WebLog Journal of Aquaculture

Case Report
Published: 28 Nov, 2025

Blue Crab Invasion and Sustainability of Maritime Trade: Ecological and Socio-Economic Adaptation in Mediterranean Sea in the Context of Climate Change

***Sami Mili*[1,2]* and *Rym Ennouri*[3,4]**

[1]*University of Carthage, Laboratory of Fisheries Sciences, National Institute of Marine Sciences and Technologies, 28 rue du 2 mars 1934, Salammbô 2025, Tunis, Tunisia*

[2]*University of Carthage, Faculty of Sciences of Bizerte, Zarzouna, 7021 Bizerte, Tunisia*

[3]*University of Carthage, Higher Institute of Marine Sciences of Bizerte, Errimel, B.P. 15, 7080 Bizerte, Tunisia*

[4]*Laboratory of Ecology, Biology and Physiology of Aquatic Organisms, Faculty of Sciences of Tunis, University of Tunis El Manar, Tunis, Tunisia*

WebLog Open Access Publications
Article ID : wjaq.2025.k2801
Author : Prof. Sami Mili, Ph.D.

Abstract

The BLEU-ADAPT project, carried out within the framework of the Interreg Italy-Tunisia cross-border cooperation programme, investigates the marine biological invasion of two blue crab species (*Callinectes sapidus* and *Portunus segnis*) in the Mediterranean Sea, focusing on their ecological impact and socio-economic consequences for coastal fisheries. Framed within the broader environment and trade nexus, this research addresses the urgent need for adaptive and sustainable resource management in the context of climate-driven species migrations and changing marine trade dynamics.

The project's theoretical approach is grounded in social-ecological systems theory and resilience thinking, integrating ecological forecasting with participatory governance models. It employs a multidisciplinary methodology that combines environmental field surveys, laboratory-based trait analysis, and socio-economic impact assessments conducted in Tunisia and Italy.

The research reveals significant ecological disruption and economic damage caused by the invasive blue crab, particularly to small-scale artisanal fisheries. These include destruction of fishing gear, reduced catch quality and increased operating costs. Predictive modelling based on functional traits indicates a likely expansion of *C. sapidus* throughout the Mediterranean over the next 30 years, while *P. segnis* is expected to remain restricted to the eastern basin.

The contribution of this research is to develop science-based, participatory management strategies that link environmental adaptation with trade sustainability. By identifying high-risk zones and egg production areas, BLEU-ADAPT supports the design of regionally coordinated mitigation efforts and the potential valorization of invasive biomass through sustainable trade channels. The study contributes to rethinking international cooperation on marine invasions, trade policy and climate adaptation, in line with the broader goals of environmental justice and blue economy development in the Mediterranean.

This presentation will reflect on how trade and environmental governance intersect in real-world coastal contexts, and how cross-border scientific collaboration can inform inclusive and resilient responses to ecological disturbances.

Keywords: Blue Crab; Marine Biological Invasions; Mediterranean Sea; Cross-border Cooperation; Climate Change

OPEN ACCESS

Correspondence:
Sami Mili, University of Carthage, Laboratory of Fisheries Sciences, National Institute of Marine Sciences and Technologies, 28 rue du 2 mars 1934, Salammbô 2025, Tunis, Tunisia/ University of Carthage, Faculty of Sciences of Bizerte, Zarzouna, 7021 Bizerte, Tunisia,
E-mail: sami.mili@fsb.ucar.tn

Received Date: *20 Nov 2025*
Accepted Date: *27 Nov 2025*
Published Date: *28 Nov 2025*

Citation:
Mili S, Ennouri R. Blue Crab Invasion and Sustainability of Maritime Trade: Ecological and Socio-Economic Adaptation in Mediterranean Sea in the Context of Climate Change. WebLog J Aquac. wjaq.2025.k2801. https://doi.org/10.5281/zenodo.17844445

Introduction

Following the first appearance of *Portunus segnis* in Tunisian waters in 2014, the government adopted a series of robust measures to curb the spread of the blue swimming crab and support local fishing communities. In 2017, an official national strategy was launched to promote the harvesting, marketing and trade of blue crabs [1, 3]. Key elements of this plan include:

- Designating collection areas where crabs caught in fishing nets must be landed rather than

released, providing an additional source of income for fishermen.

- Guaranteed purchase of all blue crab landings at a fixed price of USD 0.80 per kilogram, with the state and private industry partners subsidising this equally (USD 0.40 each).
- Demand stimulation through coordinated domestic marketing campaigns and exploration of export opportunities.
- Investment incentives aimed at attracting national and foreign capital to establish processing facilities.
- Support research by funding scientific studies on blue crab stock assessments and the development of optimised, sustainable fishing techniques.

