ADI ASSOCIATES

PA 02175/18

PROPOSAL TO CONSOLIDATE TEMPORARY TUNA FARMING AREA AT A PARCEL OF SEA APPROXIMATELY 5 KILOMETERS FROM THE SHORE (IN GENERAL AREA APPROVED FOR PA/03072/17 AND PA/05858/17) FOR A TOTAL BIOMASS OF 3,300 TONNES OF FISH

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

VOLUME 3: TECHNICAL APPENDICES

Version 1: July 2018

Report Reference:

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TERMS OF REFERENCE

FOR THE PREPARATION OF AN

ENVIRONMENTAL IMPACT ASSESSMENT

March 2018

Note 1: The Environment and Resources Authority (ERA) reserves the right to modify these Terms of Reference according to any relevant environmental and planning considerations that may emerge at any relevant stage of the EIA or the permit application process, as well as in the event of any changes or updates to the proposed development. ERA also reserves the right to request additional or amended studies should the findings of the EIA be insufficient to adequately inform the decision-making process or if the EIA identifies matters which should be subject to further investigation.

Note 2: Unless otherwise agreed with ERA, all requirements set out in these Terms of Reference are to be complied with. If there are any aspects that the consultants deem irrelevant to this study, or if at any stage the consultants discover any environmentally-relevant aspect (not included in these Terms of Reference) that needs to be studied, the consultants shall inform ERA immediately, justifying their reasoning.

Note 3: Difficulties, including technical difficulties and lack of information, encountered by the consultants in compiling the required information shall be made clear in the EIA. All references to published works and sources of information shall be duly acknowledged in a manner that enables tracing of the information source and verification. No material may be incorporated by reference unless it is reasonably available for inspection by potentially interested persons within the consultation period and thereafter, and for record-keeping and unhindered perusal by ERA. Any material which is based on unavailable proprietary data shall not be incorporated by reference.

Note 4: Any requirement for confidentiality of any section or detail of the EIA must be strongly justified and a formal request in this regard must be submitted to ERA. Should ERA grant confidentiality, alternative material that is still adequate for proper assessment, public consultation and decision-making must be provided.

Note 5: Agreement on method statements, and ancillary liaison with ERA, is not mandatory but is recommended. Nevertheless, ERA reserves the right to disagree with the methodology proposed, including proposed areas of influence, and with the EIA submissions in general, and to factor such disagreement in its critique of the EIA

Note 6: During review of the EIA, ERA will submit comments for the consultants' consideration, as relevant. Following the consultants' response to ERA satisfaction, a revised second draft of the EIA, addressing the comments, will normally be required. This may take the form of a complete resubmission or of an Addendum detailing the revisions to the previous submissions, as deemed most expedient by ERA, taking into account continuity and traceability of the information, and overall user-friendliness vis-à-vis subsequent review, presentation, public consultation, record-keeping and decision-making. A complete resubmission will generally be required if changes are numerous or complex, whereas an Addendum may be preferred if changes are more limited.

Note 7: The consultants are not exonerated from obtaining any formal authorisation from ERA, and from other relevant entities, vis-à-vis any activity ancillary to the EIA (e.g. collection, sampling, capture, or waiver of access restrictions) wherever such authorisation is legally required.

Note 8: These Terms of Reference, and all ancillary correspondence, are issued without prejudice to the ERA position on the project and to ERA's final decision. Accordingly, their issuing (even when customised to address specific project details) should not be construed as evidence in favour or against the project or any component thereof, unless the contrary is clearly stated.

Note 9: Wherever relevant, references to land also include the sea, and ancillary terms such as land-take, ground cover, landscape, vehicles, access roads, etc. should be interpreted accordingly.

Note 10: Wherever any baseline studies required by these Terms of Reference is covered by already-existing data, such data should be used in preference to unnecessary duplication of baseline studies, unless the consultants or ERA or both are of the opinion that the existing data is unavailable, incorrect, outdated, unreliable, insufficient, or otherwise inadequate for the purpose of the EIA.

An Environmental Impact Assessment Report is to be prepared *for PA 02175/18: Extension to an existing tuna farm operation off the North East coast of Malta* as required by Schedule I, Category I, Section *8.2.1.1* of the Environmental Impact Assessment Regulations, 2017 (S.L. 549.46). The required components of the EIA are:

i. A **Coordinated Assessment Report**, in conformity with the following Sections of these Terms of Reference. This report should assess the project in its totality;
*[**Note:** The coordinated assessment should seek to analyse and integrate the main considerations emerging from the technical reports, rather than just reproducing excerpts from the reports.]*

ii. A separate **Appendix (or Appendices)** containing all technical studies and original survey reports as prepared by the individual specialist consultants for specific topics;
*[**Note:** Experts contributing to the EIA should be specifically asked to consider impact interactions and cross-cutting issues, and to communicate information between each other accordingly].*

iii. A separate **Non-Technical Summary** of the EIA, in both the Maltese and English languages. This should have enough details for the public to understand the project and the related environmental considerations, and should be written in reader-friendly language (*e.g.* avoiding unnecessary technical jargon);

iv. A **declaration of conformity** with regards to the identification of consultants and contributors, and conflict of interest, in accordance with sub-regulations 17(3) of the EIA Regulations (refer to Appendix 1 to these Terms of Reference); and

v. An addendum detailing the **feedback received from stakeholders, from the public, and from ERA** during the relevant consultation stages of the EIA, and how they were addressed.

