MACALISTER ELLIOTT & PARTNERS LTD

Environmental Impact Assessment Reports for Greek Aquaculture Operations – Region of the Echinadian Islands and Aitoloakarnania (Xiromeros), 2015 report

Report for the Rauch Foundation, September 2025




MacAlister Elliott & Partners Limited
56 High Street, Lymington, Hampshire, SO41 9AH, England
www.macalister-elliott.com

Table of Contents

Abbreviations and Acronyms

AMBIO	AMBIO S.A. Development Consultants
DEYA	Hellenic Union of Municipal Enterprises for Water Supply and Sewage
EAFRD	European Agricultural Fund for Rural Development
EIA	Environmental Impact Assessment
EMFF	European Maritime and Fisheries Fund
EPXSAA	Spatial Planning and Sustainable Development Framework for Aquaculture
ESYD	Hellenic Accreditation System
EU	European Union
EUSAIR	EU Strategy for the Adriatic and Ionian Sea Region
FCR	Food Conversion Ratio
g	Gram(s)
GDP	Gross Domestic Product
GIS	Geographic Information Systems
HPHSAAY	Special Spatial Planning and Sustainable Development Framework for Aquaculture
kg	Kilogram(s)
km	Kilometre(s)
km²	Square kilometre(s) – equivalent to 1 stremmata
m	Metre(s)
MAFSAP	Special Spatial Planning and Sustainable Development Framework for Tourism
MEP	MacAlister Elliott and Partners Ltd.
MERAMOD	Predictive model for aquaculture (see https://cordis.europa.eu/article/id/81735-meramod-a-predictive-model-for-aquaculture)
MoARDE	Ministry of Agriculture, Rural Development and Environment in Cyprus

MSP	Marine Spatial Planning
NAVIPE	Marine Industrial Complex
ODA	Organized Development of Aquaculture
OP	Operational Programme
OTE	Hellenic Telecommunications Organization
POAY	Area of Organized Development of Aquaculture
PAY	Aquaculture Development Area
ppt	Parts per thousand
RAS	Recirculating Aquaculture System
ROP	Regional Operation Programmes
SEIA	Strategic Environmental Impact Assessment
SWOT	Strengths, Weaknesses, Opportunities, Threats
SWSGPR	Surface Water and Groundwater and Groundwater Aquifers
t	Tonnes
WFD	Water Framework Directive
WUA	Water Use Agreement
XADA	Areas of Uncontrolled Waste Disposal
XYTA	Sanitary Waste Landfills

Disclaimer

This report is prepared from the original source reports in Greek. Every effort has been made to accurately provide English translations of the text from which these reviews are based. However, there may be some variations in the spelling of local names and differences in the acronyms and abbreviations used. Every effort has been made to standardise these throughout the reports.

Explanatory Notes

EIA report: The descriptions under the heading EIA report refer to the reported topic as described in the EIA report.

EIA analysis: The commentary described under the EIA analysis section are MEP's independent assessment of the reported section's quality and likely impact.

Assessment criteria

The following assessment categories have been used when considering various aspects of the EIA.

Critical weakness: A critical weakness refers to a significant flaw or deficiency in the EIA report that has the potential to substantially undermine the accuracy, comprehensiveness, or credibility of the assessment. This could include fundamental errors or omissions in data collection or analysis, failure to consider key environmental impacts, or lack of compliance with regulatory requirements. Critical weaknesses typically require urgent attention and correction to ensure the integrity of the assessment process and the validity of its conclusions.

Major weakness: A major weakness denotes a notable deficiency in the EIA report that, while not as severe as a critical weakness, still has a significant impact on the overall quality and reliability of the assessment. This may include inadequate documentation of methodologies, incomplete analysis of potential impacts, or insufficient consideration of alternative measures or mitigation strategies. Major weaknesses require substantial remediation to address deficiencies and improve the overall robustness of the assessment.

Weakness: A weakness refers to a less significant flaw or limitation in the EIA report that may detract from its effectiveness or thoroughness but does not severely compromise its overall validity or utility. This could include minor inconsistencies in data presentation, gaps in information, or shortcomings in the assessment of certain environmental factors. While weaknesses may not necessarily invalidate the assessment, they still warrant attention and corrective action to enhance the credibility and reliability of the findings.

Minor weakness: A minor weakness indicates a relatively minor or incidental flaw in the EIA report that has minimal impact on the overall quality or integrity of the assessment. This might include inconsistencies or minor omissions in documentation. While minor weaknesses may not significantly affect the substance of the assessment, they should still be addressed to ensure clarity, accuracy, and professionalism in the report.

Ecological indicators used in impact assessment

Key indicators used by MERAMOD to assess benthic ecosystem health in terms of severity and extent included:

Solid waste deposition severity thresholds. The MERAMOD model and the Tropomod model in Asia, use the following scales to measure impact in four degrees: barely detectable, moderate, high, and severe.

As a guide to interpretation based on model validation and application, 1.5 kg/m²/year was used to distinguish between unpolluted and polluted conditions. Above this threshold, pollution-tolerant species such as *Capitella capitata* dominate, while pollution-sensitive species disappear.

Severity thresholds of solid waste impacts

Low impact from 4.1 g/m^2/day 1.5 kg/m^2/year to 15 g/m^2/day 5.475 kg/m^2/year	This contour is used as an indication of the potential extent of influence of the deposition footprint on the seabed and overlapping between adjacent farm lease areas. Low impact is classified as between 4.1 g/m^2/day (1.5 kg/m^2/year) and 15 g/m^2/day (5.48 kg/m^2/year). At these deposition rates, the benthic environment remains relatively stable and can assimilate the organic input without significant degradation. **Environmental Effects** • Minor enrichment of sediment organic content. • Increased microbial activity and minor shifts in benthic community structure (e.g., slight increase in opportunistic species). • Oxygen levels remain sufficient to support a diverse range of macrofauna. • Redox potential remains positive or mildly reduced.
Moderate impact from 15 g/m^2/day 5.475 kg/m^2/year to 45 g/m^2/day 16.425 kg/m^2/year	The 15 g/m^2/day (5.48 kg/m^2/year) is used to predict moderate footprint severity. In *MERAMOD*, a moderate to high impact on the seabed is expected above this level of deposition. This level of deposition is commonly measured in sediment traps close to, or underneath the cages. Moderate to high impact is classified as between 15 g/m^2/day (5.48 kg/m^2/year) and 45 g/m^2/day (16.43kg/m^2/year). The sediment begins to exhibit signs of moderate enrichment and ecological stress, though recovery is still possible if inputs are reduced or managed. **Environmental Effects** • Noticeable accumulation of organic matter in sediments. • Decline in species diversity, with dominance of tolerant or opportunistic species. • Oxygen levels in sediment pore water begin to decline, especially during warm periods. • Redox potential may become negative at surface layers of sediment. • Risk of mild sulphide accumulation.
High impact from 45 g/m^2/day 16.425 kg/m^2/year to 75 g/m^2/day 27.375 kg/m^2/year	The 45 g/m^2/day (16.43kg/m^2/year) is used to predict a high footprint severity. Published data shows that depositional sites in other environments where predictions of deposition are greater than 50 g/m^2/day (18 kg/m^2/year) are no longer favoured by the industry. There will be significant enrichment of the benthic environment occurs, leading to adverse ecological conditions and potential non-compliance with environmental standards. **Environmental Effects** • Organic overloading results in hypoxic or anoxic conditions in sediment layers. • Redox values strongly negative (often below -100 mV), indicating reducing conditions.

	• Sulphide concentrations may increase, toxic to many benthic organisms. • Severe reduction in macrofaunal diversity; benthic habitat function deteriorates.
Severe impact over 75 g/m^2/day 27.375 kg/m^2/year	The 75 g/m^2/day (27.38 kg/m^2/year) contour represents a very high level of flux and is expected to cause azoic conditions on the seabed. This level of flux was modelled and observed at Tropomod (Asian) sites underneath the cages but was less commonly seen at *MERAMOD* sites (eastern Mediterranean). From previous projects, deposition of this magnitude was predicted (and measured), and that this resulted in severely degraded conditions, as well as significant black layer depth in sediments and high carbon content of sediments. Severe impact is classified as above 75g/m^2/day (27.38 kg/m^2/year). The sediment environment is overwhelmed by organic loading, leading to ecological collapse of benthic systems beneath the cages. **Environmental Effects** • Persistent anoxia; high sulphide accumulation. • Absence or near-absence of macrofauna (azoic conditions). • Hydrogen sulphide gas formation, blackened sediments, foul odours. • Severe alteration of sediment chemistry and loss of ecosystem services. • Beggiatoa on the sediment surface.

Shannon-Weiner benthic diversity index.
The **Shannon-Weiner Diversity Index (H')** is a widely used ecological metric for assessing species diversity within a biological community. It accounts for both species richness (the number of different species present) and evenness (the relative abundance of each species), offering a single value that reflects the structure and health of an ecosystem.
Formula.

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i)$$

Where:
- SSS = total number of species (species richness)
- pip_ipi = proportion of individuals belonging to the *i*th species
- ln\lnln = natural logarithm

A higher H' value suggests a more diverse and evenly distributed community, whereas a lower value indicates that a few species dominate.

In benthic monitoring near aquaculture sites, the Shannon-Weiner Index is a key tool used to evaluate changes in biodiversity due to organic enrichment—mainly from uneaten feed, faeces, and other wastes settling to the seafloor. These organic inputs alter sediment chemistry and oxygen availability, which in turn affects benthic communities.

Ecosystem condition is often classified using H' thresholds as follows:

Severity thresholds for benthic impact

H' Value	Ecosystem Condition	Interpretation
> 4	High	Diverse, undisturbed community
3–4	Good	Slightly altered; moderate diversity
2–3	Medium	Noticeable stress; moderate loss of sensitive species
1–2	Low	Strong dominance by tolerant species; low diversity
≤ 1	Bad	Severely degraded; opportunistic species dominate

As **aquaculture-induced organic loading increases**, the seafloor becomes enriched with nutrients, often leading to:

- **Hypoxia or anoxia** in sediments.
- **Reduction or loss of sensitive taxa** such as polychaetes and echinoderms.
- **Proliferation of opportunistic species**, such as Capitella spp., which thrive in enriched conditions.

These changes are reflected in a decline in H', as both the number of species and evenness decrease. Over time, persistent high loading can push the index into the "Low" or "Bad" categories, signalling ecological degradation.

Redox Potential (Eh):

Redox potential (Eh) is a key geochemical parameter used in environmental monitoring to evaluate the oxidation-reduction (redox) state of sediments. In the context of aquaculture, it serves as a proxy for **oxygen availability** in sediments—an essential factor determining the health of benthic ecosystems and the ability of macrofaunal communities to thrive.

- Eh is measured in millivolts (mV) and reflects the balance between oxidising and reducing chemical reactions in the sediment.
- High positive values indicate oxidising (oxygen-rich) conditions, while negative values indicate reducing (oxygen-poor or anoxic) environments.
- Standard measurements are often taken at depths of 2 cm and 4 cm, where most biological activity and organic matter accumulation occur.

In aquaculture environments, redox potential is often classified as follows:

Severity thresholds of sediment quality

Eh value (mV)	Sediment condition	Interpretation
> +300	Well-oxidised	Healthy, aerobic environment; supports diverse benthic fauna
+100 to +300	Moderately oxidised	Some organic enrichment; still aerobic
0 to +100	Transition zone	Oxygen depletion beginning; facultative species dominate
0 to -100	Reduced	Hypoxic, with hydrogen sulphide possibly forming
-100 to -200	Strongly reduced/anoxic	Anoxic; unsuitable for most macrofauna, dominated by anaerobic bacteria
>-200	Totally anoxic	Only Beggiatoa can survive.

Aquaculture activities—particularly from fish and shrimp farms—can increase organic matter loading to sediments due to uneaten feed and faecal deposition. This stimulates microbial activity, which in turn increases oxygen demand in sediments, resulting in:

- Lower redox values, especially at greater sediment depths.
- Formation of anoxic layers, often producing toxic compounds like hydrogen sulphide (H_2S).
- Loss of aerobic benthic organisms and an increase in anaerobic or opportunistic microbial populations.

Tracking redox potential allows for early detection of these changes and can be used as a diagnostic tool to assess sediment quality and aquaculture-induced organic enrichment.

Impact on sensitive benthic habitats

Classification of extent

Classification	Level of impact	Impacts
Low	<50	• **Seagrass**: Slight leaf epiphyte loading; limited shading or siltation. • **Macroalgae**: Minor sediment film; community largely intact. • ***Posidonia***: Minimal shoot burial; slight reduction in photosynthesis possible. • **Corals**: No visible impact unless in very close proximity.
Moderate	50-100	Increased benthic enrichment. • **Seagrass**: Risk of siltation and reduction in photosynthetic efficiency; possible leaf necrosis. • **Macroalgae**: Decline in diversity; dominance of more sediment-tolerant species. • ***Posidonia***: Moderate rhizome burial risk; decline in meadow density begins. • **Corals**: Sediment stress; reduced polyp extension and feeding; biofilm formation.
High	100 - 200	Strong impact • **Seagrass**: Smothering and decline in shoot density; increased vulnerability to pathogens. • **Macroalgae**: Severe community simplification; loss of habitat function. • ***Posidonia***: Shoot mortality; collapse of meadow structure possible. • **Corals**: Sediment suffocation, bleaching, or tissue necrosis; bioerosion.
Severe	>200	Beyond ecological assimilative capacity. • **Seagrass**: Extensive dieback; replacement by opportunistic filamentous algae or cyanobacteria. • **Macroalgae**: Complete loss of sensitive species; regime shift to detritus-dominated substrates. • ***Posidonia***: Long-term ecosystem collapse; irreversible habitat loss.

	• **Corals**: Widespread bleaching and mortality; reef framework degradation.

Executive Summary

The Strategic Environmental Impact (SEIA) study was undertaken in 2015 by AMBIO S.A. and was based on data collected and analysed in the same year.

The study adequately describes the existing laws, regulations, and governmental framework for aquaculture development and theoretical potential environmental impacts. This will have been sufficient to request increases in production licenses for existing farms and the establishment of new farms.

The EIA evaluates four possible scenarios for expansion and selects the one with the largest expansion in terms of area and production. However, the results of the multiple models included in the report indicate that the environmental damage will be moderate in some areas but severe in others. It should be noted that the report does not include the thresholds associated with each modelled result and hence the reader is unable to evaluate the extent of the proposed impact. Adding those ratings for the three standard environmental impact indicators included in the EIA (Meramod, Shannon-Weiner, Redox Eh) at ten sites indicates that a full 30% of the tests indicate high or severe impact while 57% show a moderate impact. For these reasons, moving forward with the expansion as currently proposed would pose high to severe risk and damage to the environment.

Environmental impacts

The report provides sufficient quantification of environment impact for individual farms. In the existing situation, the average estimated maximum solid waste impact for all the zones is 3.75 kg/m^2/year (Moderate impact). The majority of zones are estimated to have a light impact on the sediments however zone P10 (Mytikas) is already moderately impacted.

In the chosen scenario (Scenario 4), the average estimated maximum impact for all the zones is 7.82 kg/m^2/year (more than double). The majority of zones are now estimated to have a moderate impact on the sediments; however, zone P6 (Mavrovouros) remains moderately impacted.

In the existing situation, the average estimated maximum benthic community impact for all the zones is 2.81 (Low benthic community quality). Most zones are estimated to have good to medium quality sediments however zone P10 (Mytikas) is already low quality.

In the chosen scenario (Scenario 4), the average estimated maximum impact for all the zones is 1.57 (low quality). The majority of zones are now estimated to have low quality sediments however zone P6 (Mavrovouros) remains moderately impacted and zone P10 (Mytikas) is badly impacted.

In the existing situation, the average estimated maximum sediment oxygen impact for all the zones is -36.02. Most zones are estimated to have low impact on the sediments however zone P10 (Mytikas) is already moderately impacted.

In the chosen scenario (Scenario 4), the average estimated maximum impact for all the zones is -53.01 (47.18% worse). The majority of zones are now estimated to have moderate impact on the sediments however zones P5, P6 and P8 remail low impact.

However, the report does not provide sufficient analysis of the cumulative impacts of the multiple farms on the environment. The cumulative impact of multiple fish cage farms in a water body can

significantly affect the ecosystem, particularly concerning eutrophication, the spread of fish diseases and parasites. This is a critical weakness.

Specifically, the study is insufficient in:

- Describing present farm activities and facilities e.g., the number, and size of cages, fish production at sea and the land-based facilities, vessels and trucks, etc. It does not provide summaries of regular environmental monitoring surveys indicating the present level of impact and how this is validated with the MERAMOD model prediction. This is a weakness.
- Quantifying planned new facilities (land and sea), use of inputs (feed and fingerlings) and outputs (nutrients released to the water column). This detail is required to quantify the changes that might occur with the expansion of production and project area. This is a weakness.
- The expansion of marine fish farm sites in or along the borders of NARURA 2000 Type A areas would require detailed additional studies to map the location of seals and cetaceans to ensure that the fish farms do not pose a risk to these sensitive species. Fish farms located in these areas should also be made to follow good practices. This is a major weakness.

As a result of the accumulation of issues, the omissions in the EIA study and the overall predicted environmental impacts are deemed to be a critical weakness.

Socio-economic impacts

The study does not provide sufficient quantification of the social impacts or provide sufficient recommendations on mitigation measures. In addition, no stakeholder consultation has been reported in the study. to be able to find mutually agreed solutions to avoid conflict with other users of the space and the neighbouring communities and tourist trade on the island.

Specifically, the socio-economic aspects of the study are insufficient in:

- Factors related to social assessment and impact – major weakness.
- Quantifying planned new facilities (land and sea) and their requirement for infrastructure (roads, freshwater, sewage treatment), labour, use of inputs (feed and fingerlings) and outputs (nutrients released to the water column) - major weakness.
- Proposing environmental and social mitigation measures to reduce impact - major weakness.
- Quantification on the use of resources and how these will be addressed (road traffic, marine traffic, additional electricity supply, additional freshwater supply, etc.) - major weakness.
- Quantification, solutions and impact from the project outputs such as wastewater treatment, solid waste disposal, and organic waste disposal - major weaknesses.
- The study shows no evidence of stakeholder consultation and effort to find mutually agreed mitigation measures to reduce social impacts – critical weakness.
- Marine tourism (yachts, pleasure vessels) would be impacted by the floating cage collars as well as the boating activity during the farm operation – minor weakness.

Analysis of Impacts

As part of the analysis of the EIA, MEP reviewed the data used in the calculation of three impact models and assessed how each of the ten aquaculture sites are ranked based on internationally accepted standards. The analysis was completed for Scenario 4 which is the recommendation of the EIA's authors, Ambio Consulting.

Severity Thresholds

Solid Waste Impact	Benthic Impact	Redox Potential
---	High	---
Low	Good	Low
Moderate	Medium	Moderate
High	Low	High
Severe	Bad	Severe

Calculations of Severity Thresholds for Proposed Implementation: Xiromero Scenario 4

Aquaculture zone	Solid Waste Impact	Benthic Impact	Redox Analysis	Increase in area (str)	Increase in production (t)
P1	7.4 kg/m^2/yr	1.47	-51.33	5	4,337.5
P2	8.73 kg/m^2/yr	1.27	-53.17	71	2,806.25
P3	7.57 kg/m^2/yr	1.64	-54.16	109.25	3,592.25
P4	8.08 kg/m^2/yr	1.52	-54.28	260.06	12,110.9
P5	6.93 kg/m^2/yr	1.96	-47.06	25	868
P6	4.45 kg/m2/yr	2.42	-42.81	161.5	6,242
P7	10.3 g/m^2/yr	1.25	-58.36	45	1,737.51
P8	6.03 kg/m^2/yr	1.7	-49.61	15	1,010
P9	10.29 kg/m^2/yr	1.62	-52.35	20	1,170
P10	9.66 kg/m^2/yr	0.855	-66.95	50	866.25
Summary	*7.82 kg/m^2/yr*	*1.57*	*-53.01*	*761.78*	*33,502.96*

Regarding the Solid Waste Impact, in Scenario 4, the average estimated maximum impact for all the zones is 7.82kg/m^2/year (more than double). The majority of zones are now estimated to have moderate impact on the sediments however zone P6 (Mavrovouros) remains moderately impacted.

Regarding the Benthic Impact, in Scenario 4, the average estimated maximum impact for all the zones is 1.57 (low quality). The majority of zones are now estimated to have low quality sediments however zone P6 (Mavrovouros) remains moderately impacted and zone P10 (Mytikas) is badly impacted.

Regarding the Redox Analysis, although each individual zone remains low or moderately impacted and within acceptable levels at the near field (local scale) level, the impact of many farms in the same area can have cumulative impacts at the far field (bay scale) that can affect water quality, farming operations and local communities.

1. Introduction

1.1 Background

As the Strategic Environmental Impact Assessment (SEIA) identifies, describes and evaluates the potential significant environmental impacts that will result from the implementation of the Area of Organized Development of Aquaculture (POAY in Greek) Plan for Aitoloakarnania and the Echinades Islands.