Tunisia was among the first nations in the Mediterranean to industrialise the processing of blue crabs as a means of controlling the species' invasion. In collaboration with universities, research laboratories, fishermen's cooperatives and NGOs, the government has also launched public awareness campaigns to promote the consumption and utilisation of this new resource.

As of 2024, Tunisia has 49 seafood processing plants, including 17 factories dedicated exclusively to blue crab [3]. The largest of these, located in Ghannouch, represents a USD 70 million investment from Middle Eastern partners. This facility employs 1,600 people, 1,400 of whom are women, and can process up to 110 tonnes of blue crab per day for export. It also has refrigerated storage capacity for 6,000 tonnes of product [3].

By 2022, Tunisian fisheries had landed around 25,000 tonnes of blue crab, exporting approximately 6,000 tonnes to markets worldwide. That year, the sector generated almost USD 30 million in revenue, providing a significant socio-economic benefit from what had initially been an issue of invasive species [1].

Additionally, promoting public understanding and acceptance of the blue crab as a seafood option was made. Cookbooks have been released to encourage the public to eat blue crabs and offer step-by-step preparation tips. One such publication, titled “From Invasion to the Dish: Recipes Made with Blue Crabs, features 30 recipes developed by the female fishermen of the Kerkennah Islands. The book is available for free in Italian, French and English.

International Research Programme on Blue Crab Management

Recommendation GFCM/42/2018/7, adopted by the GFCM, established a regional research programme on blue crabs in the Mediterranean Sea to accurately assess their population status and ensure the sustainability of associated fisheries. The programme's main objective is to develop a harmonised, science-based framework for managing blue crab stocks that balances economic viability with ecological integrity [5]. The programme is organised into six distinct work packages (WPs), each addressing a specific goal:

- Biological and ecological profiling: This involves compiling comprehensive data on the life history, habitat requirements, reproductive biology and ecological interactions of the two Mediterranean blue crab species, to inform responsible fishery management decisions.
- Fisheries-independent monitoring: Collect data independently of commercial catches, such as standardised surveys and ecosystem assessments, to improve understanding of the composition of catches and the broader impacts on the marine community of the presence of blue crabs [2].
- Fisheries-dependent data collection: Systematically record and analyse landings, bycatch and fishing effort information to build a robust industry-based dataset that underpins effective regulatory and management frameworks.
- Stock assessment framework: Design and implement a dedicated stock assessment model for blue crab populations, integrating habitat distribution, life-cycle traits and fishery-specific factors to produce reliable stock status estimates.
- Technical and socio-economic evaluation: Examine the technology used for fishing gear, fishing methods and the socio-economic dimensions of blue crab fisheries to identify opportunities and constraints for sustainable exploitation and community benefits.
- Adaptive Management Development: Formulate and test management measures at local, national and regional levels that can be adjusted in response to ongoing monitoring results to maintain acceptable levels of blue crab abundance.

Coordinating these six work streams enables the GFCM research programme to deliver an evidence-based toolkit for regulating blue crab fisheries across the Mediterranean, safeguarding coastal livelihoods and marine ecosystems in the process.

BLEU-ADAPT as an International Cooperation Program

Introduction

The BLEU-ADAPT (Interreg Italy–Tunisia) initiative aimed to respond immediately to the blue crab invasion and foster adaptive management strategies in Italy and Tunisia. To this end, the project launched a series of targeted initiatives aimed at addressing the unique challenges faced by affected coastal communities.

A key aspect of the collaboration was conducting a thorough risk assessment based on ecological data and socioeconomic insights. Through participatory workshops, the team worked closely with local fishers to collect field observations and traditional knowledge, which informed a detailed map of current crab distributions. These field data were then integrated with environmental variables to model the species' likely future spread across regional waters.

Based on these analyses, BLEU-ADAPT implemented adaptive management measures that could evolve as new information became available. A coordinated communication campaign engaged with fisheries managers, policymakers and other stakeholders, while specialised training sessions empowered civil society groups to play a proactive role in monitoring and control efforts.

Recognising the blue crab’s market potential, the project also piloted value chain development in both countries. By involving fishers, processors, distributors and consumers, these pilot schemes established new commercial channels and raised public awareness, effectively transforming an ecological threat into an economic opportunity [2]. The success of BLEU-ADAPT in Tunisia has since provided a scalable template for similar interventions in other Mediterranean fishing regions.

