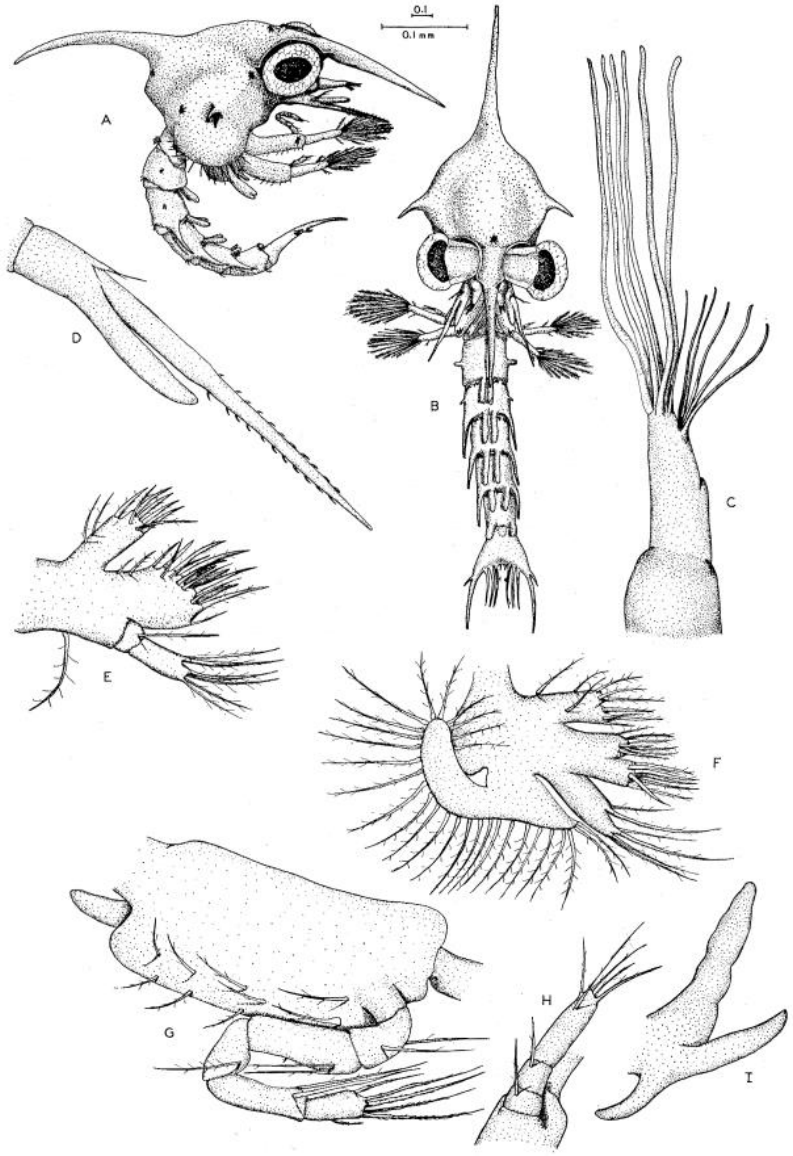

Figure 4: Side (A) and ventral view (B) of seventh zoeal stage of *Callinectes sapidus* with appendages. C, antennule; D, antenna E, maxillule; F, maxilla; G, endopodite of first maxilliped; H, endopodite of second maxilliped. Whole larva, X43; appendages, X170. From Costlow Jr *et al.*, 1959.

Chapter 3. Distribution and pathways of introduction

3.1 Distribution

The blue crab is native to the Eastern Coast of Atlantic Ocean, from Canada to Argentina, including the Gulf of Mexico. In the last decades it has been introduced in Asia and Europe, including the Mediterranean basin, Aegean Sea and Black Sea.

The first record in Europe dates back to 1901 at Rochefort, France. In 1949 it was sighted in the Mediterranean Sea in Grado, Italy. Today the species is widespread in the Adriatic, Ligurian and Ionian Sea. In Apulia, the first sighting dates back to 2001, in Salento, with an adult male. Other documented sightings were related to adult, ovigerous females. Since then, more and more sightings have been recorded by citizens and the academic world, testifying a quick expansion in the whole territory. For the Puglia Region, a specific survey has been designed, in collaboration with ERSE soc. coop. targeting the managers of the local protected areas to gather information on invasive species. Overall, the survey highlighted a wide distribution of the species, documented in the following protected areas:

- Natural Marine Protected Area Porto Cesareo
- Natural Regional Park Fiume Ofanto
- Natural Regional Park Mar Piccolo
- Natural Regional Park Dune Costiere da Torre Canne a Torre San Leonardo
- Natural Regional Park Litorale di Ugento
- Natural Regional Park Salina di Punta della Contessa
- National Park of Gargano (circumscribed to the basin of Lesina lagoon, included inside Natural Reserve Lago di Lesina)
- Natural Reserve Torre Guaceto
- Oriented Natural Regional Reserve Bosco di Cerano
- Oriented Natural Regional Reserve Litorale Tarantino Orientale

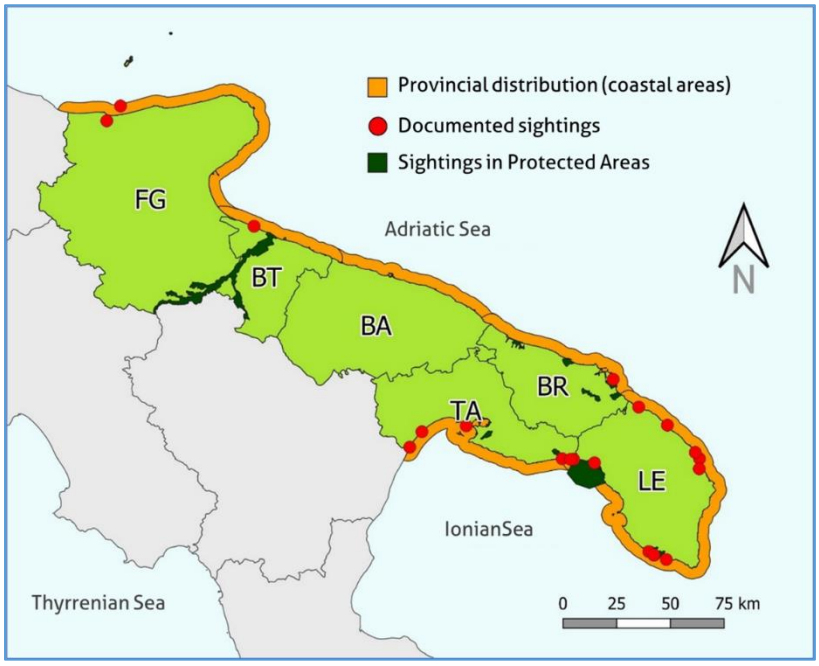

Figure 5: Regional distribution of the blue crab *Callinectes sapidus.* In orange the provincial distribution is shown, highlighting the coastal areas. In red the sightings from online databases (Mapreacter ISPRA, iNaturalist), scientific papers and the survey are reported. It is likely that the species is present in other areas not shown in the map.

3.2 Pathways of introduction

The main cause of introduction of the blue crab seems to be related with cargo shipping, being the larval stages of the species being transported through ballast waters. It also may be possible that the introduction occurred during multiple, independent events. Other pathways may be connected with fishing activities.

The first individuals may then have reproduced and migrated throughout the Basin, contributing to the diffusion of the species.

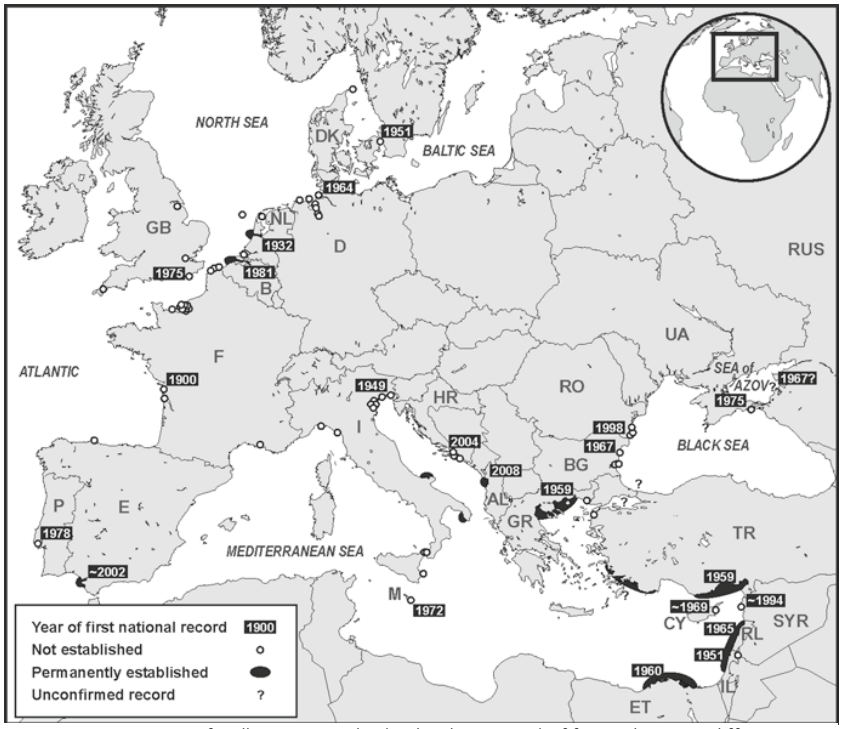

Figure 6: occurrences of *Callinectes sapidus* (with relative year) of first sightings in different areas of Europe and Western Asia. From Nehring, 2011.