Wherever relevant and appropriate, all components of the EIA should include tables and figures (*e.g.* maps, plans, photographs, photomontages, charts, graphs, diagrams, cross-sections) and quantifications**.**

The complete EIA report (including all the above components) should be submitted as a printable digital copy (in .pdf format, with copying fully enabled throughout) and as a printed copy. Likewise, in case further revision are made to the EIA Report both a printable digital copy (in .pdf format, with copying enabled throughout) and a printed copy of the concluded EIA Report, or an Addendum, is to be submitted to ERA.

Wherever any other study not forming part of the EIA (*e.g.* Appropriate Assessment) is also envisaged, this is to be submitted separately from the EIA. Cross-referencing between the EIA and any such study should be clear and reasonably limited, such that both of the following considerations are duly satisfied:

1. Alerting the reader to the fact that the aspect in question is also being addressed in another parallel study; and
2. Enabling the reader to easily follow both the EIA and the other studies as stand-alone documents.

More detailed specifications are identified in the following pages.

1.0 DESCRIPTION OF THE PROPOSED DEVELOPMENT AND ITS CONTEXT

The description of the proposal is to include the aspects outlined below, and should take into account the entire proposal and any ancillary facilities and infrastructure connected with, or arising due to, the project.

1.1 Justification for the Proposal

1.1.1 Objectives

The purpose and objectives of the proposal and whether these are related to current legal obligations, policies or plans.

1.1.2 Demand

The current and expected requirement or demand for the proposed uses, also explaining how the proposal will address the requirement/demand.

1.2 Description of the Physical Characteristics of the Whole Project and the Land Use Requirements during the Construction, Operational and Decommissioning Phases

The following aspects should be addressed for all phases of the project, clearly distinguishing between aspects relating to construction phase, operational phase, decommissioning phase, or more than one phase. References to construction phase and decommissioning phase also include ancillary site preparation, clearing, dismantling, and site reinstatement works, as relevant.

1.2.1 General characteristics

Description of the proposed facilities together with a site plan drawn to scale including:

- Proposed location, including location of cage sites (including geographical co-ordinates), within the site;
- Total area and volume of the site and cages
- Maximum number, size, type and configuration of cages located within the site and the distances between cages;
- A cross section elevation of the farm showing super structure and sub surface components of the farm relative to mean sea level including outer perimeter buoys, moorings/ anchors;
- Height above sea surface and proposed elevations of cages/ installations;
- General design including colour scheme materials and texture of structures/ installations;
- Boundary demarcation arrangements;
- Method of construction/deployment of installations;
- Specifications for mooring technologies used during operations. These should be discussed and recommendations on the favoured option should be made;
- Any site which will be used on a temporary basis during the operation phase, e.g. during the transfer of wild caught tuna to the permanent cage site; and
- Storage, packing and servicing facilities.

The description is to be consistent with the details submitted in the relevant permit applications, throughout both the EIA process and the development permission application process.

1.2.2 Construction, Operational and production processes

The relevant operational and production processes and their main characteristics, including:

- The nature and quantity of materials used or generated;
- The source, type, quantity, composition and concentration of residues and emissions including water, noise (including impulsive underwater noise), vibration, light, etc.

resulting from the proposed project; the parameters to be reported should be in line with relevant EU policy;

- The expected annual and total emissions, including Greenhouse Gases (GHG), and the contribution to total national GHG emission on an annual basis; and
- A description of the tuna penning process including:
    - An overview of the process of penning of tuna from the wild;
    - Measures to limit or reduce accidental trapping or killing of non-target species;
    - Transport of wild stock to on-growing location;
    - Management and use of any chemicals / medicinal utilised (antifouling and cleaning agents, feed supplements, chemicals, and antibiotics) and their impact on the surrounding environment;
    - Overview of feed management techniques and feeding mechanisms on the environment according to the fish feed properties;
    - Details describing the type and quantity of feed to be used as well as feeding frequency and feed conversion ratio should also be included;
    - Overview of methods for harvesting, processing, packing and export;
    - Storage of feed bait, and packing materials;
    - Types of wastes generated during the various phases of the operation and an estimate of the quantities of each waste produced;
    - Methodology and frequency of net cleaning;
    - Details regarding any fallow period of the site; and
    - Any activities on land, if relevant.

1.2.3 Project management

An indicative framework outlining the key parameters and site management arrangements during construction, operation and decommissioning phases, including:

- Works methodology;
- Expected duration of all phases, as well as season, frequency and duration of interventions; and
- Types and quantities of raw materials and primary resources to be consumed, including water, energy and other resources, and measures to reduce such consumption.

1.2.4 Access, transportation and related infrastructure

A forecast of the type, quantity and size of vessels envisaged during each phase and their respective frequency of use, as well as an identification of the routes that vessels will use to/from and within the site. The required arrangements should also be compared with the relevant existing situation. Interventions that would need to be carried out to accommodate the required vessels, and sites/structures/features likely to be affected as a result, should be identified accordingly.