Implementation of Task Groups

GT1: This work package is led by DGPAq. A grant agreement was signed in December 2019. To define the broad outlines

of their partnership and ensure the effective management of the BLEU-ADAPT project, four partnership agreements were concluded between DGPAq and its partners. PP1 : Institut National Agronomique de Tunisie (INAT) ; PP2: Institut Supérieur de la Pêche et de l'Aquaculture de Bizerte (ISPAB) ; PP3: Distretto della Pesca e Crescita Blu – COSVAP; PP4: Università degli Studi di Palermo (DISTEM Dept.).

To establish a coherent, transparent governance structure and coordinate tasks among partners, six Steering Committee meetings were held, and four semi-annual project activity reports were produced. A project kick-off meeting was held in Mazara del Vallo (Sicily), bringing together all BLEU-ADAPT stakeholders to present the project's overall objectives, specific goals and key deliverables, as well as each partner's technical and financial progress (mission report).

GT 2: To implement BLEU-ADAPT's objectives, the lead beneficiary and partners jointly developed an internal and external communication plan. This plan formalises communication among partners, key stakeholders and the general public. A range of communication materials was produced, including informational brochures, pens, USB flash drives, tote bags, roll-up banners, notepads, document folders, banners, T-shirts, caps and labels.

To boost the project's visibility, the BLEU-ADAPT website was launched, and a partnership agreement was signed between the Municipality of Kerkennah, the AJSK and DGPAq to install a 'Blue Crab' sculpture at a local roundabout. This artwork sparked controversy among local communities, who were divided over whether it was appropriate to commemorate an invasive species. Following repeated acts of vandalism, the sculpture was repaired and ultimately relocated to the ISPAB recreational area.

GT3: This task group is led by INAT and UNIPA. Both teams finalised the processing of data, the writing of technical reports and other deliverables related to risk monitoring, forecasting invasion under climate change and mapping.

As part of the first International Blue Crab Festival, two regional seminars, 'Scientists & Decision-Makers' and 'Fishers & Decision-Makers', were held in Kerkennah (see attendance lists, concept notes and festival programme). These seminars provided a forum for sharing experiences and reflections on piloting exotic species value chain initiatives and coordinating stakeholders for national invasive species strategies.

GT 4: Led by ISPAB, this package organised multiple training workshops, including webinars, with active participation from all partners.

In-person workshops on identifying invasive species were held for fishers during two field missions on the Kerkennah Islands. ISPAB also ran broader awareness sessions for all GT4 target groups, attracting over 400 participants (including scientists, civil society, national authorities, fishers and other stakeholders). One such workshop, co-hosted with INAT, attracted 69 attendees at ISPAB in Bizerte, while another delivered online via the project's platform reached 342 participants.

Webinars covered invasive species identification, fishing gear design and improvement, the blue crab value chain and invasive species control, attracting over 340 participants from all project target groups.

SWOT surveys were conducted by ISPAB researchers during their visits to the Kerkennah Islands, with interviews conducted with fishers and exporters to assess the strengths and weaknesses of the blue crab fishery (73 surveys in total). This formed the basis for a technical report.

Hands-on training for fishers in Ouled Ezzeddine (Kerkennah) focused on designing and improving crab-specific gear, and participants received traps supplied by the project. These interactive, in-person sessions featured practical demonstrations by fishing-technique specialists and elicited enthusiastic engagement from local fishers.

An exporter support workshop at Sfax's GIPP guided blue-crab exporters in developing an export plan.

A "BLEU-ADAPT" Facebook page was launched to facilitate communication between stakeholders and enable the rapid reporting of new invasive species sightings in the Gulf of Gabès, particularly around Kerkennah.

To enhance product quality, a block-ice factory was procured and installed at the Attaya fishing port for Kerkennah fishers in August 2023, boosting regional ice production capacity.

GT 5: Led by INAT, all of the activities outlined in the grant proposal for this work package have been completed. Among its flagship pilot actions, INAT and DGPAq co-organised the Blue Crab Festival in Kerkennah in October 2022.

Cooking shows by Tunisian Culinary Academy chefs and European guest chefs, as well as cooking contests featuring traditional and innovative blue crab dishes, took place in Tunisia and Sicily during the Blue Crab Festival and the two Blue Sea Land events.

A recipe book, "From Invasion to Plate: Blue Crab Recipes", was published in French, Italian and English (print and e-book) by INAT and UNIPA.

The project achieved a significant social milestone by empowering women in the Kerkennah fishing sector. On 8 November 2023, they established KHAYRAT Kerkennah, Tunisia's first Mutual Fishing Services Company (Société Mutuelle de Services de la Pêche), dedicated to promoting an invasive marine species and exemplifying tangible climate adaptation and mitigation measures. With leased premises, a bank account, legal statutes and pending national registration, KHAYRAT Kerkennah officially launched on 8 March 2024 (International Women's Day). Its founders joined the Tunisian Union of Agriculture and Fisheries (UTAP) and obtained fisherwoman certificates.