Chapter 4. Impacts

4.1 Ecological impacts

From an ecologically point of view, *C. sapidus* is considered to be highly adaptable, with the ability of stabilizing and altering trophic relationships of the local biological communities. In its native area, the blue crab is a keystone species, playing a fundamental role in the lagoon/estuarine environments by interacting with many species. The young individuals have a more omnivorous diet, feeding on plants and animals, while adults tend to be more carnivorous, eating fishes, crabs, molluscs and other invertebrates.

In the Mediterranean Sea, isotopic analyses suggested and overlap of the ecological niche between the young individuals of blue crab and other native species like the marbled crab (*Pachygrapsus marmoratus*), the leaping mullet (*Liza saliens*) or the broadnosed pipefish (*Syngnathus typhle*), while adults show affinity to the ecological niche of the green crab (*Carcinus aestuarii*).

In addition, the impact of the blue crab is represented by the direct effects it has on the species if feeds on, like the Mediterranean mussel (*Mytilus galloprovincialis*) or the Mediterranean limpet *(Patella caerulea*).

4.2 Economic impact

Bycatch of *C. sapidus* can be responsible of damaging the fish and the nets themselves, with negative economic effects on fishing industry. Among the possible impacts there is also the potential threat towards the bivalve farming industry, like for the Pacific oyster (*Crassostea gygas*), which the blue crab feeds on.

4.3 Sanitary impact

It has been observed that *C. sapidus* is a potenzial vector for pathogenic bacteria like *Vibrio cholerae*.

Chapter 5. Regulatory aspects

The cornerstone of European legislation, and consequently Italian and regional legislation, is Regulation (EU) n. 1143/2014 of the European Parliament and the Council, of 22 October 2014, laying down provisions to prevent and manage the introduction and spread of invasive alien species. It requires, inter alia, the rapid eradication or control of those species by the Member States.

This decree introduces the prohibition of "introduction, transport, detention (even in confinement), exchange, breeding, reproduction, trade and release into the environment" of the species, for public and private subjects (also individual citizens), and require eradication, where possible, and control or containment of naturally occurring sun perch populations to prevent further dissemination and mitigate negative impacts on biodiversity. Derogations from the prohibitions may be granted, subject to authorisation by the MiTE (Ministero della Transizione Ecologica), to botanical and zoological gardens, research institutes and other entities carrying out research or conservation activities ex situ. In exceptional cases, the possibility of derogating authorisation shall be granted on grounds of overriding public interest, including those of an economic or social nature. No derogation shall be granted for trade and release into the environment of species listed in the Annexes thereto.

The allochthonous species to which the aforementioned regulations apply were subsequently identified through the creation of lists of invasive alien species of Union relevance or IAS (Invasive Alien Species), through the Implementing Regulation (EU) of 13 July 2016, Commission Implementing Regulation (EU) 2017/1263 of 12 July 2016, Commission Implementing Regulation (EU) 2019/1262 of 25 July 2016.

The Italian legislation transposes Regulation (EU) No. 1143/2014 of the European Parliament and the Council by means of Legislative Decree 230/2017 of 15 December 2017. The measure lays down rules to prevent, minimise and mitigate the adverse effects on biodiversity caused by the introduction and spread, whether deliberate or accidental, of invasive alien species within the European Union, and to minimise and mitigate the impact that these species may have on human health or the economy in Italy. the Ministry of the Environment and the Protection of the Territory and the Sea has moreover published two decrees directly connected to the D.Lgs. 230/2017, that is the Ministerial Decree of 6 March 2020, that regulates the institution and the compilation of the register of the exotic species, and the Ministerial Decree of 29 April 2021, which regulates tariffs for activities provided for by D.Lgs. no. 230/2017.

The Apulia Region, net of the Community and Italian legislation on the problem of alien species, establishes a regional coordination table for the control of invasive alien species, through the Decree of the Regional Council 815/2019, of 2 May 2019.

Callinectes sapidus has not been defined as an invasive alien species of Union concern. It is however recognized as an impact and included among the 100 most invasive marine species in the Mediterranean Sea (Streftaris & Argyro, 2006), a document that, although without regulatory value, is an important source of information for conservation actions.

Chapter 6. Monitoring plan

Considering the regulatory aspects of the European Union, monitoring appears to be a key tool to determine the status of the species, by individuating the essential parameters to determine its presence, distribution, abundance, habitats and future trends.

Data must be collected through standardized methodologies, and these must be combined with information collected through previous monitoring campaigns, scientific literature, sightings, and so on. This chapter will then focus on the monitoring techniques required to reach the aforementioned goals.

6.1 Data collection

Collecting the data through bibliography represents a crucial step, as a high-quality information allows to correctly set up the monitoring protocol, together with regards to the techniques and the time scale. This information itself cannot substitute the direct data collection on the field, but it can optimize the sampling effort, with a positive impact on the economy of the project.

The information is collected from three sources:

- Scientific papers
- *on-line databases*
- Protected area manager survey

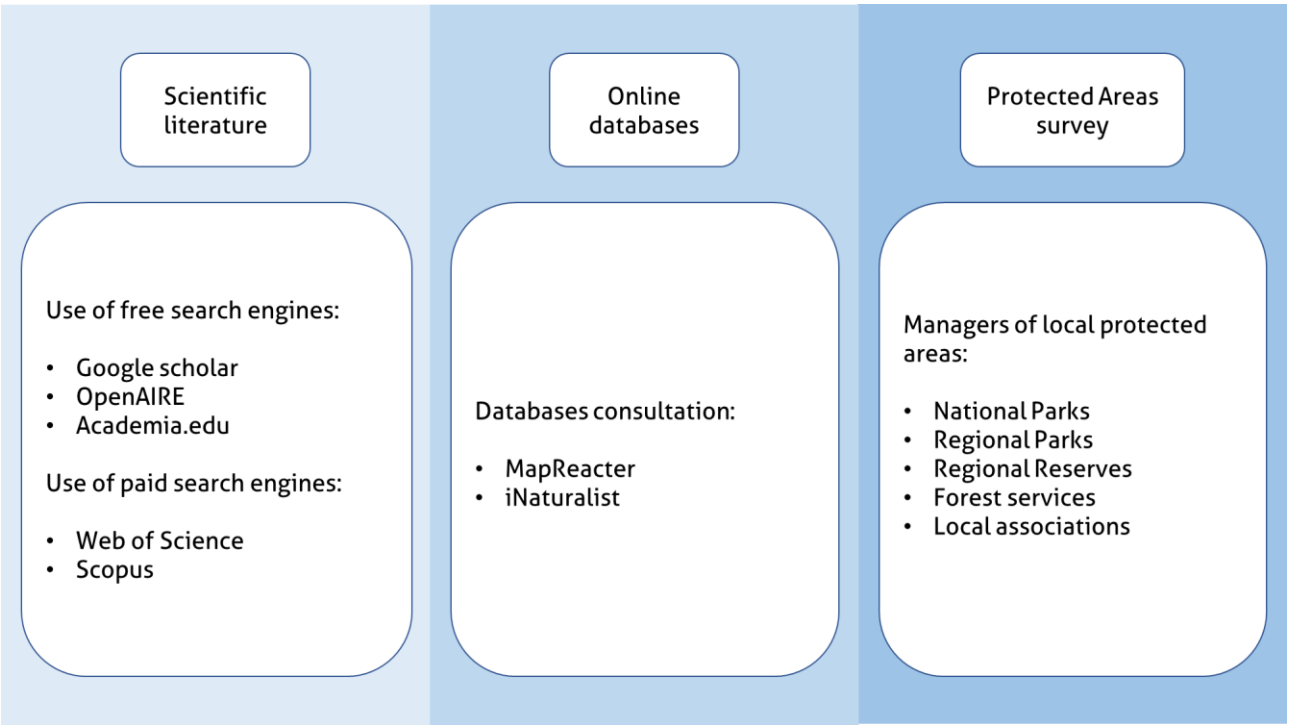

Figure 7: diagram of the source used to collect the data.

6.1.1 SCIENTIFIC LITERATURE

This source is represented by highly specific scientific journals or technical/informative material, with a major attention to the most authoritative papers (high-impact periodicals, subjected to peer-review; local journals, with high attention to the small-scale patterns). This source may give us information about distribution and abundance of the species. For the present project dedicated search engines have been consulted, as for example *Google Scholar, OperAIRE, Academia.edu, Web of Science, Scopus*.

6.1.2 CONSULTATION OF ONLINE DATABASES

This source is represented by online data collectors, like for geographical information (from which we can determine part of the spatial distribution of a species). There may be some biases due to the upload of incomplete/wrong data, especially by people participating to citizen science projects; specific databases periodically review by experts or technical staff. This tool has the advantage of being continuously updated, avoiding the usual gap between the writing of scientific papers and their publication.

For the present project two main databases have been used: *Mapreacter* from ISPRA and *iNaturalist*.