1.2.5 Waste management

1. A sufficiently detailed indication of the waste management implications likely to arise from the project, including wastes generated by ancillary facilities and wastes which may arise from accidental spillages and leakages and from repair works. Wastes should be subdivided according to the relevant project phases.
2. Management of solid and liquid wastes (including an estimate of domestic wastes, fish offal, mortalities, feed and uneaten feed, fish wastes, and other wastes generated by the service ship) and methods for their disposal and/or re-use.
3. The type, impact and mitigation from the wastes generated on site should be assessed.
4. The following information is to be provided for each waste stream, as relevant to each phase:
    - Identification of processes or activities that would result in waste generation;
    - European Waste Catalogue Codes for each waste stream, as per relevant legislation;
    - The projected quantities and rate of generation for each type of waste;
    - Information on waste handling and storage, on site as well as off site; and
    - The method of transportation and frequency.

This information should be presented in table format as follows, and should also include cross-references to the relevant regulations, particularly The Waste Regulations, 2011 (S.L.549.63):

Phase	Type of waste	EWC Code	H-Code	Activity (*e.g.* sanding, scraping, power washing etc.)	Estimated quantities	Final permitted disposal location

5. The envisaged waste management arrangements using the Best Practicable Environmental Options (BPEO) available, and the envisaged efforts to minimise waste generation and to divert waste to reuse or recycling rather than disposal.

1.2.6 Longer-term developments

Additional future developments, sea uses and other commitments that are ancillary or consequent to the project or are likely to arise in relation to the same project or its expansion, as well as longer-term needs of the proposal, including: ancillary infrastructure not accounted for in the previous sections; any consequent interventions/arrangements required to accommodate the development; any foreseeable extensions or updates to the proposal; any displacement of existing uses; and decommissioning.

2.0 ASSESSMENT OF ALTERNATIVES

An outline of the main alternatives studied and an indication of the main reasons for this choice, taking into account the relevant environmental effects and their prevention (or optimisation) at source. The following alternatives need to be duly considered, as relevant to the development itself (or to one or more phases thereof) and its requirements and constraints:

2.1 Alternative sites

2.2 Alternative technologies (including mooring, collection of uneaten fish and oily slick/scum)

2.3 Alternative layouts (including configuration and layout of cages, different mooring configurations etc.)

2.4 Downscaling of the project, or elimination of project components

2.5 Zero option (do-nothing scenario) - i.e. an assessment of the way the site would develop in the absence of the proposed project.

Note: *The zero option should be considered in sufficient detail as a plausible scenario in the EIA, wherever relevant, and not discarded upfront without proper discussion of its implications.*

2.6 Hybrids/combinations of the above

The findings of the assessment of alternatives should be summarised in a table format for ease of comparison.

3.0 A DESCRIPTION OF THE SITE AND ITS SURROUNDINGS (I.E. ENVIRONMENTAL BASELINE)

The existing environmental features, characteristics and conditions, in and around the proposed development site as well as in all locations likely to be affected by the development or by ancillary interventions and operations, are to be identified and described in sufficient detail, with particular attention to the aspects elaborated further in the next sections.

The consultants should also identify (and justify) wherever relevant:

1. The geographic area (e.g. viewshed or other area of influence) that needs to be covered by each study;
2. The relevant sensitive receptors vis-à-vis the environmental parameter under consideration (e.g. natural ecosystems, specific populations of particular species, or individual physical features);
3. The location of the reference points or stations (e.g. viewpoints, monitoring stations, or sampling points (including depth of multiple sampling points at a single sampling point in the case of water media and sediment, where applicable) to be used in the study; and
4. Other methodological parameters of relevance, also noting that the assessment will normally require both desk-top studies and on-site investigations (including visual observations and sampling, as relevant).

Note: *It is recommended that these details are discussed in advance with the Environment and Resources Authority prior to commencement of the relevant parts of the studies, in order to pre-empt (as much as possible) later-stage issues.*

Wherever relevant to the environmental aspects under discussion, reference to legislation, policies, plans (including programmes and strategies) standards and targets, should also be made, such that the compatibility (or otherwise) of the proposal therewith is also factored into the assessment required by ***Section 4*** below. The discussion should cover the following aspects, in the appropriate level of detail:

- Supra-national (*e.g.* European Union; United Nations; or other international or regional) legislation, directives, policies, conventions, protocols, treaties, charters, plans and obligations;
- National legislation, policies and plans (*e.g.* Structure Plan; National Environment Policy); and
- Sub-national legislation, policies and plans (*e.g.* local plans, site-specific regulations, action plans, management plans, and protective designations such as scheduling or Natura 2000).

Note: *In addition to already in-force legislation, policies and plans, the discussion should also cover any foreseeable future updates (or new legislation, policies and plans) likely to be fulfilled, affected or compromised by the proposed project. Furthermore, it should be noted that some cross-cutting legal/policy instruments (e.g. Water Framework Directive and Marine Strategy Framework Directive) may need to be factored into more than one aspect of the discussion.*

3.1 Sea cover and sea uses

A description of the present uses of the proposed site together with a description of other uses located within the area of influence from the site. Details including nature, magnitude, proximity to site, etc. should be included.