The main purpose of the environmental impacts which are examined by the SEIA, is the spatial development of aquaculture activity in the coastal zone (marine and terrestrial) of the area of the Echina Islands and Aitoloakarnania.

Marine fish cage culture has become an increasingly important industry in Greece, contributing to both the economy and the food security of the country. However, the industry has also been associated with a number of beneficial and detrimental environmental impacts.

Environmental Impacts

The addition of nutrients into the marine environment, often referred to as "nutrient enrichment" or "pellet rain," involves the input of nutrients from uneaten fish feed and fish waste. These nutrients can stimulate the growth of natural prey organisms, such as plankton and benthic organisms, which are important in the marine food web. However, marine fish cage culture significantly impacts marine ecosystems. Nutrient-rich waste from fish, including nitrogen and phosphorus, leads to eutrophication, causing excessive algae growth, reduced water clarity, and decreased oxygen levels, which can harm aquatic life.

Particulate waste like faeces and uneaten food increases organic sediment, affecting benthic organisms and seagrass beds, essential for ecosystem health. Chemicals used in fish cages can contaminate the environment, impacting benthic health. Additionally, fish cages can spread diseases and parasites to wild fish, with high fish densities accelerating pathogen transmission. Escaped farmed fish may also genetically dilute wild populations. These farms can disrupt natural habitats, predator-prey dynamics, and create noise pollution, further stressing marine environments.

Socio-economic Impacts

The marine fish cage farming industry plays a significant role in the economy and food security, offering substantial socio-economic benefits at both national and local levels. Nationally, it provides considerable job opportunities, contributes to foreign exchange earnings through exports, and supports economic diversification, especially in coastal regions where traditional fishing is declining. Locally, it generates employment in various sectors, aids in economic diversification, and contributes to community development through revenue that can be reinvested in projects like education and healthcare. Additionally, it supports local businesses by providing a reliable fish supply and stimulates skill development among workers.

However, the industry also presents socio-economic challenges. Environmentally, it contributes to pollution, disease spread, and habitat destruction. Socially, it often leads to tensions between fish farmers, traditional fishers, and local communities due to resource competition, lack of transparency in decision-making, and uneven distribution of benefits. Locally, the visual impact of fish cages can affect coastal aesthetics, potentially deterring tourism, while increasing local marine and road traffic, straining freshwater resources, and impacting housing markets due to worker demand. Balancing these benefits and drawbacks depends on careful management and interaction with local communities, highlighting the complexity of assessing the overall impact of the fish cage farming industry in Greece.

1.2 Study Objective

A series of feasibility studies and Environmental Impact Assessments (EIAs) have been prepared for the designated POAY's. The focus of this The EIA report states is the SEIA prepared by AMBIO in 2015.

Establishment of Areas for the Organized Development of Aquaculture (ODA) in the region of the Echinadian islands and Aitoloakarnania.

It should be noted that, according to the HPHSAAY, the study area is currently classified as a Particularly Developed Area. The coastal zone of the Echinades islands and Aitolokarnania is also an area of capital importance for the country's economy and is subject to high competition due to the many activities that are developed in it. At the same time, the dependence of aquaculture development on high-quality water resources shapes the specificity of the sector and creates the need for special regulations in its location.

The SEIA study is "Promoting areas of organised aquaculture development in areas of high concentrations of aquaculture, with a view to their rational management and development, the achievement of economies of scale and the creation of modern support facilities (storage areas, packing stations, fish hatcheries, etc.)".

2. AMBIO S.A. Development Consultants

The EIA for the Xiromero area was undertaken by AMBIO S.A. Development Consultants (AMBIO). AMBIO, based in Athens, Greece, is a prominent consultancy company in the field of fisheries and aquaculture, with a strong presence in EIAs for marine fish cages. The company's expertise extends beyond the Greek borders, with projects and clients in over eight countries, showcasing their international competence and reach.

AMBIO's approach to aquaculture and fisheries is marked by a commitment to meeting the growing global demand for aquaculture products while considering the limitations of natural resources and various production constraints. This balance between scalability and sustainability is a key aspect of their services. They are particularly adept at assisting clients to meet development goals efficiently, within budget, and to a high standard of quality.

Their services in the aquaculture sector are comprehensive, covering a wide range of areas from cage and land-based production units to hatcheries, packaging, and processing units. Their expertise also extends to logistics centres, waste processing units, and environmental monitoring systems. This demonstrates their ability to handle diverse aspects of aquaculture projects, from inception to completion.

In EIAs, AMBIO employs over thirty years of experience, positioning itself at the forefront of consulting firms in this domain. Their innovative use of the latest GIS technology and an extensive database for environmental information enables them to provide accurate analyses swiftly. The team's expertise extends to working closely with various stakeholders, including developers, architects, process engineers, and planners, to deliver environmentally positive solutions for both large and complex as well as small and niche projects.

AMBIO's services in environmental impact assessment are varied, including strategic environmental assessments, environmental and social impact assessments, environmental due diligence, risk assessment, environmental planning and permitting, water management, and waste management and recycling. This breadth of services ensures a holistic approach to environmental impact studies, tailored to the specific needs of each project.

The company's involvement in major aquaculture projects in Greece and its expansion to other countries, including Cyprus, Egypt, Italy, the UK, Kenya, Oman, Saudi Arabia, and Turkey, is a testament to its wide-ranging expertise and successful track record. AMBIO's role in the significant acquisition and reorganization of aquaculture companies in the Mediterranean further highlights their strategic and management capabilities in this sector.

Experience: AMBIO has been operating since 1993, indicating extensive experience in the broader field of environmental consulting. Their project portfolio includes a diverse range of environmental studies, encompassing renewable energy projects, infrastructure development, and aquaculture projects, suggesting their familiarity with the environmental considerations relevant to marine fish cage operations.

Expertise: AMBIO has a team of qualified environmental engineers, biologists, and other specialists with expertise in various environmental disciplines, including water quality, marine ecology, and environmental impact assessment methodologies. This expertise aligns with the key areas of focus within marine fish cage EIAs, indicating their potential ability to address the specific environmental concerns associated with these projects. The company also mentions experience with obtaining environmental permits, suggesting their familiarity with the regulatory framework for marine fish cage operations in Greece.

Competence: AMBIO's successful track record in delivering high-quality environmental studies for diverse projects suggests their competence in managing complex environmental assessments. Their commitment to quality is further evidenced by their accreditation with the Hellenic Accreditation System (ESYD), demonstrating their adherence to international standards.

3. Analysis of Xiromero EIA

3.1 Scope of SEIA

EIA report: The study notes that in addition to the environmental requirements, the objectives of the Regional Operation Programmes (ROP) of the rural unit of Western Greece also serve the European Union (EU) strategy for the Adriatic and Ionian region (approved by the EU in June 2014) and the ROP of the Ionian Islands (2014-2020). The ROP for Western Greece has five strategic objectives which impact the strategic planning and will affect the social assessment.

These are broadly as follows:

1. Strengthening research, technological development and innovation.
2. Protecting the environment – transition to an environmentally friendly economy.
3. Development-modernisation – completion of transport infrastructure.
4. Developing human resources, promoting social inclusion and combating poverty and discrimination.
5. Development-modernisation – completion of social, health and education infrastructures.

EIA analysis: The description of the project (Chapter 4) does not mention that any stakeholder or community engagement and consultation was to be, or had been, undertaken during the study.

3.2 SWOT analysis

EIA report: A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis was used to identify the Strengths and Weaknesses, as well as the Opportunities and Threats for the definition of the POAY in the Echinades Islands and Aitoloakarnania, as detailed in the table below.

Table 1: SWOT analysis of the POAY of the Echinades Islands and Aitoloakarnania

Strengths: • Completion of spatial planning for aquaculture • Recognised protected area of aquatic species of economic importance • Good status of water bodies • Distance from the commercial Port of Patras and Igoumenitsa • Connection to main roads • Important contribution to social cohesion • Important contribution to the regional and national economy	**Weaknesses:** • Complex legal framework • Competition with other activities • Limited living space for the development of new plants • Absence of a comprehensive restructuring plan for the sector
Opportunities: • Increase in production • Contributing to the protection of the marine environment	**Threats:** • Inadequate information to citizens with unsubstantiated negative publicity

• Minimise conflicts with other users of the coastal zone • Simplification of the licensing of aquaculture units integrated in the POAY • Contributing to the formulation of a comprehensive plan for the restricting of the sector • Creating a friendly investment environment • Strengthening sectoral employment / contributing to the reduction of unemployment	• Lack of experience at a national level • International financial crisis • Reduction of investment at a national level

EIA analysis: While the SWOT analysis considers many aspects of the study it does not reflect many of the social aspects such as the effect on local livelihoods and communities and the impact on community infrastructure, services and resources.

3.3 Framework and objectives of the study

EIA report: Section 3.1 International, community and national environmental protection objectives relevant to the project

EU Policies and Regulations:

- **Integrated Maritime Policy and Blue Paper.** Aims for integrated decision-making in marine environments.
- **Marine Strategy Framework Directive (2008/56/EC).** Focuses on protecting and preserving marine environments through strategic assessments and cooperation among Member States.
- **Water Framework Directive 2000/60/EC.** Integrates qualitative, ecological, and quantitative objectives for aquatic ecosystems and water resources.
- **Common Fisheries Policy and Green Paper.** Develops fisheries policy considering social, economic, and environmental aspects.
- **Marine Spatial Planning.** Addresses cross-sectoral conflicts in European seas, including fisheries, shipping, and environmental concerns.
- **European Maritime and Fisheries Fund (EMFF).** Supports sustainable fisheries, coastal and marine conservation, and marine resource use.
- **Integrated Coastal Zone Management in the Mediterranean.** Establishes a framework for managing Mediterranean coastal zones.
- **Strategy for Sustainable Development of European Aquaculture.** Addresses challenges in aquaculture for competitiveness and sustainability.
- **Strategic Guidelines for Sustainable Aquaculture Development.** Aims to overcome EU aquaculture stagnation.
- **Guidelines for Aquaculture and Natura 2000.** Guides development and conservation in Natura 2000 sites.
- **EU Strategy for the Adriatic and Ionian Sea Region (EUSAIR).** Promotes sustainable maritime and marine development in the region.

Greek Policies and Regulations:

- **National Strategy for Sustainable Development.** Integrates environmental considerations into development processes.
- **National Strategy for Marine Environment Protection (Law 3983/2011).** Aligns Greek law with EU regulations for marine environment status by 2020.
- **Biodiversity Conservation Law (3937/2011).** Focuses on sustainable management and conservation of biodiversity.
- **National Strategic Plan for Aquaculture Development (2014-2020).** Aims for sustainable sector growth, increasing production, employment, and gross domestic product (GDP).

Regional and Local Policies:

- **ROP of Western Greece (2014-2020).** Enhances competitiveness, innovation, and environmental protection.
- **ROP of the Ionian Islands (2014-2020).** Strengthens regional competitiveness through entrepreneurship and innovation.
- **Municipal Operational Programmes (2012-2014).** Focuses on environmental protection and quality of life.

Objectives of the Proposed POAY:

- Reducing intensive aquaculture impacts.
- Promoting environmentally friendly aquaculture.
- Developing sector activities.
- Protecting human and public health.
- Reducing emissions.

EIA analysis: The report adequately describes the EU, Greek, Regional and Local policies and regulations. It covers the local policies that affect the local communities but does not relate (or quantify) the impacts of the expansion of cage culture to the regional and local objectives.

3.4 Section 4 of the SEIA – Project description

The scope of the study are the areas of the Echinades Islands and West Coast of Aitoloakarnania. In the selected scenario, the total area to be occupied by the proposed production zones is 25,977.98 stremmata[1] (km^2), while the leased area in the entire POAY occupies an area of 1,842.75 km^2. An increase to the total area of the leased area by 70.48% (761.81 km^2) is proposed, of which 39.12% (422.81 km^2) is for the expansion of existing units and 31.36% (339.00 km^2) is for the new area. The water zones occupy an area of 15,202.39 km^2.

3.5 Section 5 of the SEIA – Mandatory assessment of alternatives

EIA report: Four alternative scenarios were evaluated in this study. The MERAMOD prediction model was used to assess the impacts on the ecosystem and estimate carrying capacity.

- **Scenario 1** (Zero Option) does not foresee any expansion of leased land and increase in capacity of the units, except for those foreseen by the aquaculture spatial plan.

[1] *A unit of land area mainly used in Greece and Cyrpus, equivalent to 1 km^2*

According to scenario 1, the leased land in the whole of the POAY occupies an area of 1,186 km^2. This means that the total area of leased land is expected to increase by 9.72% (105.06 km^2). The total annual capacity of the POAY amounts to 15,386.90 tonnes (t), which corresponds to a reduction of -23.59% (-4,749.80) of the existing capacity.

The reason for the reduction of the capacity is that for some units the determination of their capacity was made according to the formula of the joint circular of the MoARDE before its application was suspended, while in scenario 1 for the determination of the capacity the above formula is not used for any unit.

- **Scenario 2**, in which the layout and the area of the leased areas of scenario 1 are maintained, while the capacity of the units is calculated based on the formula of the joint circular of the Ministry of Environment and Natural Resources and the Ministry of Agriculture and Forestry.

According to scenario 2, the total annual capacity of the POAY amounts to 35,412.55 t, which corresponds to an increase of 75.86% (15,275.85 t) of the existing capacity.

- **Scenario 3**, in which the leased land of scenarios 1 and 2 is added to the total extensions needed to implement the planning and the production reconstruction plan originally prepared by the operators of the plants in the area. It also includes land for the installation of new plants.

According to scenario 3, the leased area is 2,221.18 km^2. This means that the total area of leased land is expected to increase by 105.49% (1,140.24 km^2), of which 75.97% (821.24 km^2) is for the expansion of existing units and 29.51% (319.00 km^2) is for new land.

The total annual capacity amounts to 63,837.95 t, which corresponds to an increase of 217.02% (43,701.25 t) of the existing capacity.

- **Scenario 4**, in which the leased land in scenarios 1 and 2 is retained, but the proposed expansions are redistributed to reduce the expansions in scenario 3 by approximately 25%. Capacity is calculated in the manner described in Scenarios 2 and 3.

Under Scenario 4, the leased land in the entire PPA occupies an area of 1,842.75 km^2. This means that the total area of leased land is expected to increase by 70.48% (761,81 km^2), of which 39.12 % (422,81 km^2) is for the expansion of existing units and 31.36% (339,00 km^2) for new land.

The total proposed annual capacity of the PPA is 54,877.31 t, which represents an increase of 172.52% (34,740.61 t) of the existing capacity, of which 116.79% (23,516.73 t) is for the increase in capacity of existing plants and 55.74% (11,223.88 t) is for the establishment of new plants.

EIA analysis: The report analyses 4 scenarios compared to the existing situation with Scenario 1 and 2 increasing Area by 10% and a change in production of -34% and +76%, respectively. Scenario 3 has a significant increase in area (more than double) and a major increase in production (more than triple). At, this scale of expansion, the impact on the environment is significant. Scenario 4 (the chosen scenario) the area is increased by 70% and production is increased by 173% (close to triple existing production).

	EXISTING UNITS	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Area (km^2)	**1,080.94**	1,186	1,186	2,221.18	1,842.75
Production (t)	**20,136.7**	15,386.9	35,412.55	63,837.95	54,877.31

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Area (km^2)	10%	10%	105%	70%
Production (t)	-34%	76%	217%	173%

3.6 Choice of Alternatives (Section 5.5)

EIA report: The main solution proposed in the text is the establishment of a POAY in the Echinades Islands and Aitoloakarnania, implementing scenario 4 for leased land area and capacity. The selection of this site considered several factors:

1. **Suitable land area:** The ability to secure an appropriate and sufficient land area for aquaculture.
2. **Absence of protected habitats:** No special conditions or restrictions due to protected habitats under Community and national legislation.
3. **Coexistence of similar activities:** The potential for aquaculture activities to coexist, creating economies of scale without conflicting with established land uses or causing nuisances.
4. **Economic and social benefits:** The potential for positive impacts on the economy and society.
5. **Infrastructure availability:** The presence or possibility of developing necessary infrastructure like energy, roads, and telecommunications, ensuring technical adequacy, economic viability, and environmental protection.
6. **Minimal aquatic ecosystem impact:** The chosen land area minimally impacts the aquatic ecosystem, such as the absence of estuarine ecosystems.

EIA analysis: The chosen alternative (Scenario 4) will significantly increase the area farmed (up from 1,080 km^2 to 1,843 km^2) and production volume (up from 20,137 t to 54,877 t).

	EXISTING UNITS	Scenario 4	% Change
Area (km^2)	1,080.94	1,842.75	70%
Production (t)	20,136.7	54,877.31	173%

The report does quantify the organic loading on sediments, changes to benthic communities but not quantify the positive or negative impacts of economic and social benefits at the local community level and impact on infrastructure and services at the local level.

4. Existing Environmental Situation

Description of the existing environmental situation:

- Surface Water and Groundwater and Groundwater Aquifers (SWSGPR)
- Processing and assessment of physico-chemical parameters of marine waters
- Type of seabed - ecological quality assessment
- Microbial load
- Inventory of pollution sources and data processing with analysis of zones of influence
- Habitat types - flora and fauna of the study area
- Climatic characteristics
- Oceanographic data
- Coastal area

4.1 Surface water and groundwater

EIA report: The report describes the major river systems, lakes and water quality, coastal water bodies and quality. It also describes the ground water aquifers. The surface water bodies of the study area constitute an important resource for both extensive and intensive fish farming and are therefore included in the protected areas of aquatic species of economic importance.

EIA analysis: The information is given in sufficient detail, but the report does not quantify the additional freshwater requirements for the expansion and estimate if freshwater water availability is sufficient.

4.2 Processing and assessment of physico-chemical parameters of marine waters

EIA report: The report covers an assessment of temperature and salinity through the water column based on a 2005 study. It describes the general seawater currents, dissolved oxygen levels, nitrate/nitrite/ammonia, phosphates, chlorophyll, transparency, pH, turbidity and suspended solids.

EIA analysis: The report comprehensively covers the existing seawater quality in the area but does not attempt to calculate the additional nutrient input from aquaculture and its potential impact to change the quality.

4.3 Type of seabed - Ecological quality assessment

EIA report: The report covers an assessment of seabed type and an assessment of the impact of fish cages on bottom quality was carried out by examining the benthic flora and fauna (including phyto benthos) of the study area which also includes Natura 2000 sites.

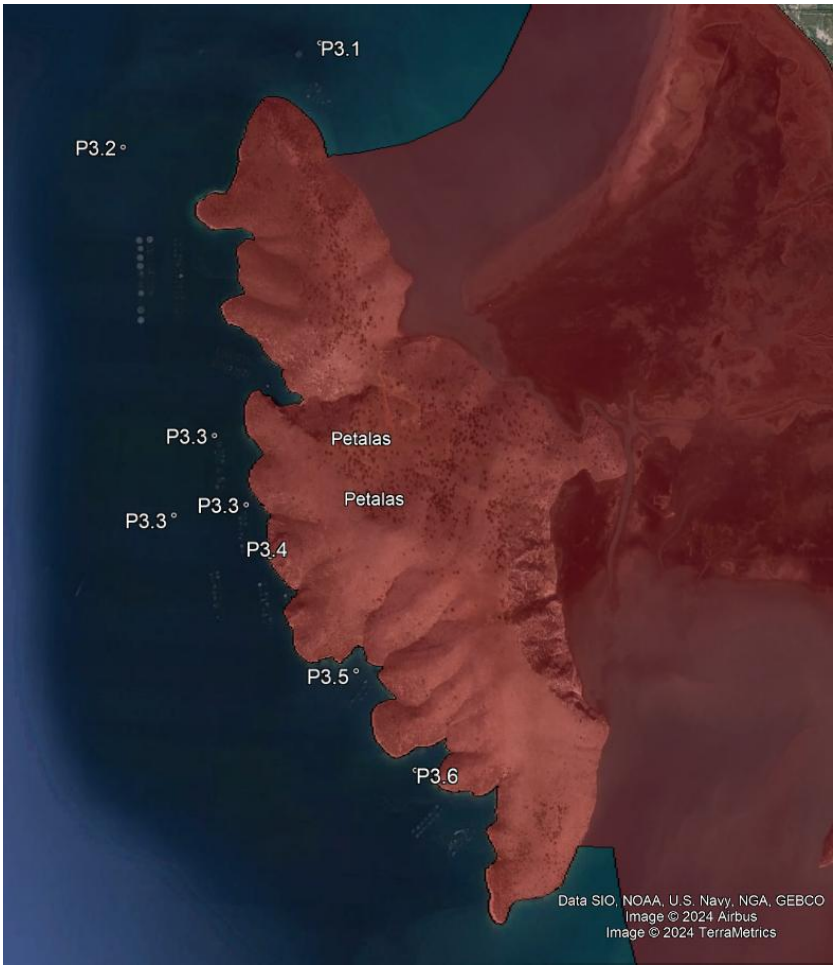
The European Commission has issued guidelines on the issue of fish farming activity within Natura 2000 sites, entitled: "Guidance on aquaculture and Natura 2000 - Sustainable aquaculture activities within the Natura 2000 network" - (Guidance on Aquaculture and Natura 2000: Sustainable aquaculture activities in the context of the Natura 2000 Network). It presents the context of aquaculture development and biodiversity conservation in Europe in policy terms,

reviews the potential impacts of the main aquaculture systems on nature and wildlife, with a particular focus on methods and tools to assess them in the light of nature conservation objectives on Natura 2000 sites. The guidelines explain how these risks should be assessed on a case-by-case basis and how they can be avoided or minimised.