6.1.3 SURVEYS

Many projects rely on the contribution of citizen science protocols, by gathering information from citizens or stakeholders. For the present project, a specific survey has been proposed to the managers of the local protected areas concerning the presence and distribution of IAS (available at the end of the document, appendix A, produced by Puglia

Region and ERSE soc. coop. s.t.p.). This tool aimed at evaluating the critical points about the impacts of these species on the habitats and on the other species, together with gathering information on existing projects for this issue.

6.2 Description of the monitoring plan

This chapter defines the specific modalities to carry out the Monitoring Plan of *Callinectes sapidus* within the Gargano National Park, specifically at the basins of Lake Varano and Lake Lesina.

Numerous blue crab monitoring protocols are known in the literature, using different fishing and catching techniques of individuals. The *Winter Dredge Survey*, a specific catch protocol for *Callinectes sapidus* carried out since 1990 in the Chesapeake Bay, north-east of the United States, the practice of which is to catch individuals by dredging the specimens sunken in the mud during the winter season.

However, the intrinsic characteristics of the territory should be taken into account in this monitoring protocol and should be calibrated according to local needs and the ecological, social and economic characteristics of the context in which it will be applied. As regards the Apulian territory, specifically estuarine and brackish areas, these are bodies of water often contained within protected areas, whose ecological and conservationist value needs special attention from the point of view of management and for which any minimum impact is potentially to be carefully weighed.

This Monitoring Plan is based on the use of specific fishing equipment and subsequent characterization of the captured individuals. The definition of a monitoring system based mainly on the use of pots, whose main objective will be to characterize the population structure (density, ratio between the sexes, spatial dispersion, distribution, age) of the blue crab in the above basins.

6.2.1 LOCATION OF MONITORING SITES

primary importance.

As a first step it will therefore be necessary to identify areas with different levels of salinity, creating three groups of transects:

- high salinity areas,
- low salinity areas,
- areas with intermediate salinity.

For each of these categories it will be necessary to identify suitable areas for the deposition of fishing equipment. In this regard it will be important to choose sites where there will be no human intervention in the short and medium terms (including ordinary fishing activities) in order to be able to repeat monitoring actions over the years and to have a set of reliable data.

Varano Lake

Salinity levels of brackish water lagoons depend mainly on the inflows of fresh and salt water into the basin and the level of precipitation, which result in a concentration or dilution of solutes. In the Varano basin the salinity levels vary from 23 to 31,9‰ (Frontalini et al., 2013), with the lowest values located in the south, further from the sea outlets, and the highest values located in the northwest region, near the mouth of Capoiale. Since the population of the target species moves to different salinity ranges based on the life cycle phase, therefore, in order to obtain a representative sampling of the entire population, n.4 sites will be identified for each salinity category according to the following subdivision:

- salinity areas >28‰ (high salinity) - 4 sites,
- salinity areas 25-28‰ (intermediate salinity) - 4 sites,
- salinity areas <25‰ (low salinity) - 4 sites.

Each site must be spaced from the others by at least 200 m and for each of these sites should be placed n. 4 pots.

NB - In order to capture the largest number of female individuals during their spawning migration into the open sea, it is recommended to place at least two sites near the mouth of the canals that lead into the sea, represented in the present case by the mouth of Capoiale and Varano.

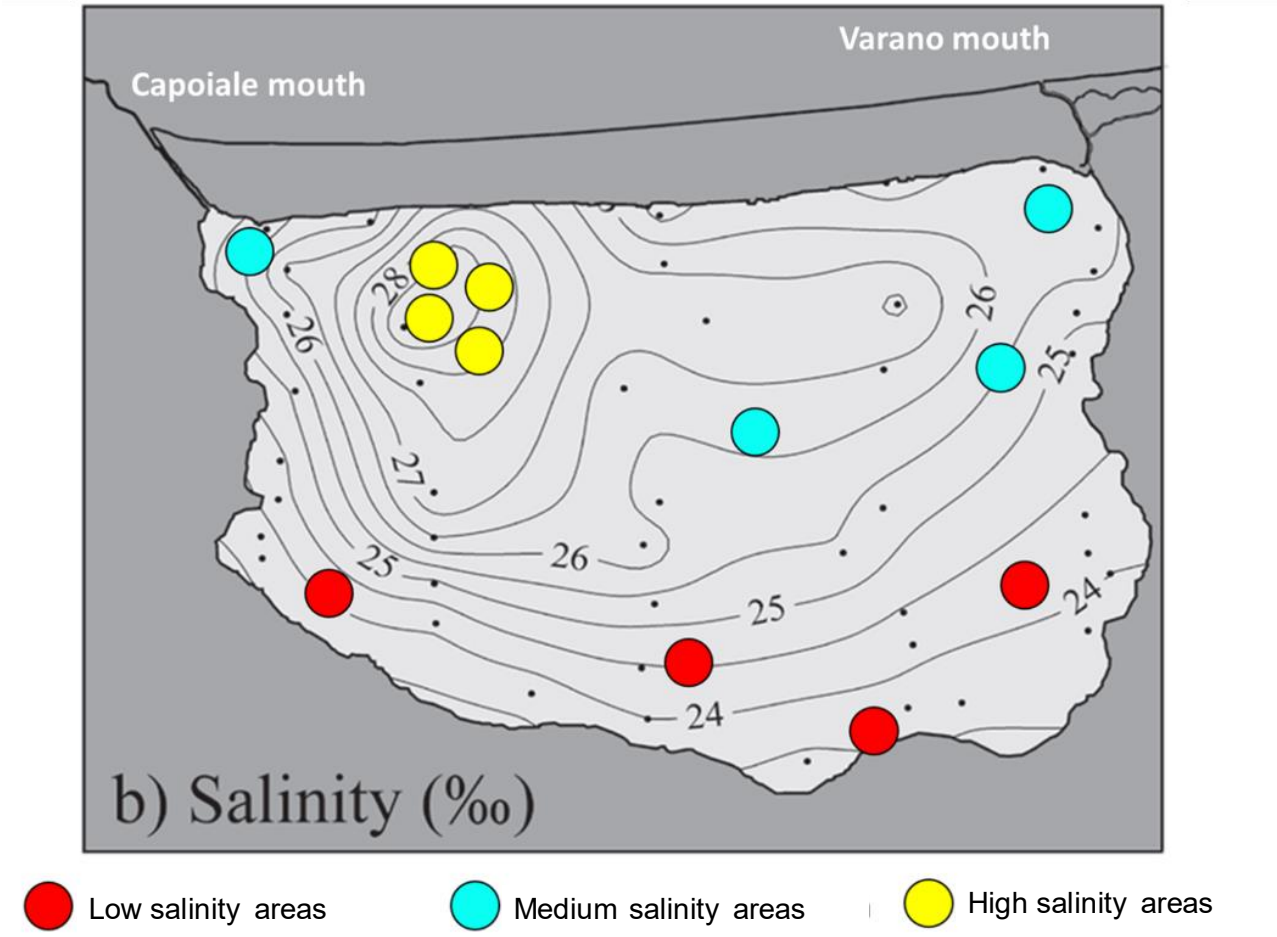

Figure 8: Salinity gradient in Varano Lake, expressed in parts per thousand with values from 24 to 28‰, with examples of sampling sites divided by classes. Image from Frontalini et al., 2013, subsequently modified.

Lesina Lake

Salinity levels in the Lesina basin vary more significantly than in the Varano Lake, averaging between 5 and 38‰ (Roselli et al., 2013), with the highest levels located mainly in the northwest of the basins. Similarly, to the Varano basin, and for the same reasons related to the life cycle of the species, we will proceed to the identification of n. 4 sites for each category of salinity, according to the following subdivision:

- salinity areas >25‰ (high salinity) - 4 sites,

- salinity areas 15-25‰ (intermediate salinity) - 4 sites,
- salinity areas <15‰ (low salinity) - 4 sites.

Each site must be spaced from the others by at least 200 m and for each of these sites should be placed n. 4 pots.

NB - In order to capture the largest number of female individuals during their spawning migration into the open sea, it is recommended to place at least two sites near the mouth of the canals that lead into the sea, represented in the present case by the mouth of Schiapparo and Acquarotta.