This women's cooperative was born from extensive training in hygiene best practices, seafood handling, preservation and processing techniques, initiated at the festival and delivered in a series of workshops by INAT.

Market studies on domestic and international blue crab consumption were completed in Tunisia. The Sicilian consumer survey was finalised in Palermo with the support of UNIPA and COSVAP. Interviews were conducted in ports, fish markets and restaurants.

A biannual action plan to promote local blue crab marketing and consumption was developed during the 'Blue Crab Paradox: Socio-Economic Opportunities *vs*. Ecosystem Impacts' workshop. This workshop also facilitated partnerships with crab export companies

and helped women to align with market requirements.

To strengthen cross-border cooperation, INAT, UNIPA, and COSVAP co-hosted a workshop for Tunisian and Sicilian crab packing and export firms to foster supply partnerships and share the Tunisian management experience. Joint visits to Sicilian ports, especially Mazara del Vallo, highlighted the use and economic viability of the project-designed crab traps in Tunisia's abundant crab fisheries.

Cross-border Cooperation and Synergies

Partner engagement: Although partners demonstrated strong commitment, some struggled to fulfil their obligations due to resource constraints or competing priorities. More robust coordination mechanisms and regular communication could have mitigated these issues.

Effectiveness of achievements: The outreach and training workshops were particularly effective in mobilising communities and strengthening their capacities.

Synergies: It was actively pursued. In collaboration with the National Agronomic Institute of Tunisia (INAT) and the Higher Institute of Fisheries and Aquaculture of Bizerte (ISPA-B), the Distretto della Pesca e Crescita Blu – COSVAP organised training workshops in both project areas (Kerkennah and Sicily) to share best practices in the management of invasive species. COSVAP and the University of Palermo, together with INAT, contributed their expertise in invasion-risk modelling and the development of adaptation strategies. The Kerkennah Youth Science Club and the Associazione Generale Cooperative Italiane helped to reinforce partnerships with civil society and the private sector, thereby promoting local stakeholders' ownership of the results.

Furthermore, the inaugural Blue Crab Festival was a direct outcome of exceptional collaboration with partners from the cross-border MED Dé.Co.U.Plages project. This partnership enabled efforts to be pooled at all levels across the targeted regions, fostering strong synergy among all collaborators and partners, and reaching a significant number of beneficiaries.

These synergies enabled a holistic, collaborative approach to tackling the blue crab invasion and promoting the sustainable development of coastal zones.

Democracy and Human Rights: The project promoted citizen participation by involving non-governmental organisations (NGOs) in the implementation of activities. Awareness workshops informed local communities about the challenges posed by invasive species and their rights as stakeholders in resource management. Public consultations, including those conducted via the Local Ecological Knowledge (LEK) method, gathered stakeholders' opinions and concerns [6].

Environmental Sustainability: The project adopted an ecosystem-based approach to invasive species management, taking into account the impact on marine biodiversity and ecosystems. Awareness-raising and training activities promoted sustainable fishing practices and marine resource management techniques. Studies were conducted to assess the environmental impact of blue crabs and to develop climate adaptation strategies.

Gender equality: The project focused on empowering rural women by involving them in the blue crab value chain. A women's consortium was established in Ouled Ezzeddine to provide training in fish product processing and marketing.

Continuity and Sustainability of Activities

Responsibilities will be allocated among the project partners to ensure the continuity of activities and the long-term sustainability of results. The Directorate General for Fisheries and Aquaculture will coordinate actions and mobilise the necessary resources. Project partners, including research institutions and civil society organisations, will contribute to the implementation of activities and the dissemination of knowledge.

Target groups and end beneficiaries will continue to have access to project outputs and products via social media channels and dissemination events, such as conferences and workshops.

Multiplier effects will be amplified at multiple scales. At the local level, pilot actions will inspire similar initiatives and encourage the adoption of sustainable practices. At the regional level, cross-border partnerships will encourage the exchange of expertise and cooperation between stakeholders on both sides of the Mediterranean. Nationally, project findings will inform public policy on invasive species management and economic development. Within the broader cooperation area, the sharing of knowledge and best practices will strengthen community ties and promote an integrated approach to marine resource management, particularly concerning shared stocks and invasive marine species.

Once the BLEU-ADAPT project has concluded, the team will continue to maintain activities in order to consolidate their achievements and, above all, guarantee the durability of the results. Following the establishment of the Khayrat Kerkennah Mutual Fishing Services Cooperative, the BLEU-ADAPT team will continue to support its founding female members by providing training and identifying additional funding opportunities to ensure the success of this new enterprise and foster a locally rooted, solidarity-based, inclusive economy. The cooperative will create jobs for young people in the target area, thereby helping to reduce unemployment and insecurity.