EIA analysis: The report does identify the potential impact of aquaculture on the seabed and the use of models to predict the impact including MERAMOD. It also describes the Shannon - Weiner index to classify the diversity of the benthic community and ORP (Redox) to classify the seasonal variations related to the seasonal variation of sedimentation.

The location of the P.O.A.Y. includes 3 areas that have been classified as protected by the Natura 2000 network Type A (SPA).

The areas are primarily terrestrial but there are existing fish farms located close to marine areas covered by SPAs where there are known to be seals (*Monachus monachus)* that frequent coastal caves in the area as well as cetaceans.



NATURA 2000 Category A sites are designated as Special Protection Areas (SPAs) under the Birds Directive. These areas are selected for the conservation of important bird species, including those listed in Annex I of the Birds Directive, as well as migratory species and regularly occurring migratory waterbirds. While the establishment of marine fish cage farms within Category A sites may not be automatically prohibited, authorities must assess potential impacts on bird species, particularly those listed in Annex I of the Birds Directive or migratory waterbirds. If the proposed aquaculture activities are determined to pose a significant risk to bird populations or their habitats, they may be subject to strict regulation or even prohibited within Category A sites.

The expansion of marine fish farm sites in or along the borders of NATURA 2000 Type A areas would require detailed additional studies to map the location of seals and cetaceans to ensure that the fish farms do not pose a risk to these sensitive species. In addition, farms located in this area should follow the EU guidance[2] on aquaculture within NATURA 2000 sites. This is a major weakness.

[2] Guidance on aquaculture and Natura 2000 - Publications Office of the EU (europa.eu)

4.4 Impact assessment based on the MERAMOD model

EIA report: To assess the impact of the expanded facilities' operation on the benthic ecosystem of the area, the MERAMOD forecasting model was used for each of the above scenarios.

In this study, the MERAMOD model was used for estimating:

- The dispersal of by-products of the rearing process (escaped food, fish faeces) on the bottom.
- The expected effects on benthic macrofauna by calculating the change of various indicators determining the biodiversity that meet the requirements of the Framework Directive 2000/60/EC for Waters such as the Shannon-Weiner index.
- The change in the redox potential of the sediment in the area.

The choice of environmental impact criteria to be assessed is good (organic deposition, Shannon-Weiner index and Redox potential). The MERAMOD model has been validated in the Mediterranean to predict the environmental impact of fish cage farms.

The MERAMOD model predicts the deposition of solids (organic nutrients) on the seabed and impact.

Organic deposition

To estimate a possible level of solid waste flux beyond which the area is considered polluted, 1.5kg/m^2/year is taken as a reference value, above which it has been observed that species considered to be indicators of pollution such as *Capitella capitata* and *Caulleriella oculata* occur, while species considered to be indicators of unpolluted areas, such as *Cirrophorus branchiatus*, *Cossura coasta* etc. are absent.

Benthic impact

Benthic impact tends to be local. However, nutrients also enter the water column from excretion and affect water quality by increasing the nutrient concentration in the water with high levels increasing the risk of triggering algal blooms.

Scenarios

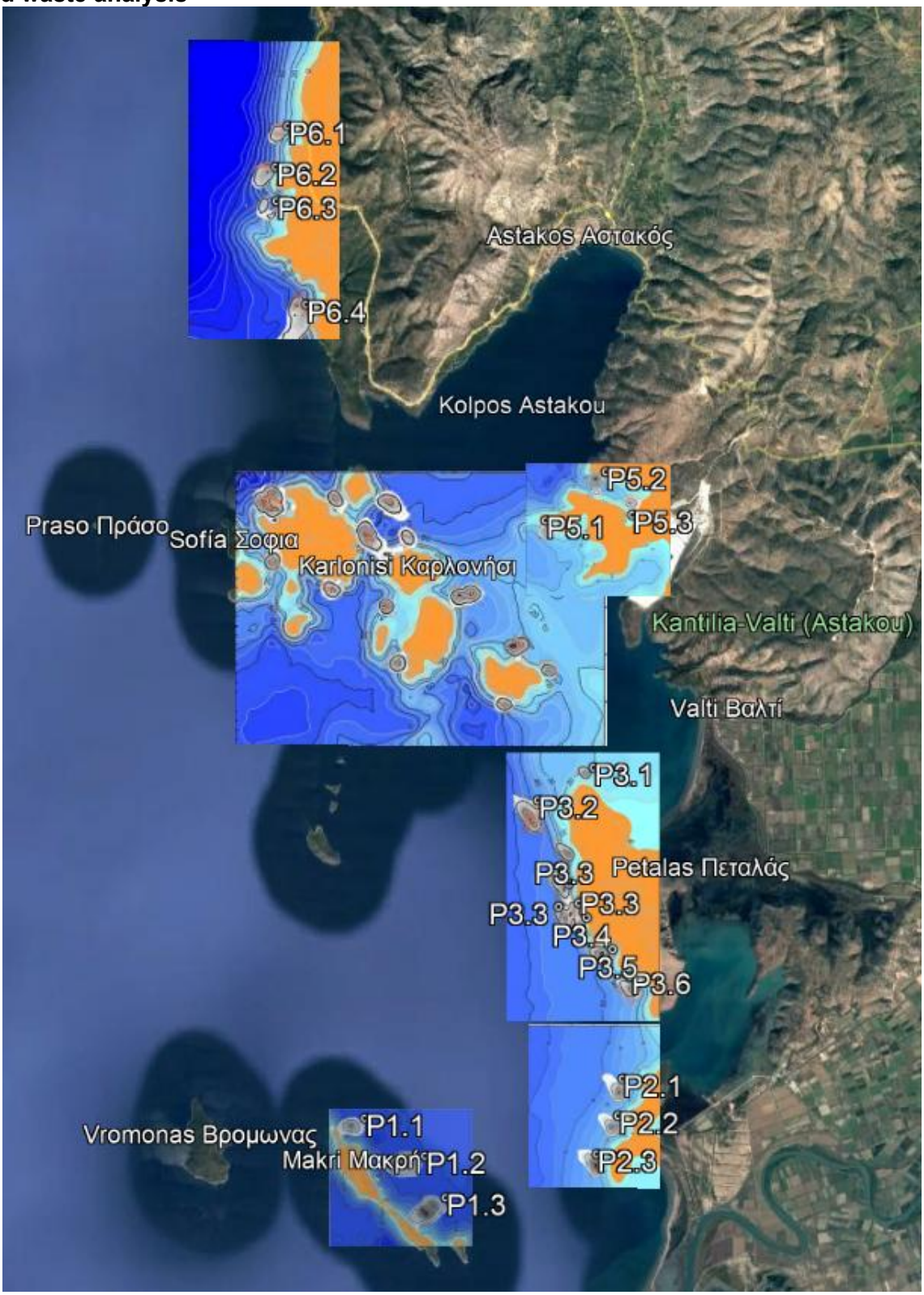
Scenario 1 (baseline scenario)	**Scenario 4 (chosen scenario)**
Scenario 1 does not foresee any expansion of leased land and no increase in the capacity of the plants, except for those provided for by the spatial planning of aquaculture, until the establishment of the POAY, i.e. the expansion of units with a leased area of less than 20 hectares (ha) up to this limit, the increase of their capacity up to 60% of the capacity calculated by the formula of οικ. 121570/1866/12-06- 2009 joint circular of the Ministry of Environment and Public Works and the Ministry of Agriculture and Forestry with a maximum limit of 300 t, while for the other units, the increase of capacity by 25%	Scenario 4 retains the leased land of Scenarios 1 and 2 but redistributes the proposed expansions to reduce the expansion of Scenario 3 by approximately 25%. Capacity is calculated in the manner described in Scenarios 2 and 3. 54,877.31 t/year

is foreseen. In addition, units under construction are included, i.e. units that have administrative acts but have not yet completed their licensing and installation. It also includes the spatial reorganisation of the units, in accordance with the conditions and restrictions laid down in the legislation in force, the results of the checks carried out by ELKETHE on the existence of the seaweed, and the design and production restructuring plan drawn up by the operators of the units in the area. 15,386.9 t/yr	

From the application of the scenarios to determine the proposed capacity of each zone, Scenario 4 was selected as the best scenario, as it brings about the optimum capacity of the WUA with the least possible impact. It is worth noting that when applying Scenario 4, the MERAMOD model predicted the absence of interactions/correlation between the environmental impacts of both the neighbouring plants and the production zones.

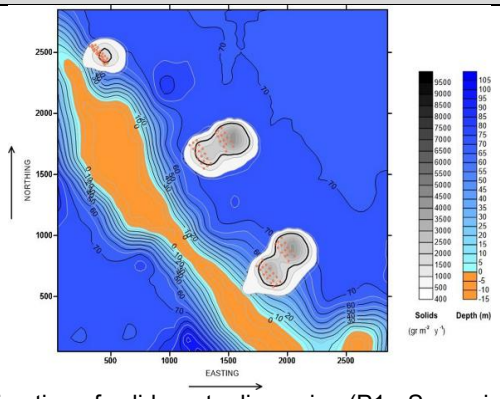
EIA analysis:
The consolidated sediment impact and the locations of the cage farms from Scenario 4 are shown in the figures below.

Solid waste analysis

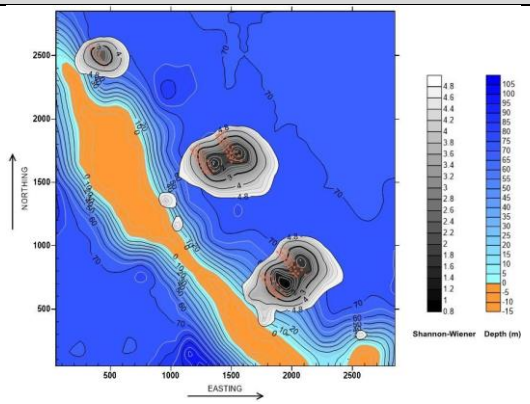


	Original	New	Increase	%
Area	1,080.94	1,842.75	761.81	170
Production (t)	20,136.7	54,877.3	34,740.6	273
Organic impact (kg/m²/yr)	3.75	7.82	4.07	209

P1 Production Zone Makri



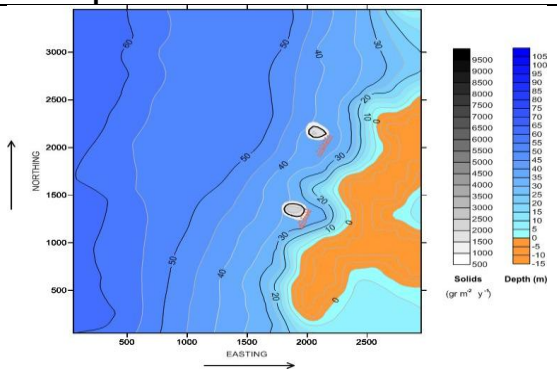
Estimation of solid waste dispersion (P1 - Scenario 1).



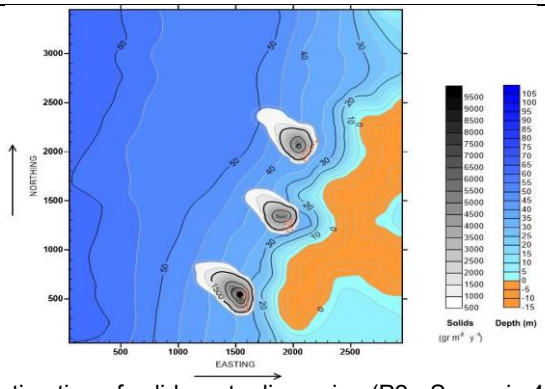
Estimation of solid waste dispersion (P1 - Scenario 4).

P1 Production Zone Makri	Scenario 1 (kg/m²/yr)	Scenario 4 (kg/m²/yr)	Increase in area (str)	Increase in production (t)
P1.1.1.A & B	4.11	10.3	0	1,590
P.1.2.A & B	4.3	7.3	0	1,862.5
P.1.3	1.91	4.6	5	525
P1	Light impact	Moderate impact	**5**	**4,337.5**

P2 Dione production zone



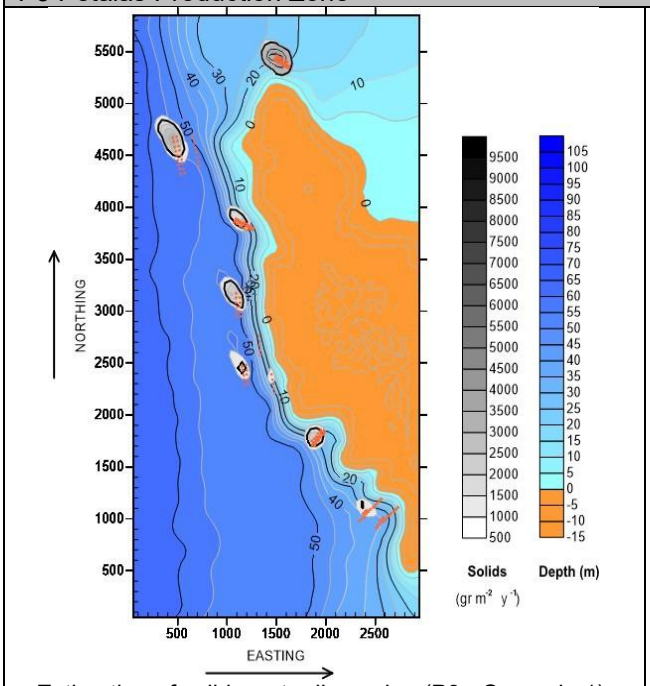
Estimation of solid waste dispersion (P2 - Scenario 1).



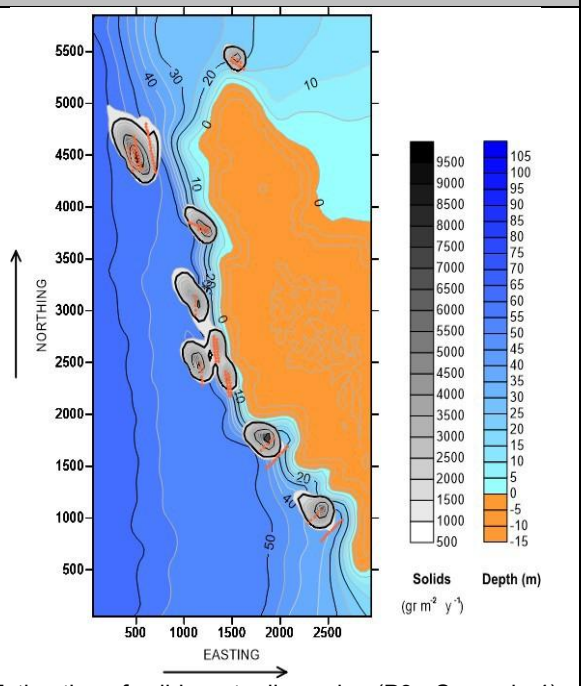
Estimation of solid waste dispersion (P2 - Scenario 4).

P2 Dione production zone	Scenario 1 (kg/m²/yr)	Scenario 4 (kg/m²/yr)	Increase in area (str)	Increase in production (t)
P.2.1.A	2.21	8.8	6	662.5
P.2.2.	2.44	7.0	15	675
P.2.3.		10.4	50	1,468.75
P2	Light impact	Moderate impact	**71**	**2,806.25**

P3 Petalas Production Zone



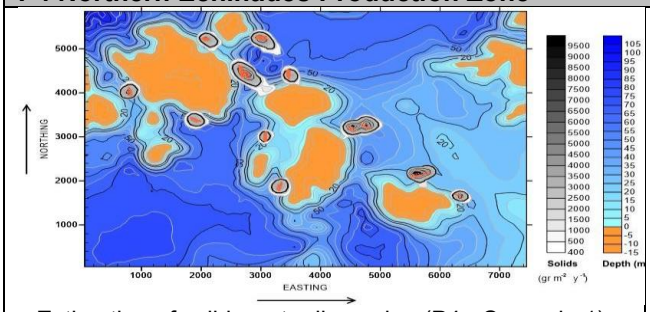
Estimation of solid waste dispersion (P3 - Scenario 1).



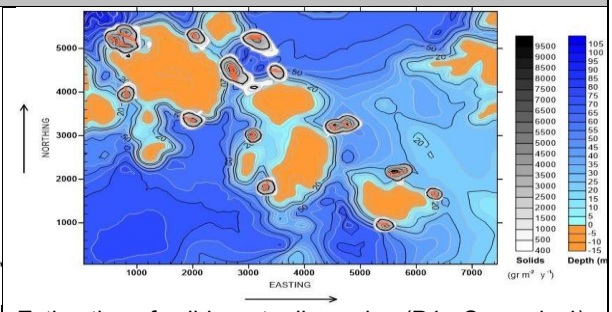
Estimation of solid waste dispersion (P3 - Scenario 4).

P3 Dione production zone	Scenario 1 (kg/m²/yr)	Scenario 4 (kg/m²/yr)	Increase in area (str)	Increase in production (t)
P.3.1.A & B	1.54	6.2	20	850
P.3.2.A & B	2.4	7.4	30	1,000
P.3.3 ABGD	2.63	7.7	19.25	2,056.25
P.3.4	2.46	6.1	5	510
P.3.5.A & B	3.85	11.4	20	-1.180
P.3.6	8.55	6.6	15	356
P3	Light impact	Moderate impact	**109.25**	**3,592.25**

P4 Northern Echinades Production Zone



Estimation of solid waste dispersion (P4 - Scenario 1).

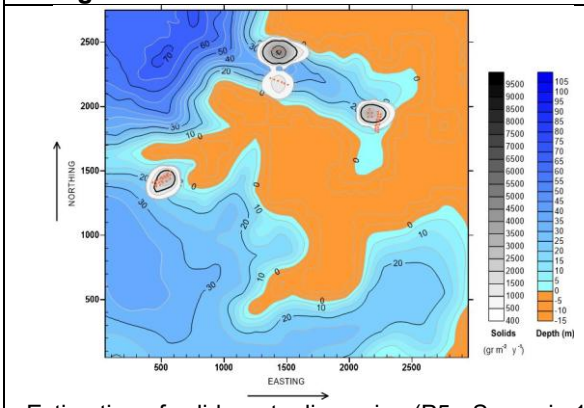


Estimation of solid waste dispersion (P4 - Scenario 4).

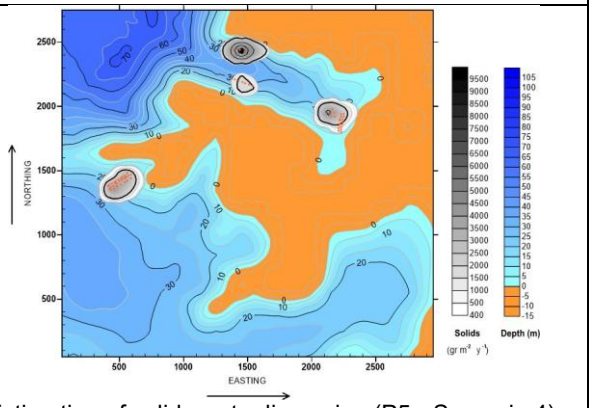
P4 Northern Echinades	Scenario 1 (kg/m²/yr)	Scenario 4 (kg/m²/yr)	Increase in area (str)	Increase in production (t)
P.4.1	3.6	7.2	5	377.5
P.4.2	9.4	12.6	20	-745.12
P.4.3.A & B	5.6	12.1	20	1,977.55
P.4.4	1.4	3.3	3.75	381.25
P.4.5	3.3	11.2	16.25	1,889.05

P.4.6	1.9	5.0	10	1,190
P.4.7	2.4	6.6	5	525
P.4.8.A & B		10.6	100	3.300
P.4.9	2.6	6.4	15	675
P.4.10	2.0	5.3	15	675
P4.11	2.2	5.7	15	609.38
P.4.12		7.7	20	646.88
P.4.13	3.6	11.33	15	609.38
P4	Light impact	Moderate impact	**260.06**	**12,110.9**

P5 Agios Panteleimon Production Zone



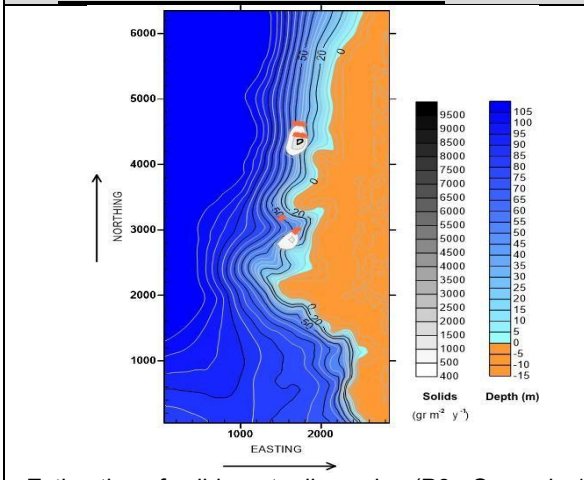
Estimation of solid waste dispersion (P5 - Scenario 1).