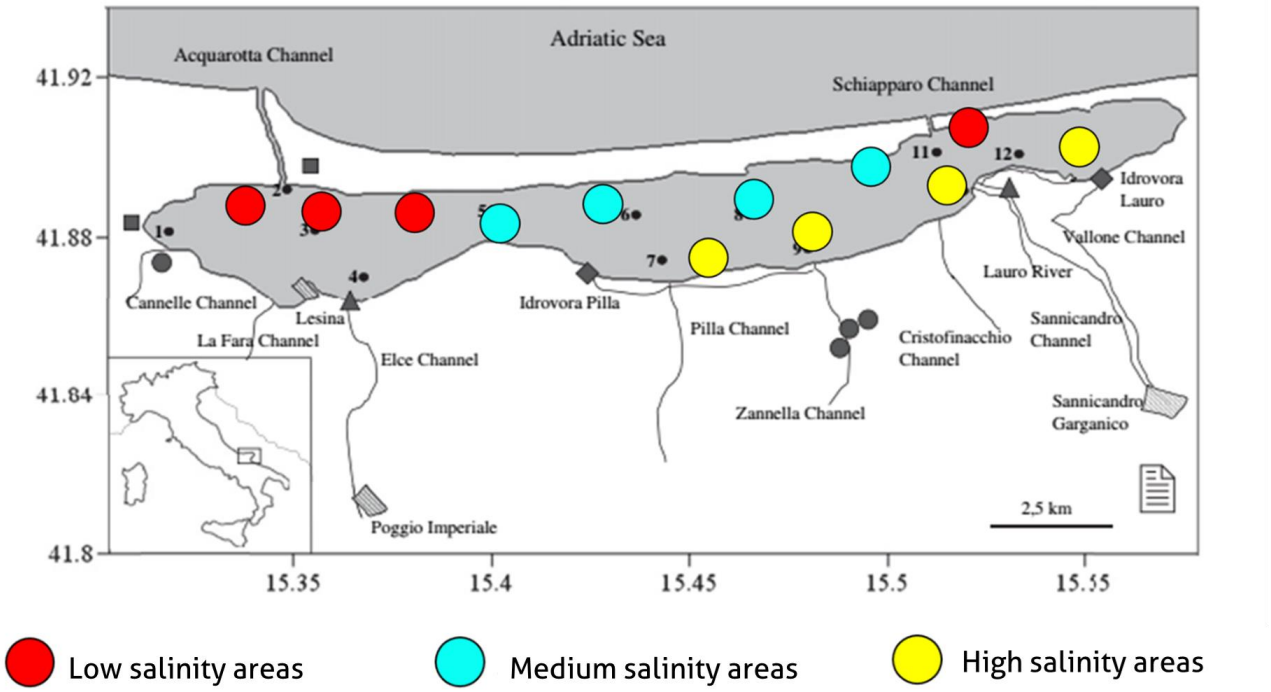

Figure 9: examples of sample sites divided by classes. Image from Roselli et al., 2008, subsequently modified.

6.2.2 SAMPLING PERIOD, FREQUENCY AND EFFORT

Varano Lake

• SAMPLING PERIOD - The sampling period should reflect the peak period of activity of the species, from spring to autumn (see para. 6.5 on the monitoring time structure).

• SAMPLING FREQUENCY - The sampling should include 3 sets of bimonthly campaigns, distributed over the months of June to November, each lasting 7 days.

• SAMPLING EFFORT - For each of the 3 macro-areas divided according to salinity values, n. 4 sites distributed randomly within each macro-area should be identified (see next par.). In each of the sites 4 pots of the type to double deception fyke net should be placed, which should be checked every day to avoid the capture of other *non-target* species.

Lesina Lake

• SAMPLING PERIOD - The sampling period should reflect the peak period of activity of the species, from spring to autumn (see para. 6.5 on the monitoring time structure).

• SAMPLING FREQUENCY - The sampling should include 3 sets of bimonthly campaigns, distributed over the months of June to November, each lasting 7 days.

• • SAMPLING EFFORT - For each of the 3 macro-areas divided according to salinity values, n.4 sites distributed randomly within each macro-area should be identified (see para. next). In each of the sites 4 pots of the type to double deception fyke net should be placed, which should be checked every day to avoid the capture of other non-target species.

6.2.3 GENERATION OF RANDOM SAMPLING POINTS

The selection of the four sampling sites to be allocated for each of the 3 identified macro areas (defined according to salinity, as shown in the previous figure) should be made through a generator of random points in space, in order to limit human error in the monitoring phase. The latest versions of the GIS software offer this possibility, through the prior identification of the polygons of interest and the use of the "Random Points Generation" function. However, as mentioned above, priority should be given to those points where major anthropic interventions are not planned in the coming years, thus repeating the process of calculating points in the event that they overlap with sensitive areas.

6.2.4 MODE OF INTERVENTION

Selection of fishing gear and baits

The capture activities may be carried out through the use of fixed gillnets of the type to double-stranded marten, cylindrical in shape and with a diameter of 40-50 cm and length 60-80 cm for each section, used extensively for catching blue crab and found to be among the most efficient also in literature (Atar et al., 2002). To facilitate the transport of recommend the use of cylindrical pots spring, easily foldable. As for baits, the use of parts of fish or chicken is commonly used for fishing this species. The fish seems to have a greater effectiveness, especially if rich in fats, even if having a faster perishability. The chicken, on the contrary, resists longer and has the advantage of being cheaper, being able to use scrap parts such as the neck and thus reducing part of the costs.

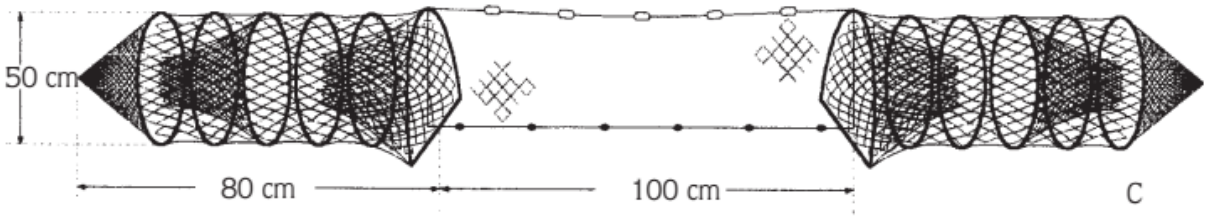

Figure 10: Double-deceptive Fyke net-type pot, ideal for capturing specimens of *Callinectes sapidus* (from Atar et al., 2002).

Each net must be numbered, and its location recorded by GPS. Once collected the data can be filled with bait and placed on the bottom, foreseeing the use of a float to subsequently identify the exact location of this during the stages of patrol.

Sampling period, frequency and effort

Unlike other trapping techniques, which rely on dredging individuals in the seabed during the winter hibernation period, the catch of blue crab through pots should be carried out during periods of activity of the species, where water temperatures are higher. Samples should therefore be taken far from the winter season, preferably from late spring to early autumn.

The capture sessions include three sets of bimonthly campaigns during the appropriate seasons, between the months of June and November. Each campaign will last one week, and every two months two campaigns of this type will have to be carried out (see diagram of Gantt par. 6.4). During the catch period, fishing gear shall be triggered and spawned and checked once a day to avoid excessive retention of non-target species to be released, and any overcrowding within them, which would impair the effectiveness of sampling.

Catch Per Unit Effort (CPUE), an indirect measure of the abundance of target species whose analytical simplicity lends itself to the application of this protocol, will be used to assess catch effectiveness, including by non-specialists, applicable for *C. sapidus* with the following formula:

CPUE = n° balance of captured individuals/n° of pots/catch time

6.2.5 DATA COLLECTION THROUGH FIELD CARDS

Once trapped, the biometric data of the individuals and the information about the trapping site will be noted down. The field sheet (Annex B) will contain the following information:

General information (for each trap):

- Water body name
- Site name
- Date
- Time
- Geographical coordinates and GPS track denomination
- Trap number: sequential number of det. of each station
- Locality
- Weather conditions
- Operator: name of/operator/s
- Chemical-physical parameters of the water body: O2, pH, T (°C), salinity, conductivity

Biometric parameters of *Callinectes sapidus* individuals divided by trap:

- **Carapace length**: sometimes expressed as *Carapace Length (CL)*
- **Carapace width**: sometimes expressed as *Carapace Width (CW)*
- **Weight**
- **Sex**
- **Photos of individuals**: recommendable for data reliability

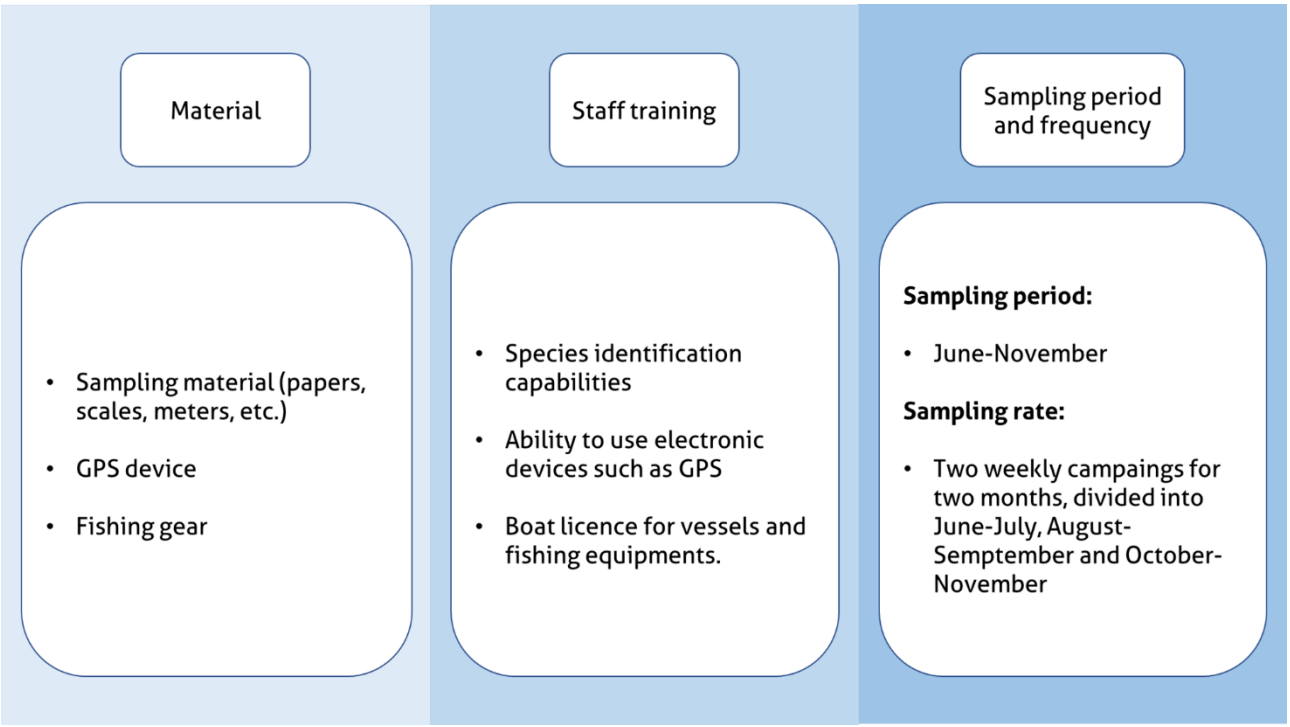

Figure 11: Essential information for sampling *Callinectes sapidus* individuals

6.2.6 MAPPING OF MONITORING POINTS BY GIS

Spatial mapping is an important phase of data collection, in which the information found must be standardised so that it can be analysed using GIS spatial processing software. Therefore, the data to be collected during the mapping phase, necessary for the production and processing of spatial geometries, shall be provided:

- **Location of monitoring sites**: collection of individual point data representing monitoring sites divided by macro-areas. It will be sufficient to take through the GPS point the best representative centroid of the places of deposit of the pots (as illustrated in an example way in figure 9).