Thanks to the consortium established by BLEU-ADAPT, scientific collaboration between partners has been strengthened. Further initiatives, such as new agreements, follow-on projects, scientific publications and the valorisation of BLEU-ADAPT's results, are underway to implement a sustainable development programme for coastal zones.

Summary and Key Results of the Project

In December 2019, the Presidency of the Sicilian Region's Regional Programming Department, acting as the Managing Authority of the Italy–Tunisia 2014–2020 Interreg CBC Programme, together with the DGPAq as Lead Beneficiary, signed the grant agreement for the project "Marine Biological Invasion and Fisheries: Damage Assessment, Mitigation and Climate Adaptation (BLEU-ADAPT)".

To formalise their partnership and ensure effective project governance, four partnership agreements were concluded in September 2019 between the DGPAq and its project partners: PP1 INAT, PP2 ISPAB, PP3 COSVAP and PP4 UNIPA. To establish a robust and coherent management structure, the Steering Committee convened six times and produced four six-monthly activity reports to monitor progress.

The Lead Beneficiary and partners jointly developed an internal and external communication plan to support all project objectives, activities, and outputs. This plan governs communication among partners, with key stakeholders, and with the general public. A range of promotional materials was produced, and a sculptural installation themed on the blue crab was erected to raise awareness.

During the inaugural International Blue Crab Festival, two regional seminars were held: one bringing together scientists and policymakers, and the other bringing together fishermen and policymakers. These workshops provided a forum for sharing experiences from pilot projects that promote the value chain of non-native species, and for coordinating stakeholders in the development of national invasive species strategies.

DGPAq procured and installed refrigerated storage facilities for fishermen in Kerkennah. The team responsible for Work Package 3 managed the analysis of data and produced the technical reports and other deliverables on 'Monitoring, Forecasting and Risk Analysis of Marine Invasions under Climate Change', including habitat mapping.

ISPAB (PP2) delivered multiple in-person and online training and awareness-raising workshops for project beneficiaries, including scientists, fishermen, civil society actors and seafood industry professionals. During the gear-improvement workshops held on the Kerkennah Islands, the artisanal fishermen of Ouled Ezzedine received newly designed crab pots. These highly interactive sessions, led by fishing-gear specialists and including practical demonstrations, were very well received.

Chefs from the Tunisian Academy of Cuisine conducted culinary "cooking shows" alongside European guest chefs, and cooking competitions showcased traditional and novel blue crab dishes in Tunisia and Sicily during the Blue Crab Festival and the two Blue Sea Land events. Following the Kerkennah Festival, INAT and UNIPA jointly published an electronic and paperback recipe book entitled “From Invasion to Plate: Blue Crab Recipes”, in French, Italian and English.

Remarkably, the BLEU-ADAPT team exceeded project expectations in terms of consortium cooperation. From the outset, they supported the women of the Kerkennah archipelago, culminating in the creation of Tunisia’s first mutual fishing-services cooperative, “KHAYRAT Kerkennah” (Kerkennah Treasures), dedicated to women’s economic empowerment, at the 2022 festival.

COSVAP's activities included: collecting ecological knowledge data via participatory protocols in collaboration with fishing associations; organising events to promote blue crab as a fishery product and encourage its consumption in Italy through pilot initiatives; managing logistics for seminars and workshops; producing four scientific documentary films on the blue crab under UNIPA’s scientific coordination.

Despite the restrictions on in-person meetings imposed by the pandemic, COSVAP conducted surveys of fishers, procured training equipment and provided information to fishers and civil society groups. They participated in the inaugural Kerkennah Blue Crab Festival to learn from the experiences of Tunisian fishers, produced four documentary videos and a recipe book showcasing fisher training, and organised a workshop at the Global Seafood Expo in Barcelona. COSVAP also supplied crab traps, which were distributed following a call for expressions of interest. In total, over 500 people, including fishers, researchers and civil society members, took part in seminars, cooking demonstrations and training sessions. These were supported by UNIPA and INAT, and involved both Tunisian and Italian fishers.

By the end of the project, community recognition of the blue crab phenomenon had increased significantly. Initially, fishers had perceived the species as too rare to pose a threat, but COSVAP found that this had changed. However, as blue crabs infested Sicily’s coasts in subsequent years, fishers urged the development of strategies to limit the invasion. They concluded that changing fishing methods and promoting the crab as a valuable resource rather than merely viewing it as a nuisance was the only viable solution. This shift in perspective also garnered media and political attention, underscoring the need for a governmental response.