The assessment shall first consider the proposed development in isolation and assess the impacts arising from the proposed development. These include impacts of the proposal on the adjacent sea uses including any existing sensitive receptors/uses with particular reference to (i) bunkering sites and related activities; (ii) navigational routes (international and local); (ii) fisheries; (iii) shipping and yachting;
(iv) diving and tourism; and (v) candidate Marine Conservation Areas, during construction and operation.

3.2 Marine environment

3.2.1 Hydrodynamical modelling and impacts on water quality

A detailed wave and hydrodynamic model that includes mathematical modelling adopted for the determination of:

1. The best design for all the components of the proposed project shall be undertaken;
2. The effects of the proposal on water circulation;
3. Dispersion models, including:
    - Dispersal of oil slicks/ fish oils and nutrients
    - Settlement of uneaten feed
    - Impact on the coast
    - Impact on the underlying sediment
4. Wave statistical characteristics (including probability tables for extreme conditions).

and shall include physico-chemical parameters, such as prevailing and local currents and their velocity; wave exposure; water depth/bathymetry and sea-bottom type.

3.2.2 Ecology (including Marine Ecology and Avifauna)

1. A full benthic survey of the existing benthic environment on and around the area that will potentially be affected shall be undertaken prior to starting operations. The study shall include:
    a. Offshore bathymetric maps;
    b. Aerial imagery of the area;
    c. Details and maps of any services / utilities;
    d. Description of the sea-bed morphology and of the sediment characteristics of the site;
2. A survey of the area defined by the cage moorings and the area to be potentially affected by the fish farm and dispersal of nutrients, consisting of a detailed survey with adequate maps, plans, diagrams, photographs of the marine biotopes/habitats types of the area;
3. An investigation of the ecology of the site and its surroundings (including, as relevant: flora, fauna, avifauna, fish and other aquatic organisms (including marine mammals and turtles), benthic, burrowing and pelagic organisms, their habitats and ecosystems), duly covering the relevant seasons to ensure adequate coverage of all relevant species and ecosystem components;
4. A noise and vibration study providing detailed information on any impacts on sensitive receptors (fauna and avifauna, natural ecosystems) due to increase in pressure in the area, and the cumulation with other existing sources including maritime vessel traffic and with other predicted sources such as new developments;
5. A reporting of the conservation status and ecological condition of the area and the state of health of its habitats, species and ecological features;
6. Identification of all relevant species and assemblages (e.g. protected species or habitats, key species relevant to habitat characterisation, and monitoring indicators), and assess their abundance and distribution patterns as well as the species' ecological niches. The findings should be supported by adequate maps and photographs. Classification of habitat types and species should be conducted in accordance with recognised classification systems (e.g. EUNIS and Palaearctic), to ERA satisfaction;
7. A reporting of all protected, endangered, rare, unique, endemic, high-quality, keystone, invasive/deleterious, or otherwise important species, habitats, ecological assemblages, and ecological conditions found in the area under study;
8. A prediction of the potential impacts of the proposed project on the ecology of the site and its surroundings, including loss, damage or alteration of habitats and species populations (including potential increases in ambient noise levels in the marine environment) including alteration in the habitats and species' condition/state of health as measured through indicators used/specified for assessment of status in relevant EU policy;
8. The nature of the changes (whether temporary or permanent) and effects of such changes on the ecological features; and
9. Other relevant environmental features.

Note 1: *Separate Terms of Reference are being issued for the Appropriate Assessment (AA) in line with the Flora, Fauna and Natural Habitats Regulations, 2006 (S.L. 549.44).*

3.3 Marine Archaeology and related Material Assets

Refer to Appendix 2.

3.4 Infrastructure and Utilities

The assessment should also identify any existing or projected infrastructural services located within the area of influence of the development (even if not related to the demands of the development) that might be affected by the development or which may need to be displaced or diverted as a consequence of the development or its ancillary operations and interventions.

3.5 Other relevant environmental aspects and features

Other relevant environmental features or considerations not identified in the preceding sections should also be identified and described, as relevant.

4.0 Assessment of environmental impacts and environmental risks

The proposed area is considered to be totally exposed, therefore the level of risk needs to be assessed and the practical feasibility of the project discussed.

All likely significant effects and risks posed by the proposed project on the environment during all relevant phases (including construction, operation and decommissioning) should be assessed in detail, taking into account the information emerging from Sections 1, 2 and 3 above. Apart from considering the project on its own merits (*i.e.* if taken in isolation), the assessment should also take into account the wider surrounding context and should consider the limitations and effects that the surrounding environmental constraints, features and dynamics may exert on the proposed development, thereby identifying any incompatibilities, conflicts, interferences or other relevant implications that may arise if the project is implemented.