With regard to the information to be included in the attribute table of the geometries described above the following data shall be recorded:

- **Scientific name.**
- **Location** (site).

- site ID (e.g. *Callinectes* 1).
- Salinity category (e.g. high salinity area).
- Number of used traps: e.g. 4 traps per site.
- Year of sampling.

Table 2: Example of a table of attributes for point geometries for *Callinectes sapidus* sampling sites.

ID	Specie	Sito	ID sito	Salinità	N_trapp	Year
1	*Callinectes sapidus*	Varano Lake	Callinectes 1	High salinity area	45	2021
2	*Callinectes sapidus*	Varano Lake	Callinectes 5	High salinity area	/	2021

6.3 Possible risks

Fishing also exposes other non-target species to the risk of capture. This phenomenon, known as bycatch, represents the discard of the catch consisting of all those organisms that are caught unintentionally together with the species of interest, which is usually discarded. For this reason, the daily control of the individuals present in the nets is fundamental, in order to avoid the unnecessary excessive permanence of these species and their possible death.

In the Lesina and Varano basins, the specific risk is linked to the common species living there, such as the flathead grey mullet (*Mugil cephalus*), the European bass (*Dicentrarchus labrax*), the gilt-head (sea) bream (*Sparus aurata*) or other species whose state of conservation is not optimal, such as the European eel (*Anguilla anguilla*).

6.4 Evaluation of monitoring outcomes

The main purpose of monitoring *Callinectes sapidus* within the basins of Lesina and Varano will be to define its population structure and at the same time to remove the individuals from the basin as a containment action of the species (for details see next Ch.). The results of this monitoring protocol, which has been extended over time, will therefore have the function of defining spatial and temporal changes in terms of abundance, age distribution and sex of the blue crab in these basins, providing a case study for finding crucial information for the application of management interventions as defined in the next chapter. The protocol should therefore be repeated over the years based on the results of the evaluation phase, in order to obtain a set of reliable and statistically valid data. In particular, the evaluation provides for a comparison of the results obtained over the years, expressed in CPUE; the observation of a decreasing trend of the variable over time is considered positive; on the contrary, a possible increase in the CPUE is considered negative, index of ineffectiveness of the management action (for which reference is made to the following chapter). The monitoring time scale may be increased and/or the number of seasonal seasons decreased (e.g. bimonthly) if the trend of the CPUE variable is stable for at least three consecutive years.

6.5 Temporal structure of the monitoring

The diagram on the following page outlines the time sequence in which monitoring is to be carried out for the purposes described above. The proposed timescale is 36 months, for a total of 3 years: based on the outcome of the final evaluation phase, it is possible to review the monitoring plan as specified in the previous paragraph for the years following the current one.

	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Year 1	Identification of monitoring sites											
						I+II campaign						
								III+IV campaign				
										V+VI campaign		
												evaluation
Year 2	evaluation											
						I+II campaign						
								III+IV campaign				
										V+VI campaign		
												evaluation
Year 3	evaluation											
						I+II campaign						
								III+IV campaign				
										V+VI campaign		
											evaluation	

Chapter 7. Management plan

7.1 Objective of the management plan

The objective of this management plan is to contain the blue crab population *Callinectes sapidus* within the Lesina and Varano basins, where the presence of the species has been established for some time, located in the northern part of the Gargano peninsula and contained in all part within the homonymous National Park and at the Nature Reserve of Lake Lesina.

Eradication protocols for *C. sapidus* are not likely to be applicable even at local level, due to its wide distribution within the Mediterranean basins and the risk of subsequent recolonizations that would jeopardize the success of such actions over time. This plan will therefore focus on the management of the species in spatially localized contexts, through containment actions aimed at maintaining numerically stable the populations of blue crabs present.

7.1.1 TECHNICAL CHARACTERISTICS

The management plan will provide for two main phases for the containment of the population of *Callinectes sapidus*: the first will be closely linked to the monitoring phase, while the second, more targeted, will be aimed at the specific containment of female spawning during their migration into the open sea. The monitoring actions, in fact, while representing a phase mainly aimed at the study of the evolution of the populations of blue crab in terms of abundance and composition, will also have among its purposes to remove the individuals caught by the basins, conceptually overlapping with containment actions. From a practical point of view, however, the capture effort of this phase, especially if applied to the lakes of Lesina and Varano as a whole and aimed at the entire population of *C. sapidus*, is not an effective tool for the containment of the populations present, for which it will be necessary to expand the catch effort and to carry out more targeted catch campaigns and strategic portions of the two basins (see par. 7.3).

7.2 Preliminary phase

After the capture and collection of biometric data, specimens of *Callinectes sapidus* should subsequently be retained and removed. In fact, trapping is considered one of the most effective techniques for killing aquatic invertebrate populations, thanks also to the non-invasive methodology and no side effects for non-target species if properly conducted. The captured individuals will be subjected to suppression by euthanasia, through freezing at -4° C for at least 2 h, in order to ensure the effectiveness of the operation.

As far as disposal is concerned, two routes may be followed:

- Disposal and disposal of carcasses: In the case of disposal, the carcasses must be removed as required by Regulation CE no. 1069/2009, in compliance with the current rules of hygiene and health.
- Commercial use of the resource: the captured specimens may be stored and placed on the market, after proper treatment and respecting national and local regulations (see details in the following paragraphs).

7.3 Phase of containment

7.3.1 SELECTIVE FISHING OF OVIGEROUS FEMALES

This measure constitutes the central stage of the action plan, intercepting female blue crab individuals during their reproductive migration, where they head to the open sea for spawning.

A non-selective intervention applied to the entire lagoon population may not be effective as the trapping results are poor, if the density of crabs is too high (an excessive number of individuals severely limits the effectiveness of the pot traps, which soon reach the limit containment capacities, without necessarily having eliminated the most sensitive targets of the population, that is, the breeding individuals). On the other hand, selective intervention targeting only breeding females makes it possible to identify a limited target within the population (however composed exclusively of sensitive targets), on which the entire fishing effort can be concentrated; the migratory habits of the target component also allow to focus this effort in a limited space, using the natural bottlenecks represented by the marine areas of the lagoons (connecting channels). In addition to containing the economic resources, necessary to ensure the achievement of the result, selective fishing of spawning individuals also minimises the ecological impact of the management action: the sampling operations are in fact limited both in space (channel bed of communication with the sea) and in time (reproductive period, migration phase of the female sheep) to the benefit of the bycatch risk reduction as defined above. In addition, it is possible to continue to benefit from the possible positive ecological effect resulting from the presence of blue crab populations residing in the lagoon (composed mainly of non-migratory males) which exert some control over other populations of invasive alien species, including the Chinese muscle *Arcuatula senhousia* (Benson, 1842). It is stressed that the objective of this plan, namely the containment and management of the target species, does not provide for its eradication but only for the numerical containment of populations and the prevention of further expansion. Therefore, attention should be paid to the possible positive effects of the permanence of viable blue crab populations in the areas affected, both in ecological terms (containment of additional IAS) and in economic terms (creation of a local micro-economy based on fishing, in particular breeding females, of blue crab: see next paragraphs).

For this reason, catch sites should be set up close to the mouth, which will act as selective fishing grounds, acting as an interceptor of ovigerous females. In this phase the females, rich of eggs (in number until 8 million per individual), go in open sea passing obligatorily, in the case of the basins of Lesina and Varano, through the "narrows" represented by the channels of outlet into the sea. It will therefore be appropriate, during the monitoring phase, to choose within the group of transects in environments with high salinity of areas close to the foci that can serve as funnel, so as to intercept as many migrating sheep and goats as possible and prevent the expansion of the local population (and not only).

7.3.2 SAMPLING PERIOD, FREQUENCY AND EFFORT

Lake Varano

• SAMPLING PERIOD - The sampling period must reflect the reproductive period of the species, from spring to autumn.

• FREQUENCY OF THE SAMPLING - The sampling must include 8 monthly campaigns, distributed over the months of April to November, each lasting 7 days.