COSVAP further engaged with island fishermen to inform them about the project's goal of transforming the blue crab into an economic opportunity. Unfortunately, the outbreak of the novel coronavirus (SARS-CoV-2) slowed activities and confined stakeholder engagement to online platforms, prompting partners to explore new ways to continue with the project.

Strategic Guidelines for Managing Blue Crab Populations

Concerns over the spread of blue crabs (*C. sapidus* and *P. segnis*) have been escalating for years. From the outset of their invasion, intensive harvesting and processing were considered the main defence against their spread. However, alongside these direct control methods, a range of additional measures is necessary for the effective management of these species throughout the Mediterranean.

As in Spain, France and Italy, comprehensive action plans have been established to mitigate the impact of blue crabs on local economies and native biodiversity [5]. Complete eradication, removing every individual from an invaded area, is no longer feasible given that self-sustaining breeding populations are already entrenched within regional ecosystems. The priority now is to mitigate their numbers to preserve native species and alleviate the socio-economic pressures on small-scale fisheries and aquaculture.

This paper outlines recommendations to help Mediterranean nations adapt these measures to their specific ecological conditions and economic circumstances. The goal is to propose five targeted strategies, supplemented by a governance framework, that together form a coordinated, science-based Mediterranean response.

- Monitoring and impact assessment (national/regional): Systematic surveys to track blue crab populations and quantify their ecological effects.
- Spatial management and fisheries (national/regional): Designation of control zones and development of regulated fishing protocols.
- Consumer awareness and socio-ecological outreach (national/regional): Education campaigns that highlight the benefits of consuming blue crab and the broader ecological issues involved.
- Prompt detection and quick response (national/international): Protocols for the swift identification and containment of new infestations.
- International Cooperation (international): Cross-border

research and management programmes to harmonise efforts across the Mediterranean.

These five pillars are underpinned by a governance structure that ensures consistent implementation, stakeholder engagement and periodic scientific review, thereby maximising the effectiveness of the collective Mediterranean strategy against blue crab invasions.

Monitoring and Impact Assessment

In order to investigate the structure of the blue crab population and its ecological effects, it is essential to select pilot sites that accurately reflect the broader pattern of invasion at national and regional levels. These locations will serve as experimental 'laboratories' for carrying out the activities set out in Action 1.

The initial task involves detailed monitoring of blue crab demographics and life-history traits. Key metrics include carapace length, wet weight, sexual maturity status, egg mass and egg colour. By tracking size-class distribution and sex ratio over time, population structure and growth rates can be inferred. To generate reliable datasets, sampling should occur at least once or twice a month in the long term [5]. Additionally, conducting simultaneous surveys across multiple fisheries within each invaded region will reveal spatial patterns of abundance and habitat utilisation, helping to identify priority areas for targeted removal. Environmental parameters such as temperature [4], salinity and dissolved oxygen must also be logged during sampling to assess the influence of abiotic conditions on population dynamics [1].

Effective management also relies on robust stock assessments. Biological investigations should cover reproductive biology (including maturity schedules and breeding seasons), growth rates and movement patterns, potentially using acoustic tagging or telemetry to map migrations [6]. Stock assessment models adapted from conventional fisheries frameworks will then estimate the harvest levels required to suppress blue crab populations below recruitment thresholds, while avoiding the overexploitation of non-target species.

Lastly, the ecological ramifications of the invasion must be quantified through food-web studies. Stable isotope analysis and stomach-content surveys will clarify the blue crab's trophic position, as well as its impact on native species and ecosystem processes [5]. Evaluations of ecosystem services, such as local fisheries yield and aquaculture productivity, will further illuminate how blue crab proliferation disrupts the benefits that these systems provide. Where historical data exist, comparing pre- and post-invasion biodiversity baselines will improve our understanding of the crab's ecological footprint and inform future mitigation strategies.

Spatial Management and Fisheries

In order to manage blue crab populations effectively, it is recommended that control periods be implemented based on continuous population monitoring, particularly during biologically sensitive phases such as the reproductive season. Since females often limit population growth, identifying the optimal times, locations and methods for capturing the greatest number of females during these critical periods is essential [5]. Research has shown that interventions have the greatest impact during mating periods and the migration of egg-carrying (ovigerous) females. At each designated pilot site, the aim would be to identify female migration routes before their offshore movement, potentially by installing physical barriers between coastal lagoons and the open sea.