In this regard, the assessment should address the following aspects, as applicable for any category of effects or for the overall evaluation of environmental impact, addressing the worst-case scenario wherever relevant:

1. An exhaustive identification and description of the envisaged impacts;
2. The magnitude, severity and significance of the impacts;
3. The geographical extent/range and physical distribution of the impacts, in relation to: site coverage; the features located in the site surroundings; whether the impacts are short-, medium- or long-range; and any transboundary impacts (i.e. impacts affecting other countries);
4. The timing and duration of the impacts (whether the impact is temporary or permanent; short-, medium- or long-term; and reasonable quantification of timeframes);
5. Whether the impacts are reversible or irreversible (including the degree of reversibility in practice and a clear identification of any conditions, assumptions and pre-requisites for reversibility);
6. A comprehensive coverage of direct, indirect, secondary and cumulative impacts, including:
    - interactions (e.g. summative, synergistic, antagonistic, and vicious-cycle effects) between impacts;
    - interactions or interference with natural or anthropogenic processes and dynamics;
    - cumulation of the project and its effects with other past, present or reasonably foreseeable developments, activities and land uses and with other relevant baseline situations; and
    - wider impacts and environmental implications arising from consequent demands, implications and commitments associated with the project (including: displacement of existing uses; new or increased pressures on the environment in the surroundings of the project, including pressures which may be exacerbated by the proposal but of which effects may go beyond the area of influence; and impacts of any additional interventions likely to be triggered or necessitated by situations created, induced or exacerbated by the project);
7. Whether the impacts are adverse, neutral or beneficial;
8. The sensitivity and resilience of resources, environmental features and receptors vis-à-vis the impacts;
9. Implications and conflicts vis-à-vis environmentally-relevant plans, policies and regulations;
10. The probability of the impacts occurring; and
11. The techniques, methods, calculations and assumptions used in the analyses and predictions, and the confidence level/limits and uncertainties vis-à-vis impact prediction.

The impacts that need to be addressed are detailed further in the sub-sections below and should be presented in summary chart format.

4.1 Effects on the environmental aspects identified in Section 3

The assessment should thoroughly identify and evaluate the impacts and implications of the project on all the relevant environmental aspects identified in Section 3 above, also taking into account the various considerations outlined in the respective sections.

4.2 Environmental risk

The assessment should also address, in sufficient detail, any relevant environmental risk (including major-accident scenarios such as contamination, emissions, major spillages, etc.) likely to result in environmental damage or deterioration. The range of accident scenarios considered should exhaustively cover, as relevant:

1. One-time risks (*e.g.* during construction or decommissioning works);
2. Recurrent risks during project operation (including risk of disease transmission); and
3. Risks associated with extreme events (*e.g.* oil spills, fish mortality rates or natural disasters on the project).

The assessment should include, as relevant: a quantification of the risk magnitude and probability; and risk analysis vis-à-vis any hazardous materials stored, handled, or generated on site or transported to/from the site.

4.3 Effects on Human Populations resulting from impacts on the environment

This assessment should also identify any impacts of the development on the surrounding and visiting population that may result from impacts on the environment.

4.3.1 Effect on public health

The EIA shall include a detailed description of the measures envisaged to prevent, minimise and where possible offset any significant adverse health effects, including cumulative impacts of the development on the general public, their social activities and on the area affected by the proposed development. This should include details of the monitoring programmes that may be proposed. The EIA shall also identify, describe and discuss in detail the possible health effects of any residual impacts that cannot be mitigated. This shall be presented as a separate Section/Chapter in the EIA.

In the case of health-related effects, reference should be made to published epidemiological and other studies, as relevant, and the views of the Environmental Health Directorate should be sought.

4.4 Other Environmental Effects

Any other environmental effects deemed relevant to the project but not fitting within any of the above sections should also be identified and assessed.

5.0 REQUIRED MEASURES, IDENTIFICATION OF RESIDUAL IMPACTS, AND MONITORING PROGRAMME

5.1 Mitigation Measures

A clear identification and explanation of the measures envisaged to prevent, eliminate, reduce or offset (as relevant) any significant adverse effects of the project during all relevant phases including construction, operation and decommissioning [see ***Section 1.2.3*** above]. Such measures could include technological features; operational management techniques; enhanced site-planning and management; aesthetic measures; conservation measures; reduction of magnitude of project; and health and safety measures. Particular attention should be given to mitigation of impacts on the marine resources and of conflicts between the different uses on site.

Mitigation measures for accident/risk scenarios should be packaged as a holistic plan that includes the integration of failsafe systems into the project design as well as well-defined contingency measures.

The recommended measures should be feasible, realistically implementable to the required standards and in a timely manner, effective and reliable, and reasonably exhaustive. They should not be dependent on factors that are beyond the developer's and ERA's control or which would be difficult to monitor, implement or enforce. The actual scope for, and feasibility of, effective prevention or mitigation should also be clearly indicated, also identifying all potentially important pre-requisites, conditionalities and side-effects.

Management plans for the site including measures on how to control biomass, spreading of diseases, etc. These should include a framework for the:

- Environmental Management Plan (including provisions to be taken in case of deterioration of water quality and disruption to the benthos).
- Waste Management Plan
- Risk assessment and contingency planning for disasters and other contingencies (high mortality, oil spills from bunkering area.)
- Risk assessment for accidents by oncoming shipping traffic.

5.2 Residual Impacts

Any residual impacts [*i.e.* impacts that cannot be effectively mitigated, or can only be partly mitigated, or which are expected to remain or recur again following exhaustive implementation of mitigation measures] should also be clearly identified.

5.3 Additional Measures

Compensatory measures (*i.e.* measures intended to offset, in whole or in part, the residual impacts) should also be identified, as reasonably relevant. Such measures should be not considered as an acceptable substitute to impact avoidance or mitigation.

If the assessment also identifies beneficial impacts on the environment, measures to maximise the environmental benefit should also be identified.