• • WITHDRAWAL EFFORT - For each of the two mouths of outlet to the sea, represented by the mouths of Capoiale and Varano, 4 sites will have to be identified, divided into two groups, one at the most internal to the basins and

one at the most external, close to the sea. In each of the sites 10 nets should be placed, of the type to double deception fyke net (see Ch. 6), which should be checked every day to avoid the capture of other non-target species.

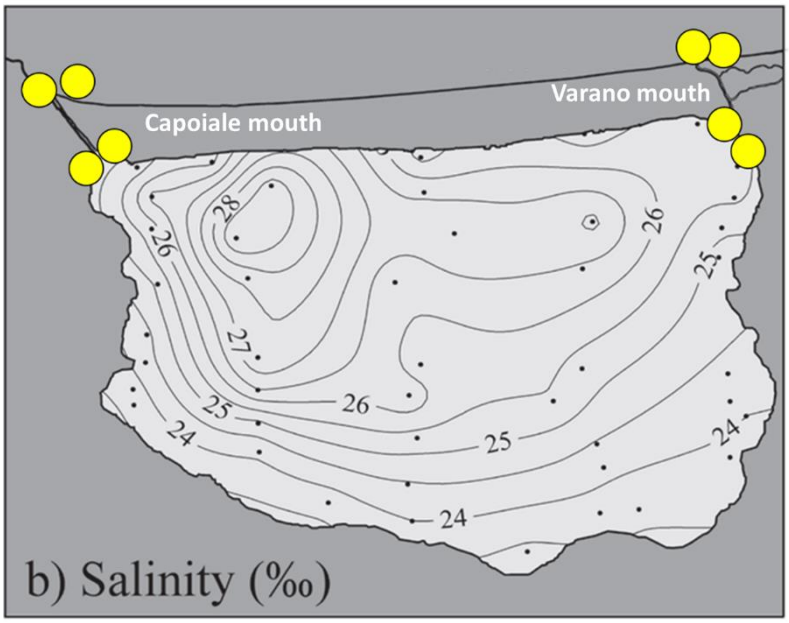

Figure 12: Image of Lake Varano with the canals of Capoiale and Varano. In yellow the 4 sampling sites for each channel, distributed in pairs inside and outside the basins.

Lake Lesina

• SAMPLING PERIOD - The sampling period must reflect the reproductive period of the species, from spring to autumn.

• FREQUENCY OF THE SAMPLING - The sampling must include 8 monthly campaigns, distributed over the months of April to November, each lasting 7 days.

• WITHDRAWAL EFFORT - For each of the two mouths of outlet to the sea, represented by the mouths of Acquarotta and Schiapparo, 4 sites will have to be identified, divided into two groups arranged one at the most internal to the basins and one at the most external, close to the sea. In each of the sites 10 nets should be placed, of type to double deception fyke net (see Ch. 6), which should be checked every day to avoid the capture of other non-target species.

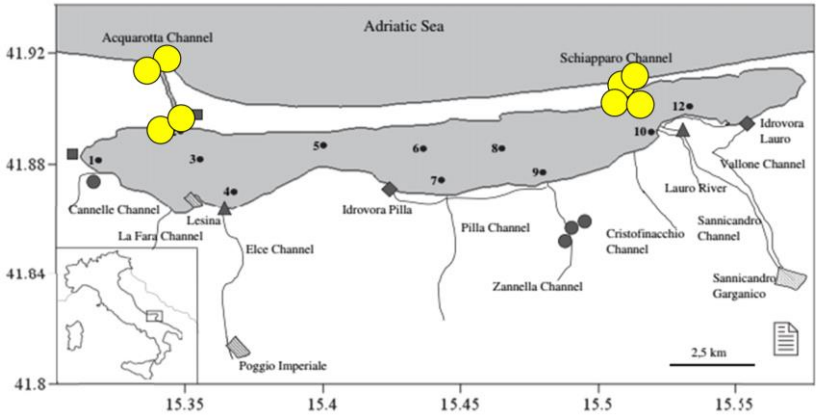

Figure 13: Image of the Varano Lake with the canals of outlet to the sea Acquarotta and Schiapparo. In yellow the 4 sampling sites for each channel, distributed in pairs inside and outside the basins.

7.4 Temporal structure of the containment plan

The following diagram outlines the time sequence in which containment campaigns are to be carried out for the purposes described above. The proposed timescale is 36 months, for a total of 3 years: at the end of each year, based on the results of the final phase of evaluation of the monitoring plan (winter months: see related paragraph for more details) the need to continue with the containment plan for the following year (see next paragraphs) should be assessed. This schematisation represents a calendar structured on a monthly catch frequency.

	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Year 1	Identification of monitoring sites											
				I campaign								
					II campaign							
						III campaign						
							IV campaign					
								V campaign				
									VI campaign			
										VII campaign		
											VIII campaign	
												Evaluation
	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Year 2	Evaluation											
				I campaign								
					II campaign							
						III campaign						
							IV campaign					
								V campaign				

									VI campaign			
										VII campaign		
											VIII campaign	
												Evaluation

	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Year 3	Evaluation											
				I campaign								
					II campaign							
						III campaign						
							IV campaign					
								V campaign				
									VI campaign			
										VII campaign		
											VIII campaign	
												Evaluation

By superimposing the monitoring phase to the containment phase, the timing of the activities can be summarized through the following Gantt diagram (in green the containment campaigns, in blue the monitoring campaigns):

	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Year 1	Identification of monitoring sites											
	Identification of catch sites											
				I campaign								
					II campaign							
						III campaign						
							IV campaign					
						I+II campaign						
								V campaign				
									VI campaign			
								III+IV campaign				
										VII campaign		
											VIII campaign	
										V+VI campaign		
											evaluation	

Year 2

Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Evaluation											
			I campaign								
				II campaign							
					III campaign						
						IV campaign					
					I+II campaign						
							V campaign				
								VI campaign			
							III+IV campaign				
									VII campaign		
										VIII campaign	
									V+VI campaign		
										evaluation	

Year 3

Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Evaluation											
			I campaign								
				II campaign							
					III campaign						
						IV campaign					
					I+II campaign						
							V campaign				
								VI campaign			
							III+IV campaign				
									VII campaign		
										VIII campaign	
									V+VI campaign		
										evaluation	

7.5 Disposal of carcasses and commercial use

As far as disposal is concerned, two possible routes may be followed:

- Disposal and disposal of carcasses: In the case of disposal, the carcasses must be removed as required by EC Regulation no. 1069/2009, in compliance with the current rules of hygiene and health.

- Commercial use of the resource. The captured specimens may be stored and placed on the market, after proper treatment and in compliance with national and local regulations (see details in the following paragraphs).

The use of the species for commercial purposes as a management strategy deserves a particular deepening. Already Article 22 of Legislative Decree no. 230/17 provides for the possibility of temporary authorisation for the commercial use of specimens of invasive alien species of Union or National importance, as part of the management measures aimed at their eradication, numerical control or containment, in strictly justified cases and provided that all appropriate checks are in place to avoid any further spread (Reg. EU 1143/14). Unfortunately, this decree does not apply to this specific case law as this list of invasive alien species of national importance has not yet been developed, making this decree important not so much for its application effects as to focus on this type of management.

In its original range, *Callinectes sapidus* represents one of the most valuable economic resources in fishing, producing in the United States alone an annual gain of around $150-$200 million for a total of 70-100 thousand tons of product. In the eastern coast of the Atlantic Ocean and in the Mediterranean Basins, where the species is now present for more than a century, a management strategy with commercial purpose struggles to spread, excepting for some isolated reality as in the case of Tunisia, where a growing market is being structured (FAO, 2021).

Figure 14: Collection of fished blue crab specimens in Somerset County, New Jersey, USA (Photo by Will Parson/Chesapeake Bay Program).

There are numerous examples of commercial use of invasive alien species, including crab species, such as the green crab (*Carcinus maenas*) in North America and Australia or the red royal crab (*Paralithodes camtschaticus*) in Northern Europe. *Callinectes sapidus*, like the aforementioned species, has the ideal characteristics to be subject to management through fishing, thanks to its abundance, Edibility and the presence of already well-structured markets already that can provide important information on the export of this type market also in our country.

The marketing of an invasive alien species, however, poses management and conservation problems, mainly due to the lack of specific regulations and the risk of future introductions driven by economic reasons. For these reasons, the narrow context in which this Protocol applies fits optimally to an experiment of a commercial nature, with the possibility of evaluating the whole process (through analyses such as SWOT) and create a local market that can act as a trigger for future expansion. The presence of the Gargano National Park represents in this sense an interesting opportunity, due to the possibility of creating a specific quality mark (similar to other protected areas such as the National Park of Abruzzo or the Regional Park of Migliarino, San Rossore, Massaciuccoli) which has the role of promoting at the same time a new commercial-gastronomic culture and an important conservation action. In order to achieve this, is therefore necessary to build a trade management partnership for the species resulting from the proposed small-scale fishery action. This partnership should involve the following actors:

- The National Park of Gargano, for the realization of the "brand" product and its marketing in a local micro-economy (with possible scalability to later levels in case of positive yield).
- Region of Apulia, for the granting, by way of allocation to the Parliamentary control bodies, of the necessary authorizations in the matter of marketability of the product, as well as of the drawing licences (in agreement with the managing body of the territory, in this case the Gargano National Park).
- Stakeholders #1: fishermen currently operating with specific license in the areas subject to intervention and/ or involved ex novo by the regional authority in the project (see previous point).
- Stakeholders #2: local business actors, e.g. retailers (fish shops, sellers, etc.), restaurateurs, operators of reception facilities, for the development of a micro-economy chain focused on the purchase and the proposal of the blue crab as a product of the territory, in agreement with the bodies responsible for the management of the brand (Park) and the control of the supply chain (Region, see previous points).
- Stakeholders #3: citizenship, which must be involved in the sale of this new product, through promotion and awareness-raising actions aimed at a greater knowledge of the species from the food and culinary point of view (actions that can be undertaken by the Park and/or the Region under the Management Plan). As an example, free catering events open to citizens, show-cooking events at catering premises or publication of informative leaflets containing recipes for the proper promotion of this new potential resource may be organized. In this context, the involvement of the categories of stakeholders concerned is necessary.