Control efforts should use highly effective fishing gear capable of removing large numbers of crabs. It is also crucial to develop and test fishing tools adapted specifically to target blue crabs while minimising disruption to local habitats [6]. While various types of fishing gear are already in use across the Mediterranean, their efficiency varies according to local conditions [4]. Therefore, as the first step in the broader monitoring programme, it is recommended that different types of gear be evaluated to identify those that perform best in the specific habitats of each pilot site.

At the national level, the establishment of a domestic blue crab marketing value chain is proposed to facilitate the rapid sale of harvested crabs, reducing overreliance on international exports. This would reduce competition in the international market and provide economic support for small-scale fishermen. Such a value chain is particularly important for capitalising on catches made during control campaigns. It would offset the financial losses currently experienced by artisanal fisheries and aquaculture operations due to the invasive impact of blue crabs. Furthermore, integrating marketing into population control strategies transforms commercial exploitation into a tool for ecological management [2].

Creating a structured and functional blue crab value chain requires coordinated collaboration between government agencies, artisanal fishers and aquaculturists, seafood distributors and restaurant owners [5]. This multi-stakeholder approach would ensure the efficient distribution and processing of blue crabs into market-ready products, enhancing both ecological control and socio-economic benefits.

Consumer Awareness and Socio-ecological Outreach

Involving stakeholders is crucial to establishing a sustainable blue crab value chain. Raising public awareness is fundamental to encouraging the consumption of blue crabs and developing a viable market. Activities such as culinary demonstrations, cooking classes, television features and recipe contests can normalise the presence of blue crabs in local diets [3]. Highlighting the nutritional benefits of blue crab meat can motivate consumers to purchase it and include it in their meals.

Educating the public about the various applications of blue crabs will encourage people to view this species as more than just a new food source, but also as a potential raw material for various industries [5]. For instance, chitin extracted from blue crab shells has applications in food technology, cosmetics, and medicine, providing added value and utility beyond culinary use.

Furthermore, it is crucial to communicate the wider socio-economic and ecological implications of the species' expansion. Emphasising that the commercial exploitation of blue crabs can function as a form of population control adds another layer of relevance to their market integration [2]. Public outreach events organised in cooperation with government agencies, researchers, fishermen and local managers should include educational sessions, interactive presentations and informational games to highlight the ecological impact and economic potential of effective blue crab management [6]. Media outlets such as documentaries, TV programmes, radio shows and news articles can serve as key tools for disseminating this information.

Engaging with stakeholders, particularly fishers, community leaders and consumers, is also essential to ensure the long-term success of control strategies. Incorporating Local Ecological Knowledge (LEK) into planning helps to tailor management efforts to local

circumstances and to enhance community support [6]. Surveys and interviews should be conducted regularly during the implementation of management actions in order to track how stakeholder perceptions evolve and to assess the correlation between these perceptions and observed ecological changes. These insights serve as valuable indicators of project impact and public acceptance [5].

Finally, stakeholders should be directly involved in crab removal and control operations, working alongside scientists and environmental managers. Their hands-on participation will support the practical implementation of control measures and strengthen collective ownership and responsibility for addressing the blue crab invasion.

Prompt Detection and Quick Response

Raising public awareness and sharing the best ways to deal with blue crab encounters, such as avoiding releasing them and reporting sightings, are crucial steps in managing their spread. To reduce the risk of accidental introductions, particularly through recreational activities, targeted communication campaigns should be developed [6]. These could take the form of informational brochures, educational workshops, social media outreach, and organised events focused on control efforts. Such initiatives would help to discourage the unintentional release of blue crabs caught during recreational fishing, which could otherwise facilitate their spread.

Coordinated citizen science initiatives are also vital for tracking the spread of blue crabs and supporting Early Detection and Rapid Response (EDRR) strategies. These programmes should include user-friendly digital platforms that allow individuals to easily report blue crab sightings [5]. Ideally, these reports would include key data such as GPS coordinates, observation dates and photos. Alongside public participation, advanced monitoring tools such as environmental DNA (eDNA) sampling should be implemented to identify the presence of blue crabs before they can be visually confirmed [1]. This dual approach enables quicker interventions, including containment or targeted harvesting, to prevent the establishment of new populations.

In addition, surveillance systems must be deployed in regions not yet affected by invasions. These early warning systems are particularly important for managing the spread of *P. segnis*, another invasive crab species that is still expanding its range in the Mediterranean [6]. Early detection in these areas will enable the authorities to implement containment strategies swiftly before the species becomes established.

International Cooperation

Effective management of blue crab invasions requires international collaboration. Cross-border initiatives between the northern and southern shores of the Mediterranean are essential for pooling expertise and tackling shared challenges [5]. International conferences and technical workshops provide valuable opportunities to exchange best practices in control measures and the sustainable use of blue crabs.