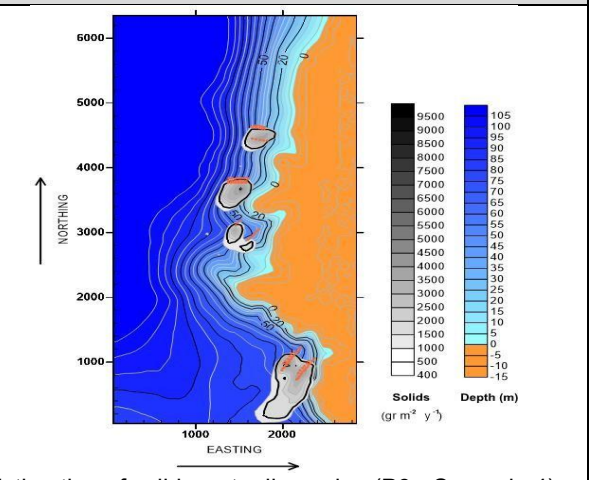
Estimation of solid waste dispersion (P5 - Scenario 4).

P5 Agios Panteleimon	Scenario 1 (kg/m²/yr)	Scenario 4 (kg/m²/yr)	Increase in area (str)	Increase in production (t)
p.5.1	3.2	4.3	15	255
P.5.2.A & B	8.1	11.4	0	425
P.5.3		5.1	10	190.5
P5	Light impact	Moderate impact	**25**	**868**

P6 <u>Mavrovouros</u> Production Zone



Estimation of solid waste dispersion (P6 - Scenario 1).

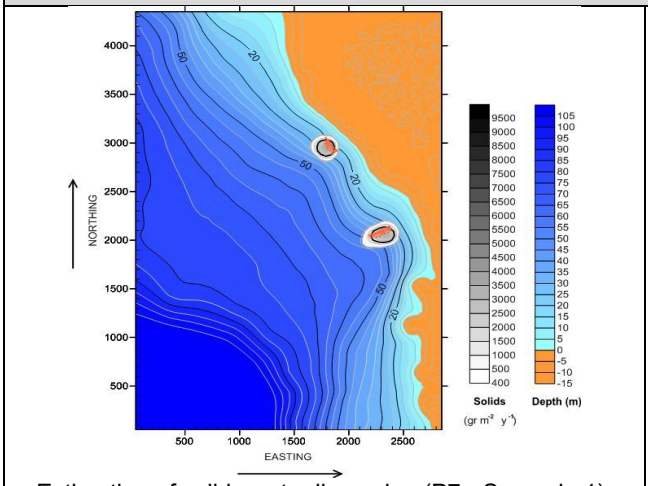


Estimation of solid waste dispersion (P6 - Scenario 4).

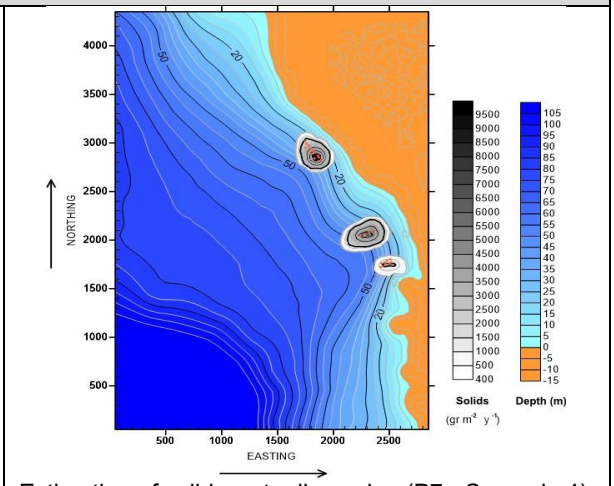
P6 <u>Mavrovouros</u>	Scenario 1 (kg/m²/yr)	Scenario 4 (kg/m²/yr)	Increase in area (str)	Increase in production (t)

P.6.1.A & B	1.3	4.2	5	525
P.6.2.A & B	1.5	3.9	7.5	800
P.6.3.A & B		5.0	99	3,267
P.6.4		4.7	50	1,650
P6	Light impact	Light impact	**161.5**	**6,242**

P7 Berina Production Zone



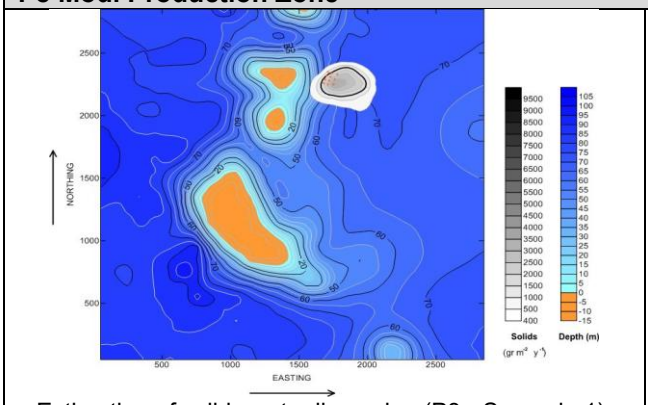
Estimation of solid waste dispersion (P7 - Scenario 1).



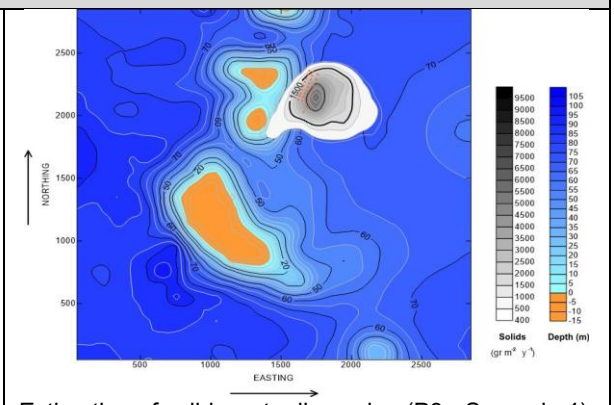
Estimation of solid waste dispersion (P7 - Scenario 4).

P7 Berina	Scenario 1 (kg/m²/yr)	Scenario 4 (kg/m²/yr)	Increase in area (str)	Increase in production (t)
P.7.1.A & B	3.5	8.1	20	790.63
P.7.2	7.2	12.5	25	946.88
P7	Light/moderate	Moderate	**45**	**1,737.51**

P8 Modi Production Zone



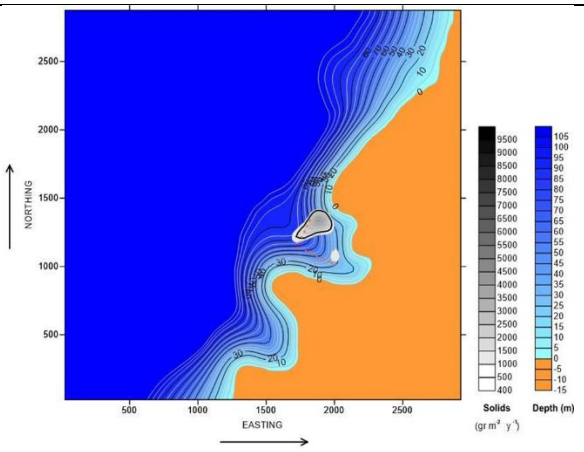
Estimation of solid waste dispersion (P8 - Scenario 1).



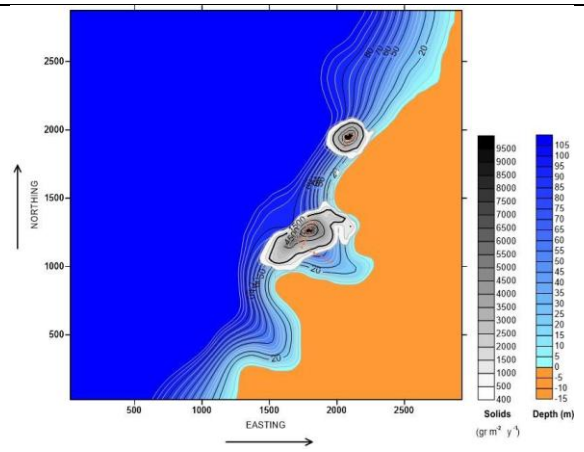
Estimation of solid waste dispersion (P8 - Scenario 4).

P8 Modi	Scenario 1 (kg/m²/yr)	Scenario 4 (kg/m²/yr)	Increase in area (str)	Increase in production (t)
P.8.1	3.71	6.03	15	1,010
P8	Light impact	Moderate impact	**15**	**1,010**

P9 Kalamos Production Zone



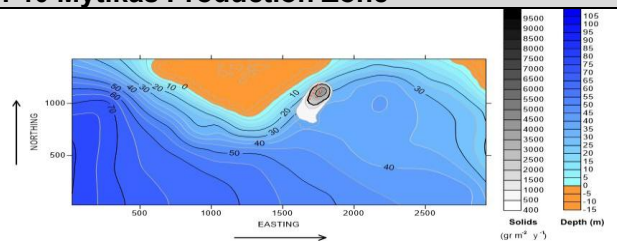
Estimation of solid waste dispersion (P9 - Scenario 1).



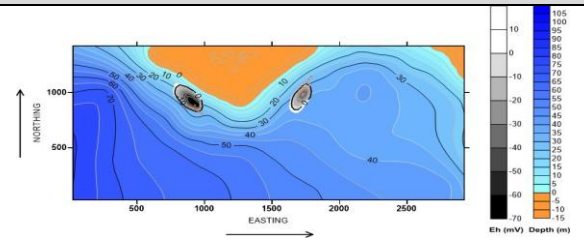
Estimation of solid waste dispersion (P9 - Scenario 4).

P9 Kalamos	Scenario 1 (kg/m^2/yr)	Scenario 4 (kg/m^2/yr)	Increase in area (str)	Increase in production (t)
P.9.1	4.2	9.88	0	710
P.9.2		10.7	20	460
P9	Light impact	Moderate impact	**20**	**1,170**

P10 Mytikas Production Zone



Estimation of solid waste dispersion (P9 - Scenario 1).



Estimation of solid waste dispersion (P3 - Scenario 4 same as Scenario 3).

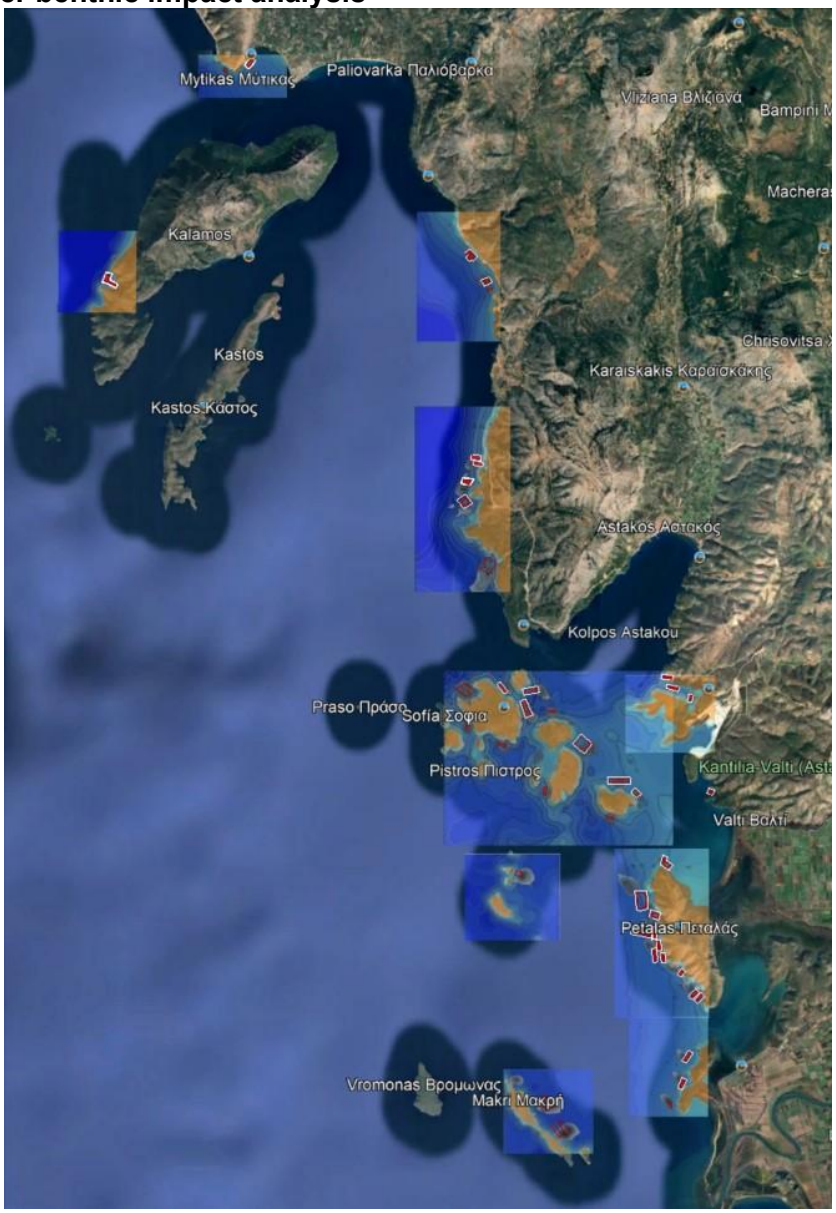
P10 Mytikas	Scenario 1 (kg/m^2/yr)	Scenario 4 (kg/m^2/yr)	Increase in area (str)	Increase in production (t)
P.10.1	6.8	8.91	30	435
P.10.2		10.4	20	431.25
P10	Moderate impact	Moderate impact	**50**	**866.25**

EIA analysis: In the existing situation, the average estimated maximum impact for all the zones is 3.75kg/m^2/year. Most zones are estimated to have light impact on the sediments however zone P10 (Mytikas) is already moderately impacted.

In the chosen scenario (Scenario 4), the average estimated maximum impact for all the zones is 7.82kg/m^2/year (more than double). The majority of zones are now estimated to have moderate impact on the sediments however zone P6 (Mavrovouros) remains moderately impacted.

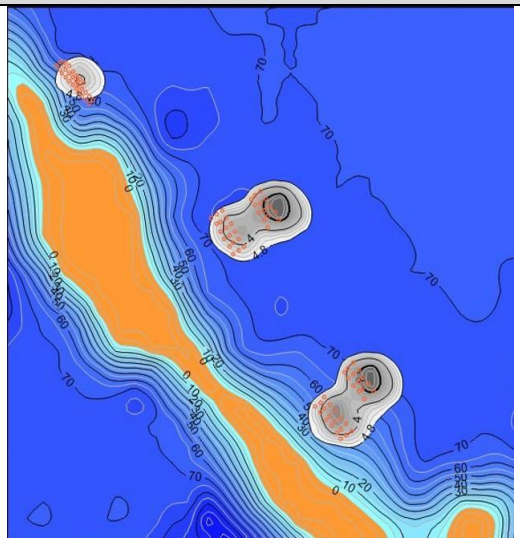
Aquaculture zone	Scenario 1	Scenario 4	Increase in area (str)	Increase in production (t)
P1	3.44 kg/m^2/yr	7.4 kg/m^2/yr	5	4,337.5
P2	Light 2.33 kg/m^2/yr	8.73 kg/m^2/yr	71	2,806.25
P3	3.57 kg/m^2/yr	7.57 kg/m^2/yr	109.25	3,592.25
P4	3.45 kg/m^2/yr	8.08 kg/m^2/yr	260.06	12,110.9
P5	5.65 kg/m^2/yr	6.93 kg/m^2/yr	25	868
P6	1.4 kg/m^2/yr	4.45 kg/m2/yr	161.5	6,242
P7	5.35 kg/m2/yr	10.3 g/m^2/yr	45	1,737.51
P8	3.71 kg/m^2/yr	6.03 kg/m^2/yr	15	1,010
P9	Light	10.29 kg/m^2/yr	20	1,170
P10	6.89 kg/m^2/yr	9.66 kg/m^2/yr	50	866.25
Xiromero	3.75 kg/m^2/yr	7.82 kg/m^2/yr	761.78	33,502.96

Shannon-Weiner benthic impact analysis

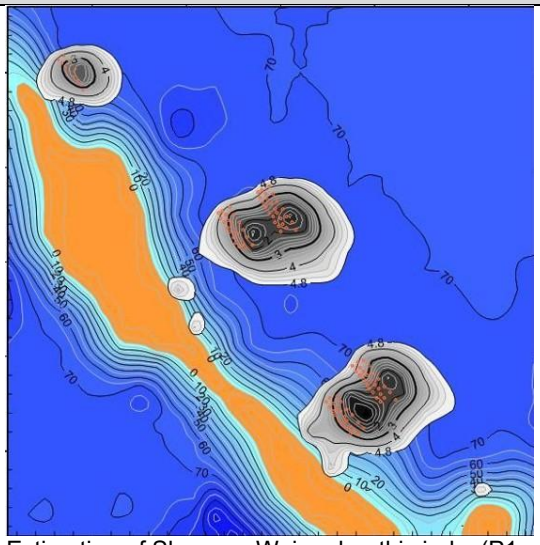


	Original	New	Increase	%
Area	1,080.94	1,842.75	761.81	170
Production (t)	20,136.7	54,877.3	34,740.6	273
Shannon-Weiner index	2.81	1.57	1.24 decrease	44%

P1 Production Zone Makri



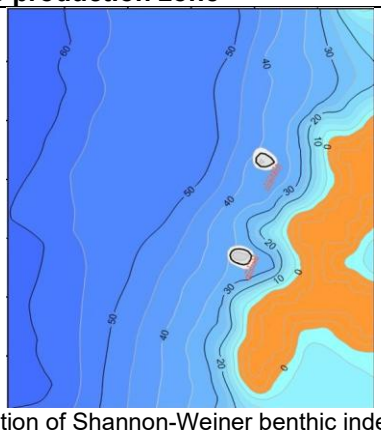
Estimation of Shannon-Weiner benthic index (P1 - Scenario 1).



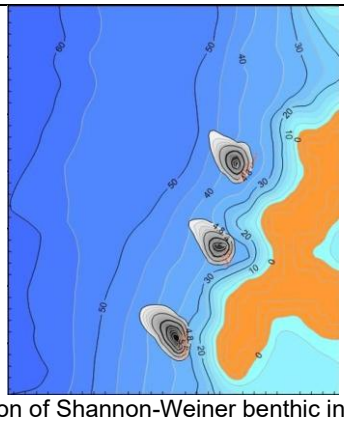
Estimation of Shannon-Weiner benthic index(P1 - Scenario 4).

P1 Production Zone Makri	Scenario 1 (S-W#)	Scenario 4 (S-W#)	Increase in area (str)	Increase in production (t)
P1.1.1.A & B	2.5	0.9	0	1,590
P.1.2.A & B	2.4	1.3	0	1,862.5
P.1.3	3.8	2.2	5	525
P1	**2.90**	**1.47**	**5**	**4,337.5**

P2 Dione production zone

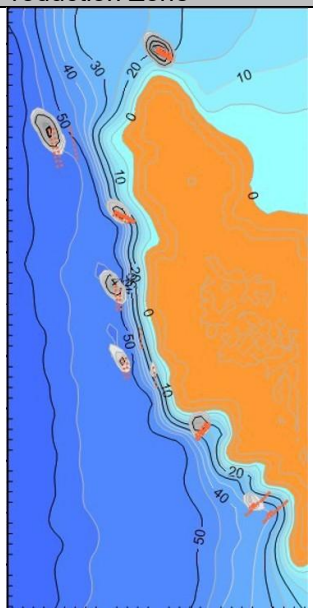
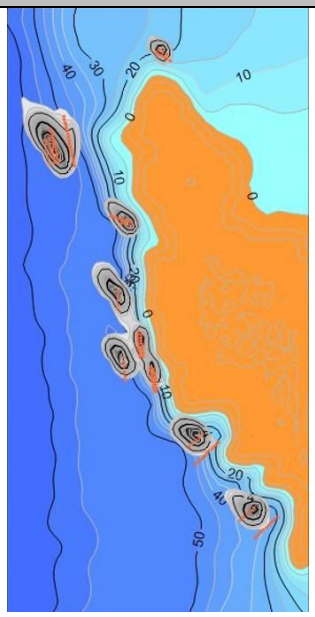


Estimation of Shannon-Weiner benthic index(P2 - Scenario 1).

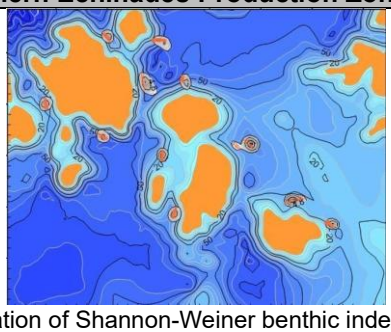
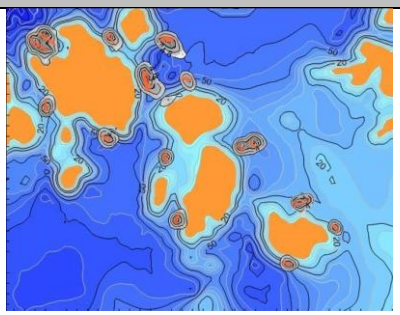


Estimation of Shannon-Weiner benthic index(P2 - Scenario 4).