7.6 Staff employed

The implementation of this Management Plan requires the presence of adequately trained technical and operational staff, capable of coordinating, controlling and carrying out field activities.

7.6.1 COORDINATION TEAM

The first phase will be that of technical-operational coordination regarding the organization of the intense activities, the timing of the activities, the acquisition and management of the equipment and the support for the activities on the field, both as regards the monitoring plan and the management actions. We recommend a staff of at least two people, whose main tasks are summarized below:

- Scheduling the detailed calendar of activities.
- Research and organization of personnel involved during the operational phase (see para. below).
- Identification of sampling sites.

- Equipment preparation and retrieval (nets, baits, boats, field equipment, etc.).
- Collection and analysis of data from monitoring and management phases by sampling.

7.6.2 FIELD TEAM

In this second phase, the staff involved will have the main task of dealing with the operational phase in the field, both as regards the monitoring plan and the management interventions. There should be an adequate number of operators to ensure that monitoring and management actions are carried out to cover all necessary shifts in the planned monitoring and containment campaigns.

The monitoring phase will involve the development of 6 campaigns (3 bimonthly sets) of 7 days each and the identification of 12 sites with 4 pots each, for a total of 48 pots to be checked in each day of activity for each of the two basins. It is therefore recommended to set up n. 3 teams for each basin composed of at least 2 people, involved in the patrol of pots, in the collection of individuals and biometric parameters and in the disposal of carcasses.

The containment phase will involve a smaller number of capture sites (8, 4 per mouth of outlet to the sea in both the basins of Lesina and Varano), for a higher number of campaigns of activity, quantified in the number of 8 campaigns each of 7 days. For each campaign, it is recommended the setting up of n. 2 teams for each basin divided for each of the two foci, involved in the patrol of pots, in the collection of individuals and biometric parameters, and in the disposal of carcasses.

Before starting the operation, the operational team shall be adequately formed by the coordination team, whose operators may carry out the activities of both phases provided that they do not overlap. It is suggested the active involvement of stakeholders who already operate on the reference basins (e.g. shellfish fishermen) in the composition of the operational teams, so as to benefit from the experience already gained on site.

7.7 Cost estimates

In this paragraph the cost estimates for the project are provided, divided per year and per phases, in reference to the previous chapters. Fares and estimated costs include staff, vehicles and material costs, and they are based on mean market values, thus they may undergo downward adjustments during the executive steps of the project, where the real costs are produced by local operators or through specific administrative procedures (which may take into account downward offers), or where the costs may be optimized according to the local specific conditions (which may differ to those proposed by the theoretical plan). In order to ease these revisions, for each cost item the unit cost is provided (day/man, daily expense, etc.), which may be used in eventual recalculations of the final balance according to the new conditions.

Estimates are to be considered inclusive of all the expected expenses for the execution of the Plan, without taking into account eventual fundings provided by the local managers through the use of resources at their disposal (internal staff, agreements/contracts with local companies, etc.). These resources could eventually be allocated as components to co-finance the project, in order to request specific funds.

Concerning the disposal of the carcasses, we estimate a cost of 123,97€ plus VAT up to 10kg of material, adding 8,50€/kg for each extra kilogram (source: Protected Marine Area Torre Guaceto). Finally, cost estimates are based

exclusively on the costs of the plan, not taking into account eventual economic returns given by the commercialization of the blue crab, which would limit the expenses.

	Team	Job	Daily operators cost	Daily fuel cost	Daily cost	Estimated days	Estimated expense
Year 1	Coordination team	Coordination	500 €	/	500 €	20	10.000 €
						TOT. TEAM	10.000 €
	Team field	Monitoring step	900 €	60 €	960 €	42	40.320 €
	Team field	Containment step	600 €	40 €	640 €	56	35.840 €
	Team field	Materials	/	/	/	/	36.000 €
						TOT. TEAM	112.160 €
						TOT. YEARLY	122.160 €
	Team	Job	Daily operators cost	Daily fuel cost	Daily cost	Estimated days	Estimated expense
Year 2	Coordination team	Coordination	500 €	/	500 €	10	5.000 €
						TOT. TEAM	5.000 €
	Team field	Monitoring step	900 €	60 €	960 €	42	40.320 €
	Team field	Containment step	600 €	40 €	640 €	56	35.840 €
						TOT. TEAM	76.160 €
						TOT. YEARLY	81.160 €
	Team	Job	Daily operators cost	Daily fuel cost	Daily cost	Estimated days	Estimated expense
Year 3	Coordination team	Coordination	500 €	/	500 €	20	10.000 €
						TOT. TEAM	10.000 €
	Team field	Monitoring step	900 €	60 €	960 €	84	40.320 €
	Team field	Containment step	600 €	40 €	640 €	112	35.840 €
						TOT. TEAM	76.160 €
						TOT. YEARLY	86.160 €
						TOT. PROJECT	289.480 €

7.8 Possible risks

Similarly to the monitoring phase, the capture phase at the mouth of the basins is a critical phase for species not covered by this project. Fishing operations also expose other non-target species to the risk of capture (bycatch phenomenon). Risk reduction measures will consist of day-to-day monitoring of netss in order to avoid the unnecessary excessive permanence of such non-target species and their possible death.

In the specific, in the Lesina and Varano basins the risk is linked both to the common species living in these basins such as the flathead grey mullet (*Mugil cephalus*), the European bass (*Dicentrarchus labrax*), the gilt-head (sea) bream (*Sparus aurata*) or other species with a more precarious conservation status such as European eel (*Anguilla anguilla*)

7.9 Monitoring of the progress of the intervention and future actions

The management plan, if properly applied, should keep the number of individuals of *Callinectes sapidus* below the guard values, ensuring the existence of a population whose impact is significantly less than the current situation and preventing its further expansion.

Depending on the outcome of this plan, there are several possible scenarios, summarised below:

- The use of the resource for commercial purposes does not find its application. However, population abundance has fallen significantly over the years: the catch effort applied to the plan is functional to its objectives and should be maintained as an effective containment strategy to limit the effects of the species on the local ecosystem and biodiversity. As there is no evidence of marketing, carcasses must be disposed of in accordance with the most appropriate rules.
- The commercial use of the resource is not applied and the population remains constant or even undergoes a demographic increase: the catch effort applied to the plan is not sufficient, and is of little or no significance in its goal of reducing the number of individuals. It will therefore be necessary to increase the catch effort until there is a significant decrease in the population. As there is no evidence of marketing, carcases must be disposed of in accordance with the most appropriate rules.
- The use of the resource for commercial purposes has its application and evolution: the fishing of the individuals of *C. sapidus* settles permanently, ending up representing an ecologically and economically sustainable management mechanism, such that containment actions by capture are self-sustaining. Consequently, the management of the species naturally passes to the involved stakeholders, which continue it indefinitely adopting the guidelines defined in the present management plan, eventually improving them based on the experiences acquired over time. Monitoring actions may be carried out at a reduced rate of time (see the dedicated section) based on information collected year by year in relation to fishing productivity, as well as the results of the campaigns themselves.
- The commercial use of the resource finds its application and evolution, as defined for the previous case, however the monitoring reveals that the population remains constant or even undergoes a demographic increase. In this case, the collection effort should be increased through the greater involvement of stakeholders and/or their more correct training in the management of the species.

From this point of view, the monitoring phase is the fundamental tool to study the trends of blue crab populations over the years, to assess the effectiveness of containment actions and to calibrate subsequent interventions according to the results obtained.

These actions should be related to prevention and communication strategies described in the following chapter.

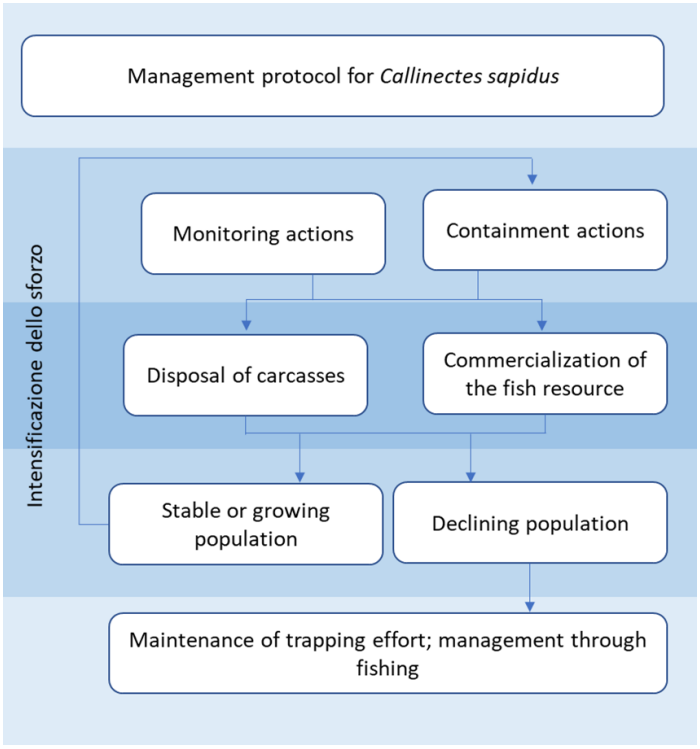

Figure 15: Diagram of management actions and future actions.