Participating in large-scale project calls, such as those issued by European or regional funding bodies, can encourage closer cooperation between Mediterranean countries. This would facilitate the exchange of knowledge, the adoption of harmonised methodologies and the generation of comparable data across the region.

To strengthen these efforts, the establishment of a Mediterranean Blue Crab Action Committee is recommended. This committee would coordinate regional strategies and align national efforts [5]. The GFCM Blue Crabs Programme could support and facilitate its creation, serving as a regional consortium to lead joint action, policy alignment, and information sharing.

Governance

Governance structure: The effective implementation of the proposed action plan relies heavily on a well-structured governance system. This system should include representation from all relevant stakeholders, such as government ministries, scientific experts, fishers, aquaculture professionals, and ecosystem managers. Where applicable, it should also include actors involved in food services and value chains. The governance body is expected to convene at least twice per year to assess the progress of implemented actions. It is responsible for establishing performance indicators to evaluate the success of the plan's execution. A key role of this group is to ensure inclusive participation and facilitate communication among all parties, including ministries, researchers, managers, fishers, aquaculture stakeholders and administrative authorities, thus promoting a comprehensive and unified approach to the issue.

Strategic Planning: The plan must outline short, medium- and long-term goals. These goals should be prioritised based on the severity of the threat posed by the invasive species, the geographical areas affected and the available resources. Additionally, all proposed actions must align with national and international regulatory frameworks to ensure legal and procedural coherence.

Resource Allocation: Resources, whether financial, human or material, must be allocated in a way that maximises the efficiency and impact of control measures. The action plan should also identify alternative or complementary funding sources, such as government grants, international aid or public–private partnerships, to support its implementation.

Monitoring and evaluation: Systems should be established to track and evaluate the effectiveness of actions undertaken, providing clear data. The plan should also encourage and support scientific research to improve our understanding of the dynamics of invasive species and their environmental impact. Based on the results of the monitoring and emerging scientific knowledge, the strategy should be updated and refined continuously.

Reporting and knowledge sharing: Regular progress reports should be produced to keep stakeholders, policymakers, and the public informed. These reports should also document best practices and lessons learned to support the replication of successful approaches in other regions or contexts.

Finally, the regional and national action plans outlined in this framework should be implemented in coordination with research activities and interventions led by the General Fisheries Commission for the Mediterranean (GFCM), particularly through its ongoing blue crab research programme. Collaborating with the GFCM ensures alignment with broader, Mediterranean-wide management efforts and facilitates knowledge exchange across countries.

References

1. Besbes N, Reale S, Scibetta S, Piazza C, Lo Monaco D, Di Bella C, Sadok S. Molecular Barcoding Identification of the Invasive Blue Crabs Along Tunisian Coast. Fishes 2024, 9, 485. https://doi.org/10.3390/fishes9120485

2. Ennouri R, Zarrouk H, Fatnassi M & Mili S. Development of the fishing and commercialization of the blue crabs in Bizerta and Ghar El Melh lagoons:

A case study of promotion opportunities of blue growth in Tunisia. J. Aquac. Mar. Biol., 2021, 10(2): 66–74. DOI: 10.15406/jamb.2021.10.00308

3. Khamassi F, Rjiba Bahri W, Mnari Bhouri A, Chaffai A, Soufi Kechaou E, Ghanem R, & Ben Souissi J. Biochemical composition, nutritional value and socio-economic impacts of the invasive crab *Callinectes sapidus* Rathbun, 1896 in central Mediterranean Sea. Mediterranean Marine Science, 2022, 23(3), 650–663. https://doi.org/10.12681/mms.28878
4. Marchessaux G, Ghanem R, Chaffai A, Bahri W, Marsiglia N, Gjoni V, Souissi G, Sara G. The use of thermal performance analysis to improve conservation management: the case of the invasive Red Sea swimming blue crab, *Portunus segnis*. Global Ecology and Conservation. 2024, 54, 3071. DOI:10.1016/j.gecco.2024.e03071
5. Marchessaux G. UNEP/MAP-SPA/RAC, 2025. Best practices and management measures of the blue crabs in the Mediterranean. Ed. SPA/RAC, Tunis. 23 pp. 2025.
6. Rifi M, Basti L, Rizzo L, Tanduo V, Radulovici A, Jaziri S, Uysal I, Souissi N, Mekki Z, Crocetta F. Tackling bioinvasions in commercially exploitable species through interdisciplinary approaches: A case study on blue crabs in Africa's Mediterranean coast (Bizerte Lagoon, Tunisia). Estuar. Coast. Shelf Sci. 2023, 291, 108419. https://doi.org/10.1016/j.ecss.2023.108419