P2 Dione production zone	Scenario 1 (S-W#)	Scenario 4 (S-W#)	Increase in area (str)	Increase in production (t)
P.2.1.A	3.6	1.31	6	662.5
P.2.2.	3.5	1.52	15	675
P.2.3.		0.97	50	1,468.75
P2	**3.55**	**1.27**	**71**	**2,806.25**

P3 Petalas Production Zone	
 Estimation of Shannon-Weiner benthic index(P3 - Scenario 1).	 Estimation of Shannon-Weiner benthic index(P3 - Scenario 4).

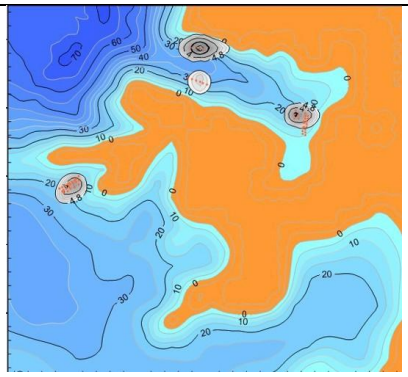
P3 Dione production zone	Scenario 1 (S-W#)	Scenario 4 (S-W#)	Increase in area (str)	Increase in production (t)
P.3.1.A & B	4.16	1.6	20	850
P.3.2.A & B	3.53	1.4	30	1,000
P.3.3 ABGD	3.4	1.27	19.25	2,056.25
P.3.4	3.47	2.05	5	510
P.3.5.A & B	2.73	1.76	20	-1.180
P.3.6	1.16	1.76	15	356
P3	**3.08**	**1.64**	**109.25**	**3,592.25**

P4 Northern Echinades Production Zone	
 Estimation of Shannon-Weiner benthic index (P4 - Scenario 1).	 Estimation of Shannon-Weiner benthic index (P4 - Scenario 4).

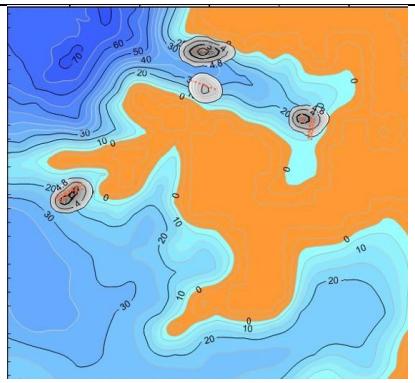
P4 Northern Echinades	Scenario 1 (S-W#)	Scenario 4 (S-W#)	Increase in area (str)	Increase in production (t)
P.4.1	2.29	1.95	5	377.5
P.4.2	1.47	0.88	20	-745.12
P.4.3.A & B	1.88	0.93	20	1,977.55
P.4.4	3.59	2.99	3.75	381.25
P.4.5	2.97	0.79	16.25	1,889.05

P.4.6	3.89	2.05	10	1,190
P.4.7	3.5	1.65	5	525
P.4.8.A & B		0.9	100	3.300
P.4.9	3.37	0.9	15	675
P.4.10	3.81	2.05	15	675
P4.11	3.67	1.79	15	609.38
P.4.12		1.52	20	646.88
P.4.13	2.85	1.38	15	609.38
P4	**3.03**	**1.52**	**260.06**	**12,110.9**

P5 Agios Panteleimon Production Zone



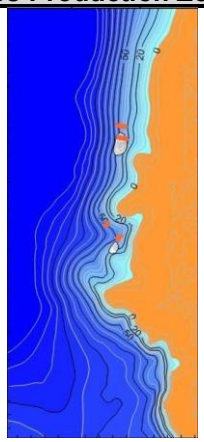
Estimation of Shannon-Weiner benthic index (P5 - Scenario 1).



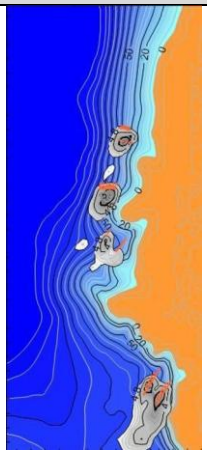
Estimation of Shannon-Weiner benthic index (P5 - Scenario 4).

P5 Agios Panteleimon	Scenario 1 (S-W#)	Scenario 4 (S-W#)	Increase in area (str)	Increase in production (t)
p.5.1	3.09	2.54	15	255
P.5.2.A & B	1.33	1.16	0	425
P.5.3	2.8	2.18	10	190.5
P5	**2.41**	**1.96**	**25**	**868**

P6 Mavrovouros Production Zone



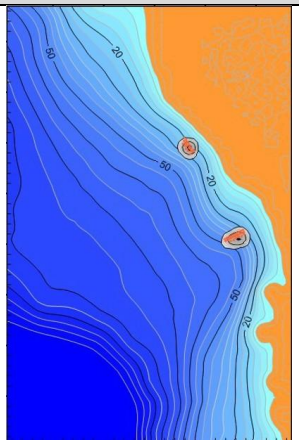
Estimation of Shannon-Weiner benthic index (P6 - Scenario 1).



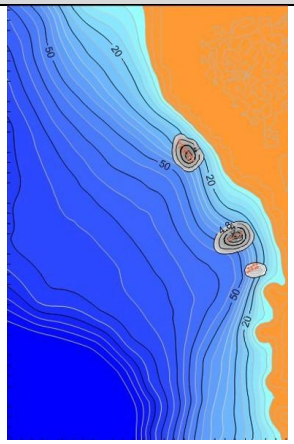
Estimation of Shannon-Weiner benthic index (P6 - Scenario 4).

P6 Mavrovouros	Scenario 1 (S-W#)	Scenario 4 (S-W#)	Increase in area (str)	Increase in production (t)
P.6.1.A & B	4.34	2.52	5	525
P.6.2.A & B	4.17	2.66	7.5	800
P.6.3.A & B		2.28	99	3,267
P.6.4		2.21	50	1,650
P6	4.26	2.42	**161.5**	**6,242**

P7 Berina Production Zone



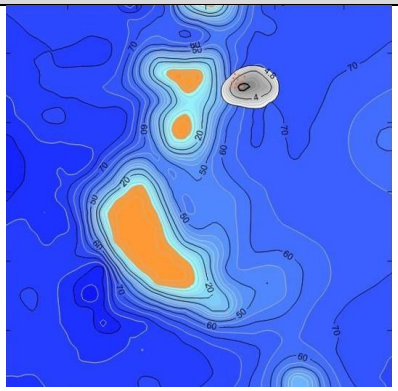
Estimation of Shannon-Weiner benthic index (P7 - Scenario 1).



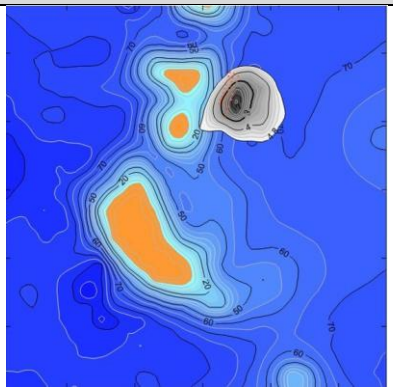
Estimation of Shannon-Weiner benthic index (P7 - Scenario 4).

P7 Berina	Scenario 1 (S-W#)	Scenario 4 (S-W#)	Increase in area (str)	Increase in production (t)
P.7.1.A & B	2.9	1.3	20	790.63
P.7.2	2.5	1.2	25	946.88
P7	**2.70**	**1.25**	**45**	**1,737.51**

P8 Modi Production Zone



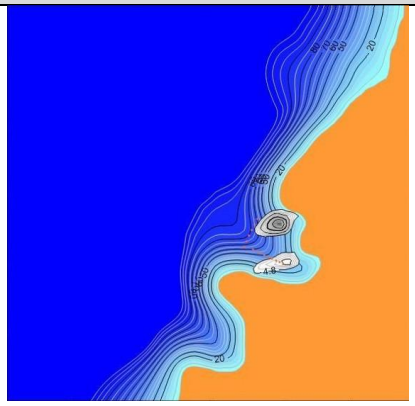
Estimation of Shannon-Weiner benthic index (P8 - Scenario 1).



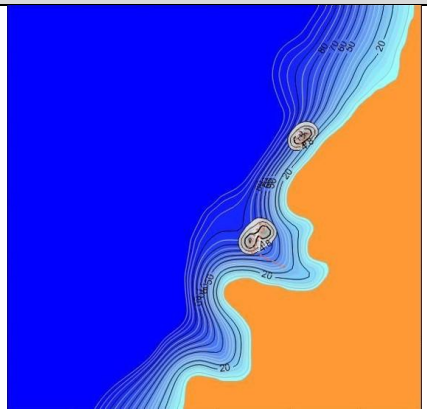
Estimation of Shannon-Weiner benthic index (P8 - Scenario 4).

P8 Modi	Scenario 1 (S-W#)	Scenario 4 (S-W#)	Increase in area (str)	Increase in production (t)
P.8.1	2.7	1.7	15	1,010
P8	**2.7**	**1.7**	**15**	**1,010**

P9 Kalamos Production Zone

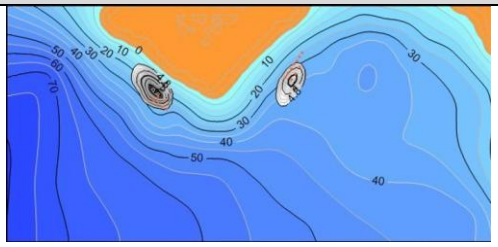


Estimation of Shannon-Weiner benthic index (P9 - Scenario 1).



Estimation of Shannon-Weiner benthic index (P9 - Scenario 4).

P9 Kalamos	Scenario 1 (S-W#)	Scenario 4 (S-W#)	Increase in area (str)	Increase in production (t)
P.9.1	2.4	1.75	0	710
P.9.2		1.49	20	460
P9	**2.40**	**1.62**	**20**	**1,170**

P10 Mytikas Production Zone	
 Estimation of Shannon-Weiner benthic index (P9 - Scenario 1).	 Estimation of Shannon-Weiner benthic index (P3 - Scenario 4 same as Scenario 3).

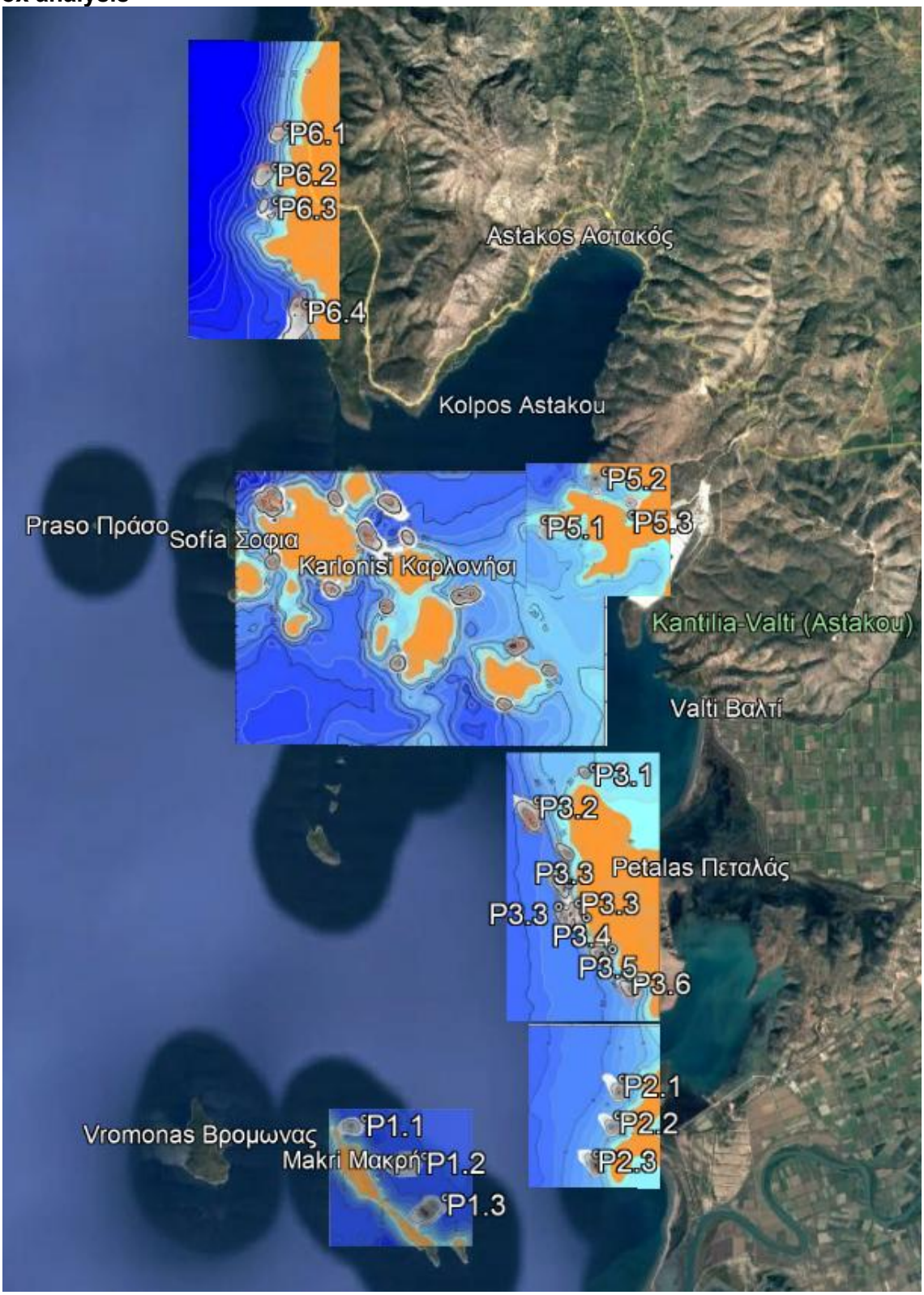
P10 Mytikas	Scenario 1 (S-W#)	Scenario 4 (S-W#)	Increase in area (str)	Increase in production (t)
P.10.1	1.04	1.04	30	435
P.10.2		0.67	20	431.25
P10	**1.04**	**0.855**	**50**	**866.25**

EIA analysis: In the existing situation, the average estimated maximum impact for all the zones is 2.81 (Low benthic community quality). Most zones are estimated to have good to medium quality sediments however zone P10 (Mytikas) is already low quality.

In the chosen scenario (Scenario 4), the average estimated maximum impact for all the zones is 1.57 (low quality). The majority of zones are now estimated to have low quality sediments however zone P6 (Mavrovouros) remains moderately impacted and zone P10 (Mytikas) is badly impacted.

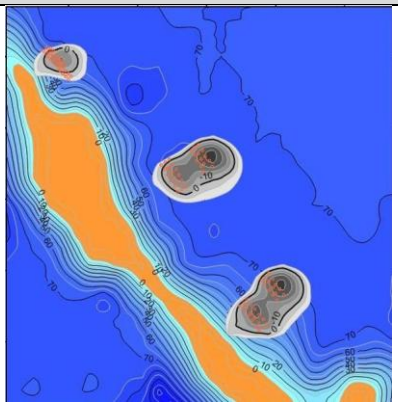
Aquaculture zone	Scenario 1	Scenario 4	Increase in area (str)	Increase in production (t)
P1	**2.90**	**1.47**	5	4,337.5
P2	**3.55**	**1.27**	71	2,806.25
P3	**3.08**	**1.64**	109.25	3,592.25
P4	**3.03**	**1.52**	260.06	12,110.9
P5	**2.41**	**1.96**	25	868
P6	4.26	2.42	161.5	6,242
P7	**2.70**	**1.25**	45	1,737.51
P8	**2.7**	**1.7**	15	1,010
P9	**2.40**	**1.62**	20	1,170
P10	**1.04**	**0.855**	50	866.25
Xiromero	**2.81**	**1.57**	761.78	33,502.96

Redox analysis

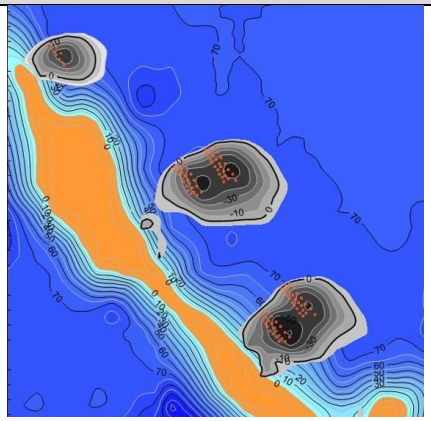


	Original	New	Increase	%
Area	1,080.94	1,842.75	761.81	170
Production (t)	20,136.7	54,877.3	34,740.6	273
Redox	-36.02	-53.01	17	47.18 worse

P1 Production Zone Makri



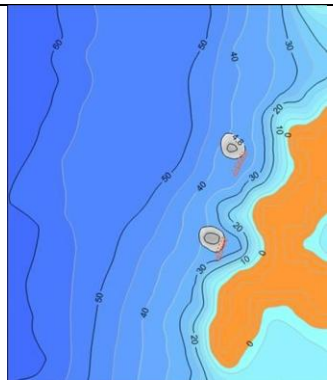
Estimation of Redox index (P1 - Scenario 1).



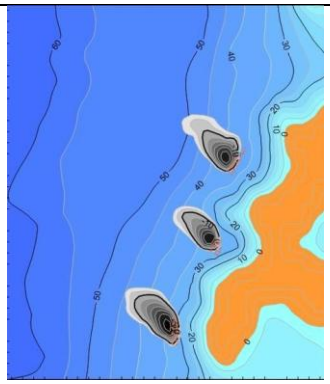
Estimation of Redox index (P1 - Scenario 4).

P1 Production Zone Makri	Scenario 1 (Redox)	Scenario 4 (Redox)	Increase in area (str)	Increase in production (t)
P1.1.1.A & B	-43	-61	0	1,590
P.1.2.A & B	-44	-55	0	1,862.5
P.1.3	-21	-38	5	525
P1	**-36.00**	**-51.33**	**5**	**4,337.5**

P2 Dione production zone



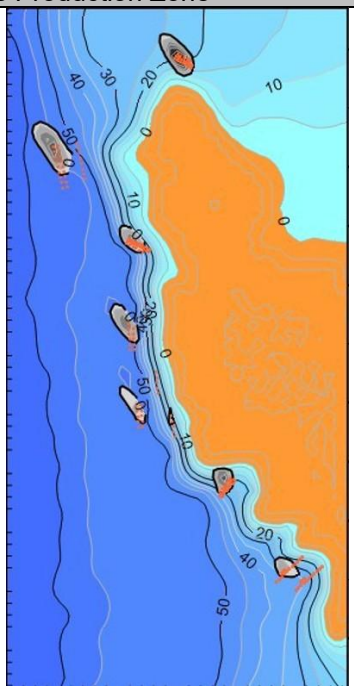
Estimation of Redox index (P2 - Scenario 1).



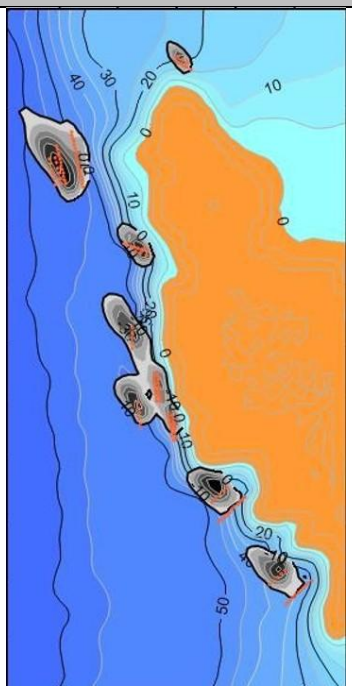
Estimation of Redox index (P2 - Scenario 4).

P2 Dione production zone	Scenario 1 (Redox)	Scenario 4 (Redox)	Increase in area (str)	Increase in production (t)
P.2.1.A	-25	-38	6	662.5
P.2.2.	-29	-59.3	15	675
P.2.3.		-62.2	50	1,468.75
P2	**-27.00**	**-53.17**	**71**	**2,806.25**

P3 Petalas Production Zone



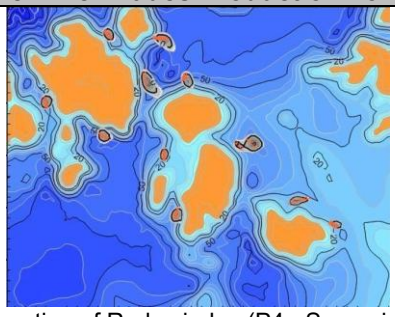
Estimation of Redox index (P3 - Scenario 1).