In both instances, the same practical considerations as indicated vis-à-vis mitigation measures should also apply.

5.4 Decommissioning Plan

A decommissioning plan (DP) should also be proposed to address the following circumstances, as relevant:

1. Removal of any temporary or defined-lifetime development (or of any structures, infrastructure or land use required temporarily in connection with it) upon the expiry of their permitted duration; and
2. Removal of the development (or of any secondary developments, infrastructure or land use ancillary to it) in the event of redundancy, cessation of operations, serious default from critical mitigation measures, or other overriding situations that may emerge in future.

The DP should also include, as relevant, a phasing-out plan, proposals for site remediation or decontamination, and methodological guidance on site reinstatement or appropriate after-use.

5.5 Monitoring Programme

A realistic and enforceable programme for effective monitoring of those works envisaged to have an adverse or uncertain impact. The monitoring programme should include:

1. Details regarding type and frequency of monitoring and reporting, including spot checks;
2. The parameters that will be monitored, their units of measurement, the monitoring indicators to be used; and standard analytical methods in line with relevant EU policy;

3. An effective indication of the required action to address any exceedances, risks, mitigation failures or non-compliances for each monitoring parameter;
4. An evaluation of forecasts, predictions and measures identified in the EIA; and
5. An indication of the nature and extent of any additional investigations (including EIAs or ad hoc detailed investigations, if relevant) that may be required in the event of any contingencies, unanticipated impacts, or impacts of larger magnitude or extent than predicted.

The programme should address all relevant stages, as follows:

(a) Where relevant, monitoring of preliminary on-site investigations that may entail significant disturbance or damage to site features (*e.g.* marine environment in terms of the benthos;, or any works that require prior site clearance or any significant destructive sampling);
*[**Note:** Official written consent from the competent authorities (e.g. Superintendence of Cultural Heritage) may also be required for such interventions.]*

(b) Monitoring of the construction phase, including the situation before initiation of works (including site clearance), during appropriate stages of progress, and after completion of works;

(c) Monitoring of the operational phase, except where otherwise directed by ERA (*e.g.* where monitoring would be more appropriately integrated into an operating permit) (including monitoring of the marine environment in terms of the benthos, water quality and other sensitive receptors); and

(d) Where relevant, monitoring of the decommissioning phase, including the situation before initiation of works, during appropriate stages of progress, and after completion of works.

5.6 Identification of required authorisations

The assessment should also identify all environmentally-relevant permits, licences, clearances and authorisations (other than the development permit to which this EIA is ancillary) which must be obtained by the applicant in order to effectively implement the project if development permission is granted. Any uncertainty, as to whether any of these pre-requisites is applicable to the project, should be clearly stated.

Note on Sections 5.1 to 5.6 above:
The expected effects, the proposed measures, the residual impacts, the proposed monitoring etc. should also be summarised in a user-friendly itemised table that enables the reader to easily relate the various aspects to each other. An indicative specimen table is attached in ***Appendix 3***.

APPENDIX 1 REQUIRED DECLARATIONS

Identification of consultants and contributors

This declaration is to be submitted with each environmental survey report forming part of the EIA.

Attn: Director of Environment and Resources (ERA).

I ____, who carried out the study (or part thereof) on ____ for the EIA for the proposed ____, hereby declare that I take responsibility for any statement and conclusion contained therein.

___________________________ ______________________________

Date Signature

Conflict of interest

Signed declaration in accordance with sub-regulation 17(3):
This declaration is to be submitted with each environmental survey report forming part of the EIA.

Attn: Director of Environment and Resources (ERA).

I, ____, hereby declare that I have no personal or financial interest in the proposed development. Moreover, I declare that I am not in any way associated with any individual, company, association or grouping that has any direct or indirect, personal, professional or financial interest in the proposed development.

__________________________ Date

__________________________ Signature

APPENDIX 2: TERMS OF REFERENCE FOR THE MARINE ARCHAEOLOGY (AS PROVIDED BY THE SUPERINTENDENCE OF CULTURAL HERITAGE, AS REVISED IN OCTOBER 2013)

1.0 Preamble

The proposed project would involve development over an extensive area and may lead to intensification of activity over a larger area. Potential impacts may occur within the footprint of the project, in the immediate environs, and along access routes to the site. Potential impacts may include direct and immediate material impacts, as well as subsequent impacts that might arise from the modification of the existing situation.

2.0 Scope and Definitions of the EIA

For the purposes of this document, cultural heritage is defined by Article 2 of the Cultural Heritage Act (2002). This includes movable or immovable objects of artistic, architectural, historical, archaeological, ethnographic, palaeontological and geological importance.

2.1 The study area shall include the total footprint of the proposed development.

2.2 In the context of this particular application, cultural heritage considerations may include features of archaeological value and potential;

The above cultural heritage definitions and considerations are not to be considered as exhaustive. The EIA must consider all other forms of cultural heritage, both known and unknown.

2.3 The Environmental Impact assessment will:

- Describe the Cultural Heritage assets within the study area;
- Assess the physical, spatial and visual impacts of the proposed development on the cultural heritage assets; and
- Propose corrective measures for the protection of the cultural resources.