Chapter 8. Prevention and communication

This chapter contains some suggestions on prevention and communication strategies for the management of *Callinectes sapidus,* in order to limit the distribution of the species.

8.1 Prevention on further introductions

The blue crab is not included in the List of Invasive Alien Species of Union Concern, regulate by Regulation (EU) 1143/2014 (adopted from Italy with D.Lgs. 230/2017), we can follow some basic guidelines aimed at preventing the diffusion of the species on the Apulian territory. Communication is mainly directed to citizens and fishermen, followed by managers of local protected areas (like the National Park of Gargano), who will be in charge of the production of physical (signs, *dépliant)* and digital (social platforms) informative material.

8.2 Early detection through sightings

The early detection of the species on a new area is a key information to limit its diffusion, and citizens can play a crucial role in this direction. With a dedicated awareness campaign, people may be able to detect and report the presence of individuals of *C. sapidus* on the territory, helped by specific platforms (online databases, like *iNaturalist*) where they

can also upload eventual pictures. This tool must be accessible by technical staff as well, represented by managers and employees of protected areas, local regional departments, guards, environmental and hunting and fishing organizations, etc., which may create a strong synergic network.

Social media platforms can rapidly spread this information, by promoting the project and the dedicated database platforms to the public.

Figure 16: example of informative panel to involve population on collecting information about the Chinese mitten crab (source: https://chesapeakebaymagazine.com/).

8.3 Promotion of the species as a food resource

In addition to the capture and sale of the individuals of blue crab, in order to create a proper market for the species, people must be correctly educated about the consumption of this potential resource. The targets of this campaign will be mainly citizens, restaurants and generally all those activities related to the sale/cooking of the resource. The fishing activities must be informed both on the threats represented by the species on the natural ecosystem and on its potentialities from an economic/gastronomic point of view.

For this reason, together with the production of informative material, some events may contribute in the promotion process, like show-cooking occasions.

8.4 Publicizing management activities

In conclusion, a proper diffusion of information about the project and the management activities on the species must be directed to all the stakeholders, in order to involve them in the project and create a proper network of knowledge. The procedures and the results must be public, through the production of specific reports and events dedicated to the population.

Chapter 9. Conclusions

The application of the Monitoring and Action Plans on the blue crab in the Lesina and Varano lagoons, if carried out with respect to the described protocols, will allow to reach the following goals:

- **Assessment of the abundance and structure of the population of *Callinectes sapidus*:** the monitoring protocol based on fishing will determine the numeric abundance and structure of the populations, in addition of individuating the higher density areas of the blue crab inside the lagoons. Biometric data collection will give us information on age classes, sex and dimensions of trapped individuals, estimating these data for the whole population. The main issue si related to the identification of proper trapping sites, which must remain stable through the years and which must not be linked with too much anthropic disturbance. The following steps, through time, will provide information about fluctuations of the population in terms of abundance and composition, giving us a feedback on the efficacy of the trapping effort during the containment stage and, more generally, on the efficacy of the whole management plan.
- **Physical removal of the captured individuals during the containment stage:** despite the strong connection between monitoring stage and containment stage, the management plan involves the capture of ovigerous females during the reproductive migration, when they move to higher salinity areas (towards the open sea) to lay their eggs. The Plan focus on the removal of these individuals through the utilization of fishing gear in the proximity of the channel connecting the lagoons to the sea, aiming at trapping the more individuals as possible, hence reducing the intake of new individuals and the expansion of the population. This Plan, together with providing estimates on the required economic resources, allows to minimize the ecological impact, by restricting spatially (close to the channels) and temporally (reproductive season and migration of ovigerous females) the fishing activities, thus reducing the risk of bycatch and the overall fishing pressure on this protected area. In addition, the presence of a small population of blue crab males in the lagoons may produce a positive impact on the area, by controlling the expansion of another IAS, the Asian date mussel (*Arcuatula senhousia*, Benson, 1842). We highlight how the present Plan is based on containment and management of the target species, and does not include the eradication of the species, buy only its numerical control and the minimization of the risk of further colonizations; subsequently, it appears necessary to focus on the eventual positive effects on the presence of small populations of *C. sapidus* inside the lagoons, both ecologically (containment of other IAS) and economically (by creating a small market based on the consumption of the blue crab as a food resource: see next paragraph.
- **Marketing of the species as a food resource:** one the potentially synergic aspects for the management of the blue crab is its utilization as an economically valuable food resource, as an integrated strategy of management and conservation. As an already commercialized species in its native territories, where the main issue is represented by its sustainable exploitation, in the introduction areas the blue crab still appears not to be able to create an economic niche in the fishing market. Its commercialization will hence represent an interesting economic experiment, for which the competent authorities may create a specific brand and combine the promotion of the food resource together with the resolution of the conservation issues. The main difficulty will

be related to the introduction of a still poorly known product, together with potential negative ecological impacts connected with the eventual reintroductions of the species as it becomes a profitable economic resource.

- **Raising awareness on citizenship and stakeholders:** about the involvement of non-technical staff, citizenship must be engaged in the management of the blue crab through awareness campaigns on the issues represented by the IAS and the key role of the citizens in their early detection. Informative material must be produced, both physically and digitally, and events, seminars, conferences and so on must be set up, communicating the proceedings and the results of the Monitoring and Management Plans. Finally, all the potential stakeholders must be involved, including restaurants, fishing activities, markets, which will be the main actors in creating a new market for *C. sapidus.*

The activities are in concordance with the goals of the Management Plan, about the containment of *Callinectes sapidus* from the lagoons of Lesina and Varano and the utilization of the individuals as a food resource. It will be fundamental to carry out the monitoring action through time, to obtain a series of data concerning the demographic fluctuations and the structure of the populations of blue crab, verifying if the fishing activities may represent a solution to its management, here and on a bigger scale. Citizens must be involved and, if properly informed, will be able to significantly contribute to the management of *C. sapidus,* through am integrated conservation strategy that could be eventually extended to other marine IAS or to other territories.

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Chapter 11. Appendices

Annex A – Survey on IAS in the Apulian territory

The following survey is part of the "BEST Project - Addressing joint Agro- and Aqua-Biodiversity pressures Enhancing SuSTainable Rural Development - Interreg Programme V-A Greece-Italy 2014/2020" (www.interregbest.eu), aiming to elaborate a monitoring protocol for evaluating threats to biodiversity caused by the presence of invasive alien species, together with a dedicated action plan for biodiversity conservation. We need to obtain a simple and clear information from the institutions directly involved in managing local flora and fauna about the most-pressing invasive alien species on the territory, ultimately looking for a monitoring protocol for the management of the 5 priority target species.

We are presently asking you a few minutes of your time to answer the following questions.

Full name

Name of the institution

E-mail contact

Which are the terrestrial plant invasive alien species that cause major threats within your territory/protected area? (Write at least one species up to a maximum of 5, or write "not relevant")

Which are the terrestrial animal invasive alien species that cause major threats within your territory/protected area? (Write at least one species up to a maximum of 5, or write "not relevant")

Which are the aquatic plant invasive alien species that cause major threats within your territory/protected area? (Write at least one species up to a maximum of 5, or write "not relevant")

Which are the aquatic animal invasive alien species that cause major threats within your territory/protected area? (Write at least one species up to a maximum of 5, or write "not relevant")

List the biotic and abiotic features (habitats and ecosystems, vulnerable species/populations) most affected by the the species mentioned above.

Define the area where the effects of the alien species take place.

Are there already ongoing monitoring protocols or action plans (eradication/containment) with respect to these species (i.e. LIFE+ Projects)? If available, share the link to the project

Within your territory of competence, are there any prevention programs with respect to future introductions of alien species? If so, which ones? If available, share the link to the program/project

Annex B – Survey card for the monitoring of *Callinectes sapidus*

WATERBODY	SITE	DATE	TIME

TRAP (name and code)	TRAP COORDINATES	FORECAST
		T (air)
OPERATORS (name, surname)		
		Cloudness

PHYSICO-CHEMICAL PARAMETERS	O_2	pH	T (water)	Salinity	Conduct.	Rain
						Wind

CAPTURED INDIVIDUALS											
ID	Carapace Length (CL)	Carapace Width (CW)	Weight	Sex	Notes	ID	Carapace Length (CL)	Carapace Width (CW)	Weight	Sex	Notes
1						26					
2						27					
3						28					
4						29					
5						30					
6						31					
7						32					
8						33					
9						34					
10						35					
11						36					
12						37					
13						38					
14						39					
15						40					
16						41					
17						42					
18						43					
19						44					
20						45					
21						46					
22						47					
23						48					
24						49					
25						50					