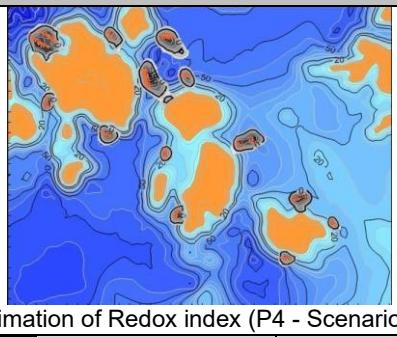
Estimation of Redox index (P3 - Scenario 4).

P3 Dione production zone	Scenario 1 (Redox)	Scenario 4 (Redox)	Increase in area (str)	Increase in production (t)
P.3.1.A & B	-16	-53.48	20	850
P.3.2.A & B	-35.2	-55.68	30	1,000
P.3.3 ABGD	-26.2	-55.68	19.25	2,056.25
P.3.4	-26.2	-51.55	5	510
P.3.5.A & B	-35.7	-60.47	20	-1.180
P.3.6	-63	-48.12	15	356
P3	**-33.72**	**-54.16**	**109.25**	**3,592.25**

P4 Northern Echinades Production Zone



Estimation of Redox index (P4 - Scenario 1).

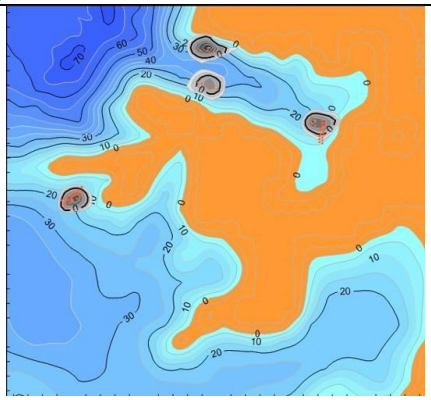


Estimation of Redox index (P4 - Scenario 4).

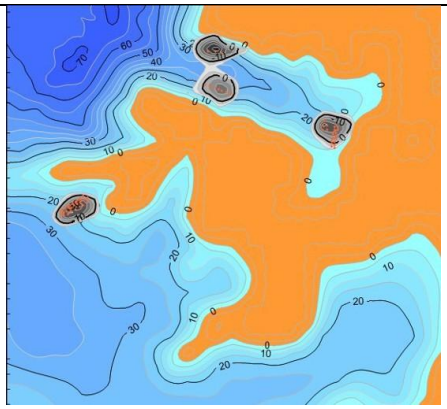
P4 Northern Echinades	Scenario 1 (Redox)	Scenario 4 (Redox)	Increase in area (str)	Increase in production (t)
P.4.1	-42.05	-52.4	5	377.5
P.4.2	-59.83	-63.68	20	-745.12
P.4.3.A & B	-48.98	-61.8	20	1,977.55
P.4.4	-23.54	-34.59	3.75	381.25

P.4.5	-33.59	-63.41	16.25	1,889.05
P.4.6	-19.84	-46.68	10	1,190
P.4.7	-29.91	.51.72	5	525
P.4.8.A & B		-62.58	100	3.300
P.4.9	-33.76	-58.84	15	675
P.4.10	-22.74	-47.67	15	675
P4.11	-25.89	-50.74	15	609.38
P.4.12		-53.32	20	646.88
P.4.13	-31.19	-55.65	15	609.38
P4	**-33.76**	**-54.28**	**260.06**	**12,110.9**

P5 Agios Panteleimon Production Zone



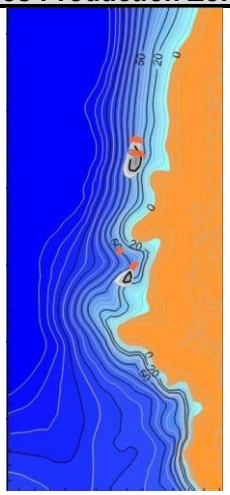
Estimation of Redox index (P5 - Scenario 1).



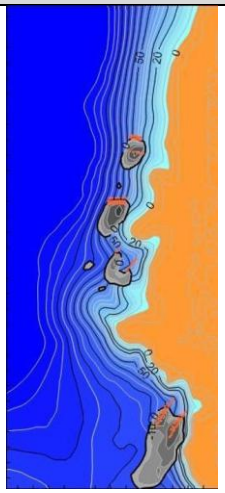
Estimation of Redox index (P5 - Scenario 4).

P5 Agios Panteleimon	Scenario 1 (Redox)	Scenario 4 (Redox)	Increase in area (str)	Increase in production (t)
p.5.1	-34.26	-41.82	15	255
P.5.2.A & B	-53.23	-56.12	0	425
P.5.3	-31.14	-43.23	10	190.5
P5	**-39.54**	**-47.06**	**25**	**868**

P6 Mavrovouros Production Zone



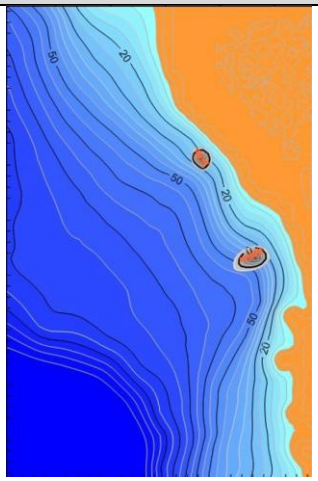
Estimation of Redox index (P6 - Scenario 1).



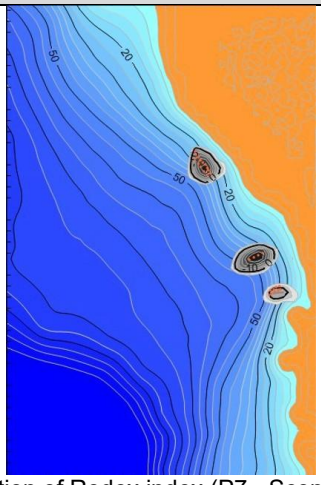
Estimation of Redox index (P6 - Scenario 4).

P6 Mavrovouros	Scenario 1 (kg/m²/yr)	Scenario 4 (kg/m²/yr)	Increase in area (str)	Increase in production (t)
P.6.1.A & B	Scenario 1 (Redox)	Scenario 4 (Redox)	5	525
P.6.2.A & B	-10.12	-39.45	7.5	800
P.6.3.A & B	-16.01	-40.64	99	3,267
P.6.4		-44.01	50	1,650
P6		-47.12	**161.5**	**6,242**

P7 Berina Production Zone



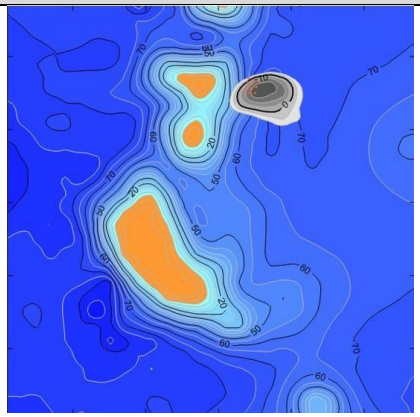
Estimation of Redox index (P7 - Scenario 1).



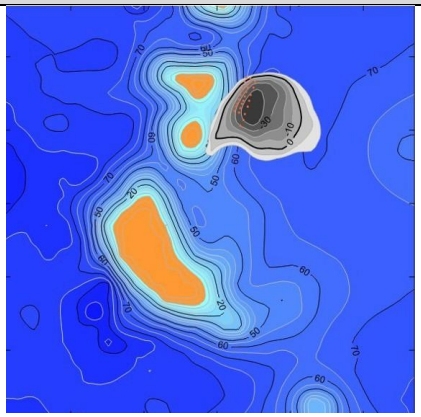
Estimation of Redox index (P7 - Scenario 4).

P7 Berina	Scenario 1 (Redox)	Scenario 4 (Redox)	Increase in area (str)	Increase in production (t)
P.7.1.A & B	-35.78	-58.97	20	790.63
P.7.2	-41.38	-57.75	25	946.88
P7	**-38.58**	**-58.36**	**45**	**1,737.51**

P8 Modi Production Zone



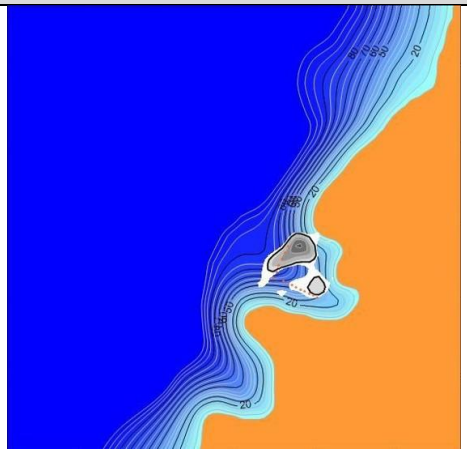
Estimation of Redox index (P8 - Scenario 1).



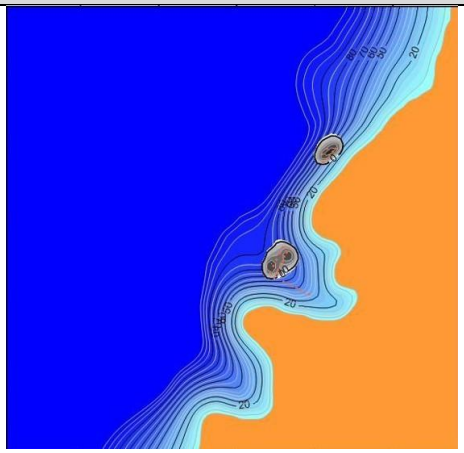
Estimation of Redox index (P8 - Scenario 4).

P8 Modi	Scenario 1 (Redox)	Scenario 4 (Redox)	Increase in area (str)	Increase in production (t)
P.8.1	-37.80	-49.61	15	1,010
P8	**-37.80**	**-49.61**	**15**	**1,010**

P9 Kalamos Production Zone



Estimation of Redox index (P9 - Scenario 1).

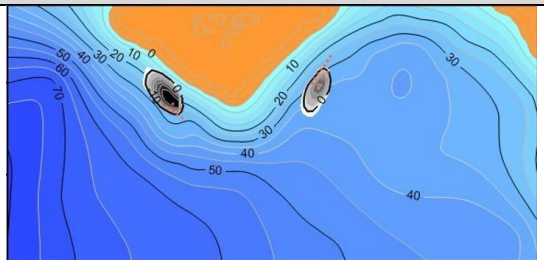


Estimation of Redox index (P9 - Scenario 4).

P9 Kalamos	Scenario 1 (Redox)	Scenario 4 (Redox)	Increase in area (str)	Increase in production (t)
P.9.1	-42.00	-50	0	710
P.9.2		-54.7	20	460
P9	**-42.00**	**-52.35**	**20**	**1,170**

P10 Mytikas Production Zone

Estimation of Redox index (P9 - Scenario 1).



Estimation of Redox index (P3 - Scenario 4 same as Scenario 3).

P10 Mytikas	Scenario 1 (Redox)	Scenario 4 (Redox)	Increase in area (str)	Increase in production (t)
P.10.1	-58.7	-61.5	30	435
P.10.2		-72.4	20	431.25
P10	**-58.70**	**-66.95**	**50**	**866.25**

EIA analysis: In the existing situation, the average estimated maximum impact for all the zones is -36.02. Most zones are estimated to have low impact on the sediments however zone P10 (Mytikas) is already moderately impacted.

In the chosen scenario (Scenario 4), the average estimated maximum impact for all the zones is -53.01 (47.18 worse). The majority of zones are now estimated to have moderate impact on the sediments however zones P5, P6 and P8 remail low impact.

Aquaculture zone	Scenario 1	Scenario 4	Increase in area (str)	Increase in production (t)
P1	-36.00	-51.33	5	4,337.5
P2	-27.00	-53.17	71	2,806.25
P3	-33.72	-54.16	109.25	3,592.25
P4	-33.76	-54.28	260.06	12,110.9
P5	-39.54	-47.06	25	868
P6	-13.07	-42.81	161.5	6,242
P7	-38.58	-58.36	45	1,737.51
P8	-37.80	-49.61	15	1,010
P9	-42.00	-52.35	20	1,170
P10	-58.70	-66.95	50	866.25
Xiromero	-36.02	-53.01	761.78	33,502.96

Although each individual zone remains low or moderately impacted and within acceptable levels at the near field (local scale) level, the impact of many farms in the same area can have cumulative impacts at the far field (bay scale) that can affect water quality, farming operations and local communities.

The cumulative impact of multiple fish cage farms in a water body can significantly affect the ecosystem, particularly concerning eutrophication, the spread of fish diseases and parasites.

- **Eutrophication**: Fish farms release nutrients such as nitrogen and phosphorus into the water through fish excrement and uneaten feed. These nutrients can accumulate due to limited water exchange. High nutrient levels can lead to eutrophication, characterized by increased algae levels in the water and, in extreme cases, can cause algal blooms. These blooms can deplete oxygen in the water (hypoxia), harm marine life, disrupt the ecological balance and sometimes cause fish kills.
- **Spread of fish diseases and parasites**: Cage farms that are close to each other can facilitate the rapid spread of diseases and parasites, such as sea lice and isopods. These pathogens can affect not only farmed fish but also wild populations if they escape or interact with wild fish. The semi-enclosed nature of the Xiromero area could exacerbate this issue by limiting the dispersal of pathogens and parasites.

These impacts can affect water quality, fish farm operations, and local coastal communities.

- **Impact on water quality**: The accumulation of dissolved nutrients from fish waste and uneaten feed can deteriorate water quality. This degradation can manifest as increased turbidity, reduced oxygen levels, and altered chemical composition of the water.
- **Fish farm operation**: The cumulative impacts of multiple farms can lead to a decline in the health and productivity of the fish stocks. Over time, farms may face increased costs due to the need for more disease treatments and potentially lower yields due to disease outbreaks or environmental stressors.
- **Effect on local coastal communities**: Local communities may experience both direct and indirect impacts. Directly, poor water quality can affect recreational activities, tourism, and the health of local fisheries. Indirectly, the community might face economic challenges if the sustainability of the aquaculture industry is compromised. Additionally, conflicts can arise between fish farmers and other stakeholders, such as local fishermen or conservation groups, over resource use and environmental concerns.

5. Proposed Monitoring and Mitigation Measures

5.1 Proposed general measures

EIA report

- Operation and management by scientific staff
- Prevention of escapes
- Fish health specialist at each hatchery
- Correct food storage
- Disease treatment and responsible disposal of mortalities
- Waste disposed of at Municipal facilities
- After shutdown, the site will be restored

Construction phase

- Use of approved materials
- Correct mooring systems and 10 meters from Posidonia beds
- Site demarcation

Operating phase

- Environmental protection
- Use of licensed vessels
- No fishing
- Net washing
- Lighting at sea
- Use of good quality feed
- Regular environmental monitoring
- Recording of waste and disposal

EIA analysis:

The report covers generic monitoring and mitigation measures for marine fish cage culture. However, Greece has laws that cover environmental monitoring during construction and building works. Specific to aquaculture, the Ministry of Environment and Energy has issued specific guidelines for the environmental monitoring of marine fish cage farms. These guidelines provide detailed recommendations on sampling protocols, data collection methods, and analytical procedures.
The Common Ministerial Decision No. 31722/2011, outlines the requirements for the licensing, operation, and control of marine aquaculture activities in Greece. The guidelines cover a wide range of topics, including:

- **Site selection and planning.** Farms should be located in suitable areas that are not likely to have a negative impact on the marine environment.
- **Water quality management.** Farms should have effective water quality management systems in place to minimize the discharge of pollutants into the water column.
- **Feeding and nutrient management.** Farms should use appropriate feeding strategies to reduce the amount of uneaten food that enters the water.
- **Waste management**. Farms should have effective waste management systems in place to collect and dispose of fish waste, dead fish, and other organic materials.

- **Disease control.** Farms should have effective disease control programs in place to prevent the spread of disease among fish.
- **Monitoring and reporting**. Farms should conduct regular monitoring of their environmental impact and report their findings to the relevant authorities.

5.2 Monitoring parameters

EIA report: The report covers the following:

- Parameters to be monitored, including:
  - Physiochemical
  - Nutrients
  - Sediment
  - Phyto and zoo benthos
- Sampling frequency per parameter
- Responsible organisation

EIA analysis: The report provides sufficient information on the sampling type, frequency and analysis.

5.3 Sampling stations

EIA report: Under the responsibility of the Management Entity of the POAY, sampling will be carried out at designated stations at selected points to monitor impact of the activity. The locations of the stations were determined considering the zones of impact from the operation of the plants as estimated by the MERAMOD model for the proposed capacity of the production system. At least one sampling station has been identified in each proposed production zone, and has been located so that the minimum distance between stations is at least 3 km.

EIA analysis: The monitoring parameters and frequency are defined and the locations identified. However, the level and thresholds for the different parameters are not defined. Directive 91/414/EEC aims to protect and conserve natural habitats and wild fauna and flora through designation of "Natura 2000" sites and specific water quality objectives may be set for these protected areas. Specific threshold levels for each parameter in other areas vary depending on the directive and the designated use of the water body but the threshold should comply to standards set by the Ministry of Environment and Energy (YPEKA).

5.4 Floating installations

EIA report: Section 8.1 outlines regulations for marine fish cage farms in a specific study area.

- Farms are typically within designated production zones, with one exception allowed at Ormos Vathi Port of Palairos.
- Operations are governed by Law 4282/2014, with special conditions including set leased areas and capacities, possible adjustments in leased land dimensions, and specific rules for relocating units within or beyond 250 m, subject to distance and environmental checks.

- New sites for new or relocated units, with leasing based on specific criteria favouring smaller, single-unit entities with investment plans.
- Experimental rearing is permitted under certain conditions, avoiding species with disease risks.
- Fishing near these farms is allowed beyond 50 m, following relevant fishing regulations.

EIA analysis: The Law 4282/2014 consists of four Chapters divided into 35 articles and establishes the Basic Law on Aquaculture Development. It defines the institutional framework for the development of the aquaculture sector in the context of its sustainable operation as regards the use of marine waters for the installation of an intensive aquaculture activity and the authorisation procedure for the establishment and operation of aquaculture units, which can be installed on water or land.

5.5 Onshore installations

EIA report: Section 8.2 outlines guidelines for land-based facilities supporting aquaculture.

- Facilities must adhere to the Aquaculture EPXSAA (Special Framework for Spatial Planning and Sustainable Development), including necessary accompanying and supporting facilities like hatcheries and packaging units.
- These facilities should ideally be located near the seashore for water access, with location and construction following specific legal provisions and promoting modern facilities in designated areas.
- Facility placement will consider the area's topography and physical condition, requiring individual authorization.
- Integration into the natural environment is emphasized, with a focus on preserving local characteristics and avoiding environmental damage, verified during the authorization process.
- Concealment and integration of facilities into the landscape using plantings and other techniques are encouraged.
- Building conditions and restrictions will align with existing legislation for areas outside urban plans.
- Traffic access to facilities will primarily use existing roads, with new roads following natural terrain and requiring specific studies.
- Watercourse protection measures include restrictions on construction that hinder water flow and infrastructure design to handle significant flood events.

EIA analysis: There will be a significant increase in the shore-based facilities to support the increase in production including feed stores, net cleaning, repairing and net stores, offices, repairs and maintenance workshops, fish packing facilities and fish hatcheries. The report states that these facilities must adhere to the Special Planning Framework for Aquaculture and outlines some of the measures.

However, there is no quantification of the additional facilities that will be required (expansion or new) and how these will impact local infrastructure and demand for local services.

5.6 Monitoring of environmental parameters

EIA report: The Management Entity of the Water Framework Directives (WFD) and unit operators within it must monitor environmental parameters as per the plan, which can be updated based on regulatory changes and scientific advancements.

The WFD Management Entity oversees inspections outside the leased land boundaries. Unit operators within the PAY are responsible for checks within their leased land, reporting results to the WFD Management Entity. However, inspections are not mandatory for operations with an annual capacity under 500 t.

EIA analysis: In Greece, the Law 4447/2016 regulates aquaculture activities and mandates environmental monitoring programs for marine fish cage farms. The scope of monitoring should include parameters such as:

- Water quality: Temperature, salinity, dissolved oxygen, pH, nutrients, and suspended solids
- Sediment quality: Organic matter content, nutrient levels, metal concentrations, and bacterial communities
- Benthic fauna: Macrofauna, meiofauna, and benthic microalgae
- Fish populations: Species composition, abundance, and health status

The Ministry of Environment and Energy has issued specific guidelines for the environmental monitoring of marine fish cage farms. These guidelines provide detailed recommendations on sampling protocols, data collection methods, and analytical procedures.

The frequency and duration of environmental monitoring depend on the size and location of the fish farm, the species cultured, and the farming practices employed. However, most farms are required to conduct monitoring at least once a month, and the monitoring period should extend throughout the entire production cycle.

Fish farm operators are responsible for documenting and reporting their monitoring data to the relevant authorities. This data is used to evaluate the environmental performance of the farms and identify potential areas of concern. Authorities may also conduct site inspections to verify the accuracy of monitoring data and ensure compliance with regulations.

5.7 Management measures

EIA report: The report recommends that if environmental degradation is detected, the following measures are proposed.