3.0 Methodology

In quantifying the cultural heritage assets within the study area, and assessing the impacts of the proposed development, the EIA will undertake:

- Description and assessment of the property;
- Desktop and archival research limited to the study area;
- Fieldwork and research, topographic survey and remote sensing as may be necessary within the site. All fieldwork has to be authorised by the Superintendence of Cultural Heritage as defined below under point 4;
- Consultations with any relevant bodies, including the Superintendence of Cultural Heritage, Heritage Malta, the University of Malta, NGOs and Local Councils;
- Compilation of an inventory of the cultural heritage assets identified within the study area. The features of cultural heritage are to be described and plotted with grid references, on Data Capture Sheets, the design of which should be approved in advance by the Superintendence of Cultural Heritage. The Data Capture Sheets will be presented as an appendix to the EIA. The analysis of the features will be included in the main report; and
- A cultural heritage Risk Assessment Map examining the various impacts of the proposed project is to be included in the EIA.

4.0 Authorisation by the Superintendence of Cultural Heritage

As per Cultural Heritage Act 2002, any form of investigation or prospection required for the identification of cultural heritage (including topographic survey and remote sensing) may only be undertaken by the Superintendence of Cultural Heritage or with its written approval.

PTOTECTIVE INVENTORY OF THE MALTESE CULTURAL HERITAGE HERITAGE DATA CAPTURE SHEET				Ref. No.
Location	Category	Type	Site Location (Address)	
Eastings	Northings	Feature	Period - Year	
S.S. No. 1 S.S. No. 3	S.S. No. 2 S.S. No. 4	Description		
Date				
Negative No.	Film No.			
Present Utilization				
Existing Legal Protection		GN. Number		GN. Date
Comments				

Buffer Zone	A	B	C	D	E	Others
Eastings						
Northings						

Site Map
Scale 1 : 2500

Archaeological Characteristics – Sketch/Scaled drawings:	
Condition:	Degree of Protection:
State of Security:	Proposed Utilization:
Basic Bibliography:	
Compiled by: Checked by: Date:	Revised by: Checked by: Date:

APPENDIX 3: SPECIMEN IMPACT TABLE

Impact type and source			Impact receptor		Effect & scale							Probability of impact occurring (Inevitable, Likely, Unlikely, Remote, Uncertain)	Overall impact significance	Proposed mitigation measures	Residual impact significance	Other requirements (monitoring, authorisations, etc)
Impact type	Specific intervention leading to impact	Project phase (construction/ operation/ decommissioning)	Receptor type	Sensitivity & resilience toward impact	Direct/ Indirect/ Cumulative	Beneficial/ Adverse	Severity	Physical / geographic extent of impact	Short- /medium-/ long-term	Temporary (indicate duration)/ Permanent	Reversible (indicate ease of reversibility) / Irreversible					

[Insert definition of relevant criteria used to describe the impacts]

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED EXTENSION OF THE TEMPORARY TUNA FARM OFF IS-SIKKA L-BAJDA, NORTH OF MALTA

MARINE ENVIRONMENT METHOD STATEMENT

INTRODUCTION

1. This method statement provides information on the marine environment (including marine ecology) input to the Environmental Impact Assessment (EIA) for the proposed extension of the temporary tuna farm located off is-Sikka l-Bajda (some 5 km offshore) in the North of Malta.

2. The proposal that is being assessed comprises the doubling of the tuna cages (form 12 to 24) without an overall increase in fish numbers; this to decrease the stocking density in the existing cages, which is having a detrimental effect on the fattening of the tuna, and to provide the necessary flexibility to adhere to ICCAT Regulations on caging of tuna..

Terms of Reference

3. The Terms of Reference provided by the Environment and Resources Authority (ERA) are:

3.0 A DESCRIPTION OF THE SITE AND ITS SURROUNDINGS (I.E. ENVIRONMENTAL BASELINE)

The existing environmental features, characteristics and conditions, in and around the proposed development site as well as in all locations likely to be affected by the development or by ancillary interventions and operations, are to be identified and described in sufficient detail, with particular attention to the aspects elaborated further in the next sections.

The consultants should also identify (and justify) wherever relevant:

1. The geographic area (e.g. viewshed or other area of influence) that needs to be covered by each study;
2. The relevant sensitive receptors vis-à-vis the environmental parameter under consideration (e.g. natural ecosystems, specific populations of particular species, or individual physical features);
3. The location of the reference points or stations (e.g. viewpoints, monitoring stations, or sampling points (including depth of multiple sampling points at a single sampling point in the case of water media and sediment, where applicable) to be used in the study; and
4. Other methodological parameters of relevance, also noting that the assessment will normally require both desk-top studies and on-site investigations (including visual observations and sampling, as relevant).

Note: *It is recommended that these details are discussed in advance with the Environment and Resources Authority prior to commencement of the relevant parts of the studies, in order to pre-empt (as much as possible) later-stage issues.*

Wherever relevant to the environmental aspects under discussion, reference to legislation, policies, plans (including programmes and strategies) standards and targets, should also be made, such that the compatibility (or otherwise) of the proposal therewith is also factored into the assessment required by ***Section 4*** below. The discussion should cover the following aspects, in the appropriate level of detail:

- Supra-national (*e.g.* European Union; United Nations; or other international or regional) legislation, directives, policies, conventions, protocols, treaties, charters, plans and obligations;
- National legislation, policies and plans (*e.g.* Structure Plan; National Environment Policy); and
- Sub-national legislation, policies and plans (*e.g.* local plans, site-specific regulations, action plans, management plans, and protective designations such as scheduling or Natura 2000).

Note: *In addition to already in-force legislation, policies and plans, the discussion should also cover any foreseeable future updates (or new legislation, policies and plans) likely to be fulfilled, affected or compromised by the proposed project. Furthermore, it should be noted that some cross-cutting legal/policy instruments (e.g. Water Framework Directive and Marine Strategy Framework Directive) may need to be factored into more than one aspect of the discussion.*

3.2 Marine environment

3.2.1 Hydrodynamical modelling

A detailed wave and hydrodynamic model that includes mathematical modelling adopted for the determination of:

1. The best design for all the components of the proposed project shall be undertaken;
2. The effects of the proposal on water circulation;
3. Dispersion models, including:
   - Dispersal of oil slicks / fish oils and nutrients
   - Settlement of uneaten feed
   - Impact on the coast
   - Impact on the underlying sediment
4. Wave statistical characteristics (including probability tables for extreme conditions)

And shall include physic-chemical parameters, such as prevailing and local currents and their velocity, wave exposure, water depth/bathymetry and sea-bottom type.

3.2.2 Ecology (including Marine Ecology and Avifauna)

1. A full benthic survey of the existing benthic environment on and around the area that will potentially be affected shall be undertaken prior to starting operations. The study shall include:
   a. Offshore bathymetric maps;
   b. Aerial imagery of the area;
   c. Details and maps of any services / utilities;
   d. Description of the sea-bed morphology and of the sediment characteristics of the site;
2. A survey of the area defined by the cage moorings and the area to be potentially affected by the fish farm and dispersal of nutrients, consisting of a detailed survey with adequate maps, plans, diagrams, photographs of the marine biotopes/habitats types of the area;
3. An investigation of the ecology of the site and its surroundings (including, as relevant: flora, fauna, avifauna, fish and other aquatic organisms (including marine mammals and turtles), benthic, burrowing and pelagic organisms, their habitats and ecosystems), duly covering

the relevant seasons to ensure adequate coverage of all relevant species and ecosystem components;

4. A noise and vibration study providing sufficient detailed information on any impacts on sensitive receptors (fauna and avifauna, natural ecosystems)due to increase in pressure in the area, and the cumulation with other existing sources including maritime vessel traffic and with other predicted sources such as new developments.
5. A reporting of the conservation status and ecological condition of the area and the state of health of its habitats, species and ecological features;
6. Identification of all relevant species and assemblages (e.g. protected species or habitats, key species relevant to habitat characterisation, and monitoring indicators), and assess their abundance and distribution patterns as well as the species' ecological niches. The findings should be supported by adequate maps and photographs. Classification of habitat types and species should be conducted in accordance with recognised classification systems (e.g. EUNIS and Palaearctic), to ERA satisfaction;
7. A reporting of all protected, endangered, rare, unique, endemic, high-quality, keystone, invasive/deleterious, or otherwise important species, habitats, ecological assemblages, and ecological conditions found in the area under study;
8. A prediction of the potential impacts of the proposed project on the ecology of the site and its surroundings, including loss, damage or alteration of habitats and species populations (including potential increases in ambient noise levels in the marine environment) including alteration in the habitats and species' condition/state of health as measured through indicators used/specified for assessment of status in relevant EU policy;
9. The nature of the changes (whether temporary or permanent) and effects of such changes on the ecological features; and
10. Other relevant environmental features

Note 1: *Should the proposal fall within (or be likely to have significant impact on) a Natura 2000 Site, Special Area of Conservation (SAC) or Special Protection Area (SPA), a stand-alone Appropriate Assessment in terms of the Flora, Fauna and Natural Habitats Protection Regulations may be required. In such instances, separate Terms of Reference are issued for the Appropriate Assessment.*

4.0 ASSESSMENT OF ENVIRONMENTAL IMPACTS AND ENVIRONMENTAL RISKS

The proposed area is considered to be totally exposed, therefore the level of risk needs to be assessed and the practical feasibility of the project discussed.

All likely significant effects and risks posed by the proposed project on the environment during all relevant phases (including construction, operation and decommissioning) should be assessed in detail, taking into account the information emerging from Sections 1, 2 and 3 above. Apart from considering the project on its own merits (*i.e.* if taken in isolation), the assessment should also take into account the wider surrounding context and should consider the limitations and effects that the surrounding environmental constraints, features and dynamics may exert on the proposed development, thereby identifying any incompatibilities, conflicts, interferences or other relevant implications that may arise if the project is implemented.

In this regard, the assessment should address the following aspects, as applicable for any category of effects or for the overall evaluation of environmental impact, addressing the worst-case scenario wherever relevant:

1. An exhaustive identification and description of the envisaged impacts;
2. The magnitude, severity and significance of the impacts;
3. The geographical extent/range and physical distribution of the impacts, in relation to: site coverage; the features located in the site surroundings; whether the impacts are short-,

medium- or long-range; and any transboundary impacts (i.e. impacts affecting other countries);

4. The timing and duration of the impacts (