- Suspension of capacity increase if not yet at proposed levels.
- Reduction of production capacity to levels set by specific Ministry circulars if relocation isn't possible.
- Suspension of the unit if it cannot be relocated.
- Relocation of the unit to a better location.
- In production zones, temporary relocation from production zones is planned if ecosystem degradation is detected. Specific relocation zones are outlined for different units.
- Production sites maintain their original area and capacity and must comply with distance regulations from neighbouring units.

- The relocation process follows the relevant Law 4282/2014.
- Units can return to their original locations if, after inspection, the ecosystem is found to have recovered.

EIA analysis: There are regulations covering the management of farms in terms of level of production, suspension or relocation if farms are found to significantly impact the environment.

5.8 Waste - animal by-products

EIA report:

- Disposal of solid waste and animal by-products through a contract with an approved treatment operator.
- Maintenance of detailed records on waste quantities, characteristics, origin, destination, collection, and transport.
- Removal of abandoned aquaculture facilities within the POAY within one year of cessation of operations.
- Issuance of a certificate by the POAY Management Body for units ceasing operations or relocating, confirming removal and environmental restoration.
- Submission of detailed removal and absorption plans to obtain the certificate, with these documents kept in the specified record.

EIA analysis: Increased fish production will also result in increased solid waste disposal, particularly the responsible disposal of fish mortalities. Dead fish will need to be transported to designated disposal facilities which employ appropriate methods to minimize environmental harm, such as incineration or specialized composting systems. There is no quantification or description for this in the report.

5.9 Main additional studies and surveys required

EIA report: The report recommends Posidonia seagrass mapping.

- Posidonia meadows, important under Directive 92/43/EEC, are prevalent in the study area, forming dense underwater habitats.
- These meadows are typically found from the coastline to 45-50 m depth, especially between 10 and 30 m depth, near the steep island coasts.
- The Ministry of Development and Food is conducting a comprehensive study to map these meadows across Greece, relevant to aquaculture development, but results are pending.
- Over forty potential aquaculture sites were examined by the Hellenic Centre for Marine Research for the presence of Posidonia grasslands, with findings detailed in an appendix.
- It's recommended that detailed mapping of these meadows follows to identify areas unsuitable for aquaculture.

EIA analysis: The report acknowledges that there is insufficient mapping of Posidonia seagrass beds in the area. This means that there is a risk that farms that are expanding (together with their increase footprint impact) as well as new farms could impact Posidonia beds that are close by.

Marine fish cages can have a significant impact on *Posidonia oceanica* seagrass beds due to:

- **Increased organic loading**: Particulate organic matter can settle on seagrass meadows, increasing nutrient levels and reducing light availability.
- **Sediment smothering**: Fish cages can also smother seagrass meadows by trapping sediments and debris. This can block light penetration and prevent the exchange of gases, which are essential for seagrass survival.
- **Anoxia**: The organic matter from fish cages can decompose anaerobically, which deduces oxygen levels in the sediment and can even produce hydrogen sulphide and other toxic substances. These substances can impact and even kill seagrasses and other organisms.

5.10 Monitoring of changes in environmental parameters in area & time scale

EIA report: The MERAMOD aquaculture environmental impact prediction model, developed under the EU-funded MERAMED Project and based on the DEPOMOD model, was used to assess impacts on the maximum allowable production of Organic Pollutants in the Eastern Mediterranean.

A study by the University of Crete's Laboratory of Marine Ecology, titled "Impact of Fish Farming on the Marine Environment and Adaptation of Production Potential to Environmental Characteristics of Marine Ecosystems" (2007), indicates that current knowledge is insufficient to determine the assimilative capacity of marine systems on large scales. This capacity refers to the ecosystem's ability to absorb inputs without exceeding certain threshold responses.

The study highlights gaps in the assessment, such as the lack of data on disease and parasite risks, which increase with the concentration of fish farms in a limited area.

The solution suggested involves environmental monitoring with an appropriate sampling scheme for WFDs and calibration of the ecosystem response.

It is proposed to initiate a specific research project to assess environmental changes over large spatial and long temporal scales. This assessment would depend on factors like the size of production per WFD, general traffic conditions in each area, specific environmental characteristics of each WFD, and other pressures on the area.

EIA analysis: The MERAMOD model is a sediment transport and particle deposition model that was developed specifically for the Mediterranean Sea. It can be used to predict the deposition of organic matter, such as fish faeces and uneaten food, from marine fish cage farms to the seabed. The model considers a number of factors, including the density of the fish cages, the feeding rate of the fish, the hydrodynamics of the water, and the characteristics of the sediment. The model has been validated for use with seabass and seabream production in cages.

6. Social Analysis of the EIA

6.1 Socio-economic benefits

6.1.1 Socio-economic benefits at the country level

Job creation. Fish cage culture employs a significant number of people in Greece, from farm workers to fish farmers to technicians and managers. According to the Hellenic Aquaculture Producers organisation the industry in 2021 directly employs 3,871 people and it is estimated directly and indirectly employs about 12,000 people.

Export earnings. Greece is a major exporter of farmed fish, with exports of over €300 million per year. This contributes significantly to the country's foreign exchange earnings.

Economic diversification. Fish cage culture provides an important source of income for coastal communities, particularly in areas where traditional fishing has declined. This helps to diversify the economy and reduce reliance on a single industry.

6.1.2 Socio-economic benefits at the local community level

Job creation. Fish cage culture can create jobs in construction, operation, maintenance, and processing. This can be a major benefit for local communities, particularly in areas where employment opportunities are limited.

Economic diversification. Fish cage culture can provide an additional source of income for local communities, which can help to diversify the economy and reduce dependence on a single industry.

Community development. Fish cage culture can generate revenue that can be reinvested in community development projects, such as education, healthcare, and infrastructure.

Increased local demand for goods and services. Fish cage culture can increase the demand for goods and services provided by local businesses, such as transportation, construction, maintenance, and supplies. This can stimulate economic activity and create jobs in the local community.

Fish supply for local businesses. Fish cage culture can provide a reliable source of fresh fish for local businesses, such as restaurants, hotels, and fishmongers. This can help to reduce reliance on imported fish and support local food systems.

Skill development. Fish farms can provide training and education to local workers in aquaculture, marine biology, and other relevant fields. This can enhance their skills and employability, making them more competitive in the job market.

6.1.3 Food security benefits at the country level

Increased fish production. Fish cage culture has helped to increase the production of fish in Greece, making it a more self-sufficient country in terms of fish supplies.

Supplementing wild fisheries. Fish cage culture can help to supplement wild fisheries, which have been under pressure due to overfishing and environmental degradation.

Reducing reliance on imports. Fish cage culture helps to reduce Greece's reliance on imported fish, which can be expensive and can contribute to food insecurity.

6.2 Socio-economic drawbacks

6.2.1 Drawbacks at the country level

Environmental impact. Fish cage culture can have a negative impact on the environment, including pollution from fish waste, the spread of diseases and parasites, and habitat destruction.

Conflict with traditional fisheries. Fish cage culture can conflict with traditional fishing practices, leading to competition for resources and disruption of fishing grounds.

6.2.2 Drawbacks at the country level

Social tensions. Fish cage culture can lead to social tensions between fish farmers, traditional fishers, and local communities, as there may be concerns about the environmental impact and the distribution of benefits.

Competition for resources. Fish farms compete with traditional fishers for resources, such as fishing grounds. This competition can disrupt traditional fishing practices and reduce the livelihood opportunities for traditional fishers.

Lack of transparency and participation. The decision-making process for fish cage culture projects is often opaque, and traditional fishers and local communities may not have a say in the size of farms and where the farms are located. This lack of transparency can lead to resentment and distrust.

Lack of benefits sharing. Traditionally, the profits from the fishing industry have been shared among the fishers and the local communities. With fish cage culture, the profits often flow to the fish farmers and the companies that own the farms, with little benefit to the local communities.

6.2.3 Drawbacks at the local level

Visual impacts on seascape. The presence of fish cages can alter the natural beauty of coastal areas, affecting the aesthetics of the seascape. The large floating structures of fish cages and feeding barges can be visually unappealing, disrupting the natural views and creating an industrial feel to the shoreline. This can be particularly noticeable in areas with pristine coastlines or with significant tourism value.

Impacts on coastal tourism and yachting. Fish cages can potentially deter tourists and yachters from visiting coastal areas, negatively impacting the local tourism industry. The sight of fish cages can diminish the perceived natural beauty of the coastal landscape, reducing the appeal for recreation and relaxation. This can be particularly detrimental for tourist destinations that rely on the pristine beauty of their coastlines.

Local marine traffic. Fish cage culture operations can increase local marine traffic, as vessels are required to transport fish, feed, and supplies to the farms, and to collect and transport fish away from the farms. This increased traffic can disrupt the movement of other vessels, such as fishing boats and pleasure craft, and can also increase the risk of collisions and accidents.

Local road traffic. The construction and operation of fish farms can also increase local road traffic, as trucks are needed to transport materials and supplies to the farms, and to carry away waste and byproducts. This increased traffic can put a strain on local infrastructure and can also contribute to air pollution.

Freshwater resources. Fish cage culture operations can consume large amounts of freshwater, which is used for cleaning fish tanks, diluting waste, and maintaining optimal water quality. This can place stress on freshwater resources, particularly in areas where freshwater is already scarce.

Housing for workers. The expansion of fish cage culture can lead to an increase in the demand for housing for workers, as fish farms need a steady supply of labour to operate efficiently. This can put pressure on local housing markets and can lead to higher housing costs such as rents.

6.2.4 Assessing the balance of benefits and drawbacks

The socio-economic impacts of marine fish cage culture in Greece are complex and there is no easy answer to whether the benefits outweigh the drawbacks. The industry has the potential to provide significant economic and food security benefits, however, it is important to manage the environmental and social impacts carefully.

The overall balance of benefits and drawbacks, as outlined in sections 6.1 and 6.2, depends on how the industry is managed and how it interacts with local communities.

6.3 Social status

EIA report of content: The study assessed the present (2015) social status, including:

- Demographics
- Employment and unemployment
- Tourism
- Infrastructure and services
- Economic conditions
- Land use
- Cultural heritage
- Protection of human and public health

6.3.1 Demographics

EIA report: Throughout the period 1991-2011, population growth is observed both in Greece as a whole (5.80%) and in the Region of the Ionian Islands (9.73%). In the Region of Western Greece, a population decrease of 2.24% is recorded from 695,391 in 1991 to 679,796 in 2011, while the highest population growth rate is recorded in the Regional Unit of Kefallinia (22.54%).

However, in the period from 2001-2011, in contrast to the previous periods, the population of Greece decreases by only 1.08%. A similar change is observed in the two regions under study - the Ionian Islands (-0,84%) and Western Greece (-5,79%).

The age distribution of the region of Western Greece and the regional unit of Aitoloakarnania is similar to that of the whole country, with the only difference being the slightly higher percentages in the age groups 0-19 years and 60 years and over in the region of Aitoloakarnania. Satisfactory population composition is recorded in the 20-39 and 40-59 age groups, accounting for more than 55% of the population.

The educational level of all the country's residents is considered satisfactory, as more than 65% of the population of both the country and the study area are primary and secondary school graduates, with 12% of the population with a tertiary level of education.

EIA analysis: The SEIA study considers that the creation of the POAY. will strengthen entrepreneurship, both locally and nationally. This is expected to increase due to the growing

demand for fish products at the global level which in turn will increase the volume of production of aquaculture products at the national level, giving Greece a higher position in the export sector. At the local level, it will create new jobs while maintaining existing ones, thus retaining the local population, and increasing social cohesion. It will also provide employment opportunities for people employed in related sectors (e.g. fishermen) whose income has declined considerably in recent years.

The SEIA study however does not evaluate the potential number of jobs that can be created by the fish farms, their quality and whether the potential recruitment can be met by local recruitment. Without an evaluation of the potential number of jobs, it is not possible to explore the potential disruption to traditional ways of life and community dynamics. Without analysis of the number of potential jobs and new facilities required it is impossible to analyse the strain the proposal will make on local infrastructure (roads, fresh water and sewage, healthcare, and schools) due to population influx and the effect of increased economic activity.

6.3.2 Employment - Unemployment

EIA report: In the region of Western Greece and the regional unit of Aitoloakarnania the economically active population in 2011 was 38,42% and 36,23%, respectively. Unemployment rates in these regions are also quite high, namely 20.99% and 21.78%, respectively, exceeding the corresponding rate for the whole country (18.73%).

Compared to the region of Western Greece, the economically active population of the Ionian Islands region is higher (42.67%) and slightly higher than the corresponding percentage of the country (42.40%). As far as the unemployment rate is concerned, the Ionian Islands region has a lower rate (17.30%) compared to both the Western Greece region (20.99%) and Greece (18.73%).

EIA analysis: Without analysis of the number of potential jobs and new facilities required it is impossible to consider the effect of the proposal on the unemployment rate in the region.

6.3.3 Tourism

EIA report: The current Special Spatial Planning and Sustainable Development Framework for Tourism (Government Gazette 3155/B/2013), considers that aquaculture activity is in principle not considered desirable in areas designated as developed or developing tourism. This, of course, on the other hand, does not necessarily suggest incompatibility between the two activities and does not constitute a proposal for exclusion, as it is typically mentioned in Article 8(D) Tourism - Aquaculture. The siting of new aquaculture facilities in areas designated as developed or developing tourism is generally not encouraged. Exceptionally, they may be allowed, provided that it is documented that measures are taken to address any negative effects on tourism.

The issue of the interaction between tourism activities and aquaculture is also highlighted in the Aquaculture EAFRD, which refers to the possibility of developing alternative tourism as a complementary -recreation and environmental education- activities, in line with international experience and practice (fishing, tourism, and fish tourism), highlighting the positive role that can be played in the local economy and society.

The importance of the tertiary sector in Greece's economy is obvious given that 82.48% of the gross value added is generated by this productive sector (2012) and as a result, tourism development is prominent. As mentioned above, both regions under consideration (Western Greece and the Ionian Islands) have a high percentage of workers in the tertiary sector and in particular in the accommodation and food services sector.

EIA analysis: The spatial structure attempted through the organization of individual aquaculture units into a single PAY, attempts to solve several problems that have so far hampered their operation and, consequently, their further development. Through the creation of the PAY, negative spatial impacts are avoided, while at the same time, emphasis is placed on any planned new uses to avoid future conflicts due to competing uses (e.g. aquaculture and tourism). It will also facilitate the permitting procedures for the plants and reduce the bureaucratic burden on investors.

6.3.4 Infrastructure

EIA report: Due to its strategic location, the Region of Western Greece connects the Peloponnese with Central Greece and Epirus. It is also the country's gateway to the Adriatic and Western Europe. The main road artery of the Region of Western Greece is the Patras- Athens-Thessaloniki-Thessaloniki-Euzona road axis. The flagship project for the approach to Western Greece and the Ionian Islands is the Rio-Antirrio Bridge, which connects the Peloponnese with the mainland.

As far as the study area is concerned, the nearest road axis starts from Aitoliko, connects to the Antirio-Ioannina highway, passes through Astakos, Mytikas, Vonitsa and connects to the Aktio-Preveza undersea tunnel.

According to the study on the definition of the Echinades road (2005), the condition of this road, which is the only axis serving the aquaculture sector, is disadvantaged in terms of its capacity for rapid transport, due to its layout and quality.

The port of Astakos connects the mainland with Kefalonia and Ithaca. The port of Messolonghi is not suitable for the handling of products as it is used exclusively as a fish warehouse for the catches of the cooperatives of the lagoon. In the past, land-based aquaculture support facilities operated within the Astakos NAVIPE, which have now ceased to operate due to its activation as a specialised port for international cargo transport.

As for the aviation sector, it is considered weak as the two nearest airports in the regional unit of Aitoloakarnania are those of Aktion and Agrinio, which are not classified as commercial.

EIA analysis: There will be significant road traffic due to the expansion of the supply of feed, live fry, packing boxes, harvested fish, and packed fish for distribution within Greece and for export. This is not quantified, and no attempts have been made to analyse the impact of this additional traffic on the rural road network.

There will be a significant increase in the use of port facilities for the transport of, feed, fry, nets, people, harvested fish, etc. This use of the ports will compete with normal use by fishermen, ferries, and recreation. This is not quantified, and no attempts have been made to analyse the impact of this additional use of port facilities.

6.3.5 Freshwater supply and sewage

EIA report: According to the Operational Programme for Western Greece, Peloponnese and Ionian Islands (2007-2013), water supply infrastructure in the region of Western Greece is a local matter. Before the implementation of the I. Kapodistrias programme, the local authorities managed individually the sources, water supply and sewerage networks. The main consumer of water in Western Greece is agricultural crops. To better manage water resources and ensure their sustainability, irrigation projects have been planned.

Various problems in the water supply of municipalities were noted:

- Aktion – Vonitsa The main problem of the municipality is the management of water resources, due to the combination of water supply and irrigation. Illegal water supply is an additional problem.
- In the municipalities of Machaira, Paleomanina, Astakos, Karaiskaki and Vassilopoulos there is also a problem in the drinking water supply network, due to the existence of a network with asbestos pipes, which is damaged and needs replacement.
- In the municipality of Lefkada, the water supply comes underground from the neighbouring Louros from the springs of St. George Philippiada. Through a network of pipelines, water is supplied to all the municipalities in the area. Despite the high rainfall rate, the island's water needs are not covered, as a large proportion of the water is not used and ends up in the sea. However, the island's lack of water resources is mainly due to geological causes. There is a particular problem in the summer months, due to the increase in the needs of the island, but also due to problems in the water supply system. In recent years efforts have been made to eliminate this phenomenon.
- Lefkada - Deficiencies have also been recorded in the wastewater management infrastructure and sewerage networks, almost throughout the Municipality. Three biological treatment plants are in operation and a fourth is planned, while the need to upgrade wastewater treatment facilities seems urgent.
- Today, the DEYA of Kefalonia is responsible for the water supply and sewerage of the municipalities of Argostoli, Lievathos and Sami. The water supply is provided by 45 boreholes from the Papadatos springs and Lake Avitho. The sewerage network includes 20 pumping stations and 2 treatment plants, one in Argostoli and one in Sami.
- In the municipality of Ithaca, the desalination plant of Vathes and the two plants in Stavros and Kionios, are facing a lack of water resources. Supplementary cisterns are used. During the summer season, water consumption increases and water carriers bring water to the island from Kefalonia.

EIA analysis: The SEIA study does not quantify the freshwater requirement and whether the supplies can meet this requirement or any additional requirement of the new facilities. There will be a requirement for the following:

- Worker drinking water
- Cleaning water (tanks, packing facility, etc.
- Domestic toilet water
- Water for ice (harvesting, packing)

6.3.6 Communications

EIA report: In the Region of the Ionian Islands, the installation of digital centres has been completed, as foreseen by Hellenic Telecommunications Organisation (OTE)'s Basic Telephony Plan. Telecommunication circuits are also installed to serve straight connections, as well as optical cables and microwave networks for interconnection with the National and International networks. Based on the Operational Programme (OP) for Western Greece, Peloponnese and Ionian Islands, a hyper-local network is proposed, combined with a high-capacity telecommunications hub, which will be connected to other countries and will be a 'gateway' to international networks.

EIA analysis: Digital communication through optical cables and microwave networks is well established and the proposed hyper-local network and high-capacity telecommunications hub will

provide future connectivity. No timescale is given for the establishment of the hyper-local network or high-capacity hub.

6.3.7 Electricity supply

EIA report: The report states that the operation of the floating facilities is not expected to affect the electricity networks of the wider area and that the electricity supply needs can be covered either by the local grid or by generators.

EIA analysis: The SEIA does not mention the electrical distribution network of the region. Neither the source of electrical generation, or its capacity is mentioned in the report. The onshore facilities will require significant electrical consumption for net cleaners, ice production, processing facilities, refrigeration, and cold storage. No recommendations or requirements for the increased aquaculture sector are mentioned in the report.

6.4 Impacts related to aesthetics

EIA report

1. Noise and light pollution (½ page)
2. Landscape (1 page)
3. Cultural heritage (1/3 page)

The study concludes that there will not be any significant impacts.

6.4.1 Impacts of noise and light pollution

EIA report: The SEIA study stated that **i**n general, the traffic of vehicles, which is necessary for the transport of feed and other equipment to the premises, will take place via the roads connecting the onshore premises to the main road network and may cause noise.

The SEIA study stated that **l**ow-intensity lighting is used to guard the units, and to avoid stress to fish populations during storms, which is not expected to affect animal behaviour, as it is limited within the boundaries of leased land.

EIA analysis:

- **Light.** Artificial light used at night can have several negative impacts on marine life as it disturbs the natural light cycle of marine organisms. Many marine organisms rely on the natural light cycle to regulate their behaviour and physiology. Artificial light at night can disrupt this cycle, leading to disorientation, reduced reproduction, and changes in feeding behaviour. Lights at night can also cause visual disturbance for coastal communities.
- **Noise**. Fish farms can generate noise pollution from boat traffic, feeding operations, and other activities. This can disturb marine life and make it difficult for some species to communicate and reproduce.

The SEIA does not consider the noise impact from fish hatchery production facilities.

The SEIA does not consider the noise from reversing forklift vehicles around the packing stations which may impact nearby residential sites.

The SEIA does not consider the perimeter mooring warning lights at night and land security lighting at night. It is prudent to have flashing warning lights at night at the perimeter of the sea cage sites together with radar reflectors to prevent collision of boats with the cages at night. The

flashing lights can be designed to be shielded from the light penetrating the water and causing light pollution. Unshielded lights might affect sea turtle behaviour, esp. in terms of nesting.

6.4.2 Impacts on the landscape

EIA report: The SEIA study recognises that the coastal zone is important for vacation and leisure and is an important national asset. The study concludes that no adverse aesthetic effects are envisaged as the units are in isolated areas without visual contact with other anthropogenic activities. In any case, when building new land or sea infrastructure, it will be a priority to find ways to integrate it into the surrounding landscape.

EIA analysis: The SEIA study does not quantify the number or size of additional land-based facilities that are expected to be constructed or located[3]. This is a major omission as it does not take into consideration the necessary land services and infrastructure requirements that are needed to support the expansion, road traffic increase, freshwater requirement, electricity requirement, housing requirement, sewage and water treatment, etc. Without quantification of these facilities and their locations, it is not possible to make an informed judgment on the impact on the landscape. The SEIA study does not take into consideration the visual seascape and its impact on yachting in the area and the use of sheltered space and bays.

6.4.3 Impact on cultural heritage

EIA report: The SEIA concluded that no impact on cultural heritage is expected during the construction phases of facilities, as there are no indications of antiquities at the construction sites (e.g. cage attachment sites), which could be degraded by these works. In addition, in the marine study area, there are no declared underwater archaeological sites, while the land facilities are not located near cultural monuments and their operation will not have any impact on cultural heritage.

EIA analysis: The area appears to be free of important historical cultural heritage except for the onshore support facilities in the location of Kastro, Astakos, Municipality of Xiromeros which are located within an archaeological site and for which no extension is foreseen**.**

6.5 Identification of residential /spatial impacts

EIA report: The SEIA concluded that the proposal for the establishment of a PAY in the area foreseen by the Specific Framework is fully in line with the guidelines of spatial planning, which clearly provides for the necessity of organising the aquaculture sector based on the PAYs.

No impacts on the residential areas are expected to occur, given that the zoning and the radii of influence, as shown on Maps S.4.1 - S.4.6, do not affect it.

EIA analysis: The SEIA study does not estimate the additional land-based facilities that will be required or provide the area or location of the facilities. The SEIA does not attempt to quantify the amount and type of land use change.

The support facilities will include coastal installations such as jetties and net washing facilities including net wash effluents (organic and solid waste). Without quantification of such facilities, the

[3] With similar scale cage farms, the onshore facilities would typically include: (i) tank based fish nursery facilities, (ii) offices & accommodation for key staff, (iii) net washing, net repair & net stores; (iv) feed stores, (v) jetty & cranes, (vi) fish packing facility with fish box storage, (vii) maintenance workshop with stores, (vii) spare materials area (cage pipes and stanchions) and (viii) parking area for trucks live fish tanks, etc.

impact cannot be assessed. The net washing process creates high nutrient effluent that needs treatment before being released back into the sea. Net washer effluent is small in volume but has high nutrient loading and inorganic particle loading (mussel shells). This requires a high level of treatment as well as sludge and solid waste disposal.

6.5.1 Impacts related to Infrastructure

EIA report: Under infrastructure, the study states that freshwater supply will come from local water supply networks or boreholes and that the electrical supply needs to be covered either by the local grid or by generators.

Both floating and land units require the existence of road infrastructure for the distribution of products.

The purpose of the creation of the PAYs is to concentrate aquaculture activity in areas where organised units already exist, thus minimising the negative impact of the PAY on the spatial organisation of the wider area and the spatial organisation of the PAYs will follow the approved zoning framework in order to avoid negative spatial impacts.

EIA analysis: The SEIA study does not estimate the increase in road traffic. The expansion of production will cause significantly higher levels of road traffic on the existing poor road infrastructure. Road traffic might include.

- Feed deliveries to the feed store
- Deliveries of fry from hatcheries to the onshore nursery unit
- Harvested fish delivered to the packing facilities and from the packing facilities to the main markets
- It is estimated that there will be a need for an additional 300 workers and these workers will have to travel to the farms and back home on a daily basis

The SEIA study does not estimate the increase in marine traffic. There will also be a significant increase in marine vessel traffic, due to factors such as:

- Changes of nets (nets taken to shore to be net washer, nets taken out)
- Feed supply to each cage
- Fish harvesting
- Cage servicing
- Diver inspection of each cage
- Cage security at night

6.6 Social impact

EIA report

Population: The aquaculture sector in Greece, primarily located in arid and remote areas, significantly contributes to local employment and economic development. It employs about 10,000 people, offering jobs to a diverse range of skill levels and providing alternatives for those in the fishing industry and young individuals. This helps maintain the local population and social structure. Aquaculture farms also economically support local communities through leasing

agreements. The proposed Water Use Agreement (WUA) is expected to further boost employment and stimulate related industries, enhancing overall economic growth in these areas.

Human health: Aquaculture's impact on human health is mainly associated with the use of antibiotics and the potential for developing antibiotic-resistant bacteria. In Europe and North America, vaccines have largely replaced antibiotics in salmonid farming, reducing the need for their use. The risk of antibiotic resistance transferring to humans is currently low, but it remains a concern, especially in the development of new aquaculture species and in ornamental fish, which are often in close contact with humans.

Efforts are needed to prevent antimicrobial resistance due to the extensive use of antibiotics in aquaculture. Consuming fishery products from polluted areas or those not fully cooked can pose health risks, highlighting the importance of good farm management and consumer education.

In the specific country context, the impact of aquaculture on public health is considered low due to strict regulations and practices that minimize disease and antibiotic use. Farms are required to comply with environmental laws, and any medicinal substances used are approved and prescribed by veterinarians. Overall, aquaculture does not pose significant health risks to the population in this context.

Material assets: The aquaculture sector can impact physical assets in several ways. It can lead to the development or improvement of road and sea transport infrastructure for efficient product transportation. The sector also involves financial transactions such as leasing sea areas from municipalities and renting or purchasing coastal land for establishing land-based units. Additionally, the creation of new jobs in the aquaculture sector can indirectly affect physical assets, as workers may invest in their local areas, potentially leading to further development.

Cultural heritage: The establishment and operation of the POAY are not expected to have any impact on cultural heritage, as the units are located at a distance from any archaeological site and always after the agreement of the competent authorities.

Regarding the areas declared as Ancient Archaeological Sites (Law 3028/2002 "For the protection of Antiquities and Cultural Heritage in general"), there are no such sites in the study area.

The study concludes that the proposal will reduce unemployment and activate local potential, providing significant growth and employment opportunities. The assembly operations of the fish cages are not expected to cause any risk of harm to human health, provided that all necessary measures for the safety of personnel as required by applicable legislation are taken.

Regarding the areas declared as Ancient Archaeological Sites (Law 3028/2002 "For the protection of Antiquities and Cultural Heritage in general"), there are no such sites in the study area.

EIA analysis: No quantification of the personnel required for the increased production is provided and without analysis, it is difficult to assess the effect on the unemployment rate.

6.6.1 Population

EIA report: The SEIA study expects the proposed WUA to enhance the employment intensity of the aquaculture sector in the study area, reducing unemployment and activating local potential, providing significant growth and employment opportunities.

Aquaculture farms are usually located in arid and/or remote areas. It is well known that in Greece such areas face problems, mainly due to the absence of development structures to retain the new population.

EIA analysis: The SEIA study does not estimate the increase in workers and skilled personnel required for the proposed increase in production and without analysis it is difficult to assess the effect on the unemployment rate. Given that many of these areas are remote and SEIA study states that developmental structures (housing, schools, healthcare) are absent no proposals are made as to how these can be addressed.

6.6.2 Human health

EIA report: The assembly operations of the fish cages are not expected to cause any risk of harm to human health, provided that all necessary measures for the safety of personnel as required by applicable legislation are taken.

EIA analysis: Only antimicrobials and vaccines are mentioned. There is no mention of anaesthetics used on farms, bioaccumulation of chemicals or medication used on the farm on wild fisheries.

No mention of human health benefits from working.

6.7 Economic impact

EIA report: The SEIA study states that the aquaculture sector currently employs directly and indirectly about 10,000 workers, mainly in the periphery of the country. It should be stressed that aquaculture complements rather than replaces fishing activity, thereby contributing to the conservation of natural fish populations, and can provide alternative employment for workers from the fishing sector. The comparative advantages of the Greek seas create positive environmental prospects for the future development of the fish farming sector and the maintenance of its leading position at the Mediterranean and European levels. At the same time, according to international experience and corresponding successful practices, the development of aquaculture has a positive impact on the economies of local communities. This is reinforced by the potential for developing alternative forms of tourism (fishing tourism, fish tourism, diving tourism) in combination with productive activities, boosting the income of producers, and diversifying and enriching the tourist product of a region.

EIA analysis: No stakeholder engagement has been made to determine current employment levels and gauge the potential employment levels required with proposed levels of production.

6.8 Solid waste disposal

EIA report: The SEIA study states that all solid waste and animal by-products will be disposed of through an approved management body.

EIA analysis: The SThe EIA report states does not estimate the scale, or type of solid waste that will be generated or give any details on how and where the solid waste will be disposed of. The report does not mention the main sources of solid waste which include

- Feed bags
- Discarded nets
- Fish mortalities
- Net washer sludge and shells

Other waste streams (such as lubricating oils, accumulators, batteries, waste electrical and electronic equipment including light bulbs, tyres, end-of-life vehicles) are not mentioned and should be collected and delivered to licensed collectors or approved alternative management systems.

6.9 Housing

EIA report: The SEIA study does not mention the additional housing needs for the workers.

EIA analysis: There will be a need for additional housing for technicians and managers who will be brought in from outside the region. An increase of additional workers will put pressure on availability (and rental price) for year-round accommodation. This needs to be quantified.

6.10 Stakeholder consultation

EIA report: The SThe EIA report states that the involvement of all stakeholders in decision-making is a central element in the planning and operation of the expanded facilities, especially in the following:

- Good spatial planning will help to separate the uses of marine and coastal space, avoiding disputes and conflicts between stakeholders and finding synergies between the activities and the respective environment in which they are carried out.
- Ensure proper involvement of stakeholders and appropriate information to the public.
- Ensure adequate monitoring of the aquaculture sector.

All the above were considered when formulating the proposed plan, as well as the objectives and priority areas given by the EU.

EIA analysis: No details of any stakeholder consultation are given in the report even though the SThe EIA report states that the involvement of all stakeholders in decision-making is a central element in the planning and operation of the expanded facilities. If this is the case. then there is

a serious omission in a SEIA study. There is no mention of social responsibility measures for the local community.

7. Conclusions

The SEIA conducted by AMBIO, while comprehensive in certain aspects, reveals significant shortcomings in addressing the full spectrum of environmental and socio-economic impacts associated with aquaculture expansion that would be expected in a SEIA. The study effectively outlines existing legal frameworks and potential environmental impacts, facilitating the process of increasing production licenses and establishing new farms. However, its analysis of environmental impacts, particularly in quantifying and assessing cumulative effects, is inadequate.

The report's environmental impact analysis indicates a notable increase in sediment impact under Scenario 4, with the average estimated maximum impact more than doubling. This suggests a heightened risk of environmental degradation. The lack of detailed analysis of cumulative impacts, such as eutrophication and the spread of diseases and parasites, is a critical gap. This oversight could lead to underestimating the broader ecological consequences of expanding aquaculture operations.

Furthermore, the SEIA's treatment of socio-economic impacts is notably deficient. The absence of a thorough social impact assessment, coupled with a lack of stakeholder consultation, raises concerns about the study's ability to identify and mitigate potential conflicts with local communities and other space users, such as the tourism sector. The insufficient quantification of the impacts of new facilities on infrastructure, labour, and resource use, including the management of waste and wastewater, indicates a major oversight in understanding the full scope of socio-economic challenges.

The study's failure to propose adequate social mitigation measures, alongside its lack of engagement with stakeholders, is a critical weakness. This could lead to social conflicts potentially undermining the sustainability of the aquaculture expansion. Additionally, the impact on marine tourism, a minor but notable concern, has not been adequately addressed.

In conclusion, while the SEIA by AMBIO provides a foundational understanding of the legal and theoretical environmental aspects of aquaculture expansion, it falls short in thoroughly assessing and mitigating the cumulative environmental and socio-economic impacts. This gap highlights the need for a more holistic and inclusive approach to aquaculture governance and planning, one that encompasses the full range of environmental, social, and economic considerations.

8. References

- Greece - National Aquaculture Legislation Overview. https://www.fao.org/fishery/en/legalframework/gr/en?lang=en
- Διαφάνεια 1 - Gov.il (Presentation on Greek Aquaculture Legislation). https://www.gov.il/en/departments/units/fishery_and_aquaculture
- Environmental impact of aquaculture in Greece. Practical experiences. https://link.springer.com/article/10.1007/s41742-020-00289-8
- Hellenic Aquaculture Producers Organisation, Aquaculture Annual report 2023. https://fishfromgreece.com/wp-content/uploads/2023/10/HAPO_AR23_WEB-NEW.pdf

Annex 1. Classification of MERAMOD prediction of impact severity.

Light impact.	The 1 g/m^2/d (0.365 kg/m^2/year) contour is used to predict footprint extent in the *MERAMOD* model. At this level, it is possible to predict that there is a fish farm or other livestock production facility in the area. Such low levels of organic matter are just detectable above natural background levels. Light impact is classified as between 1 g/m^2/d (0.365 kg/m^2/year) and 15 g/m^2/d (5.48 kg/m^2/year).
Moderate impact	The 15 g/m2/d (5.48 kg/m^2/year) is used to predict moderate footprint severity. There is some impact on the surface of the sediment, but the environment can assimilate this level of organic matter. Moderate impact is classified as between 15 g/m2/d (5.48 kg/m^2/year) and 75 g/m^2/d (27.38 kg/m^2/year).
High impact	The 45 g/m^2/d (16.425 kg/m^2/year) is used to predict a high footprint severity. There is a significant impact in the sediment and benthic communities. Published data shows that depositional sites in other environments where predictions of flux are greater than 50 g/m^2/d (18 kg/m^2/year) are no longer favoured by the industry.
Severe impact	The 75 g/m^2/d contour represents a severe impact and is expected to cause low or no oxygen conditions on the seabed resulting in severely degraded conditions, as well as significant black layer depth in sediments and high carbon content of sediments. Severe impact is classified as above 75 g/m^2/d (27.38 kg/m^2/year).

Annex 2. EIA Assessment classification

EIA Assessment classification	Assessment description
Critical weakness	A critical weakness refers to a significant flaw or deficiency in the The EIA report states that has the potential to substantially undermine the accuracy, comprehensiveness, or credibility of the assessment. This could include fundamental errors in data collection or analysis, failure to consider key environmental impacts, or lack of compliance with regulatory requirements. Critical weaknesses typically require urgent attention and correction to ensure the integrity of the assessment process and the validity of its conclusions.
Major weakness	A major weakness denotes a notable deficiency in the The EIA report states that, while not as severe as a critical weakness, still has a significant impact on the overall quality and reliability of the

	assessment. This may include inadequate documentation of methodologies, incomplete analysis of potential impacts, or insufficient consideration of alternative measures or mitigation strategies. Major weaknesses require substantial remediation to address deficiencies and improve the overall robustness of the assessment.
Weakness	A weakness refers to a less significant flaw or limitation in the The EIA report states that may detract from its effectiveness or thoroughness but does not severely compromise its overall validity or utility. This could include minor inconsistencies in data presentation, gaps in information, or shortcomings in the assessment of certain environmental factors. While weaknesses may not necessarily invalidate the assessment, they still warrant attention and corrective action to enhance the credibility and reliability of the findings.
Minor weakness	A minor weakness indicates a relatively minor or incidental flaw in the The EIA report states that has minimal impact on the overall quality or integrity of the assessment. This might include inconsistencies or minor omissions in documentation. While minor weaknesses may not significantly affect the substance of the assessment, they should still be addressed to ensure clarity, accuracy, and professionalism in the report.

Annex 3. Guidance document on Aquaculture and Natura 2000

The Natura 2000 network supports the principle of sustainable development. Its aim is not to ban human activities but rather to ensure that these are undertaken in a way that still allows to reach the conservation objectives, which have been set for the Natura 2000 site (in function of the species and habitat types of European interest present). This principle is underpinned by Article 6 of the Habitats Directive which states that within each Natura 2000 site Member States must:

- take appropriate conservation measures which correspond to the ecological requirements of the protected habitat types and species present on the sites (Art. 6.1),
- avoid damaging activities that could significantly disturb these species or deteriorate the habitats of the protected species or habitat types (Art. 6.2),
- follow the procedure laid down in Art. 6.3 and 6.4 when planning new developments that might affect a Natura 2000 site.

Different aquaculture systems may exert different impacts and cause diverse effects on the natural environment, which may include habitat loss or deterioration, species disturbance and the displacement of species as well as changes in local communities. The effects of different aquaculture systems depend on a number of factors, including the hydrographic conditions of the farm's location, the type of cultured organisms and the production method, management practices, etc. These factors must all be taken into account when assessing possible risks, together with the sensitivity or vulnerability of the ecosystem to possible pressures from aquaculture activities.

For marine fish cage farms, the following key issues that need to be addressed are

- Sedimentation
- Biogeochemical change in water

- Chemical input
- Disturbance
- Predator control
- Interbreeding (escapes)
- Pathogen transmission
- Alien species

A case-by-case approach is needed to identify the actual potential impacts, which depend on the environmental and rearing conditions and on the mitigation measures and appropriate management practices that must be applied to avoid or minimize such effects. The guidelines provide a number of specific suggestions on mitigation measures to be adopted for all aquaculture systems. For marine cage culture, control and limitation of the stock density can reduce the possible impacts caused by particulate organic waste, while the improvement of feed digestibility, as well as systems to reduce food waste, can also mitigate these impacts;

The procedure for aquaculture projects within a Natura 2000 site Articles 6.3 and 6.4 of the Habitats Directive lay down the procedure to be followed when planning new developments that might affect a Natura 2000 site. The procedure involves three stages: screening, Appropriate Assessment (AA) and, in exceptional circumstances, derogations. Every stage determines whether a further step in the process is required.

The **screening stage** is to determine whether a plan or project is '...likely to have a significant effect...' on the Natura 2000 site, implying that the Appropriate Assessment will be required. It applies to plans or projects either individually or in combination with other plans or projects. It may be that one aquaculture project alone might not have a significant effect but, if taken in combination with other plans or projects (other fish farms or other developments) within the area, the cumulative effects may turn out to be significant.

The **Appropriate Assessment** (AA) should address the potential effects on the conservation objectives of the Natura 2000 site from all the aspects of the plan or project, and cover all the stages of the aquaculture project, for instance: site preparation, building or installation of infrastructure and facilities, operation and maintenance activities, decommissioning, etc.. All the potential pressures from the planned aquaculture activities, either through direct overlap (e.g. sedimentation on seabed areas) or induced at a larger scale (e.g. nutrient enrichment), that might have significant effects on the conservation objectives of the Natura 2000 site should be identified and the sensitivity and vulnerability of the relevant species and habitats to those pressures should be considered to assess the risk of significant effects.

Mitigation measures are an integral part of the specifications of a plan or project and should be considered during the AA. In the aquaculture context, they should be understood as technically feasible solutions that are the least damaging for habitats and species and the integrity of the Natura 2000 site as a whole, especially if alternative locations are not feasible.

Once the potential effects of the plan or project have been assessed, it needs to be determined whether it will adversely affect the integrity of the Natura 2000 site, either alone or in combination with other plans or projects.

This decision-making process is underpinned by the precautionary principle. The emphasis should be on objectively demonstrating, with reliable supporting evidence, that there will be no adverse effects on the integrity of Natura 2000 sites. For this reason, the lack of scientific data or

information on the potential risk or significance of impacts cannot be a reason to proceed with the plan or project.

The third stage of the process applies in case the lack of adverse effects on the integrity of the Natura 2000 site concerned cannot be ascertained. Article 6.4 of the Habitats Directive establishes **a set of conditions which must be met for the competent authority to authorise such a plan or project in exceptional circumstances**. These conditions relate to the absence of alternatives, the presence of imperative reasons of overriding public interest and the adoption of all necessary compensatory measures. The latter constitute the “last resort” and are used only when the decision has been taken to proceed with a plan or project that could have an adverse effect on the integrity of the Natura 2000 site

By properly implementing relevant EU and national legislation most of the potential pressures and impacts from aquaculture can be prevented or minimized. In addition, the aquaculture operators are voluntarily making significant efforts to apply good management practices (e.g. codes of conduct, monitoring, certification) and organic aquaculture is promoted by the EU.

https://op.europa.eu/en/publication-detail/-/publication/5a1b8512-df3e-11e9-9c4e-01aa75ed71a1/language-en/format-PDF/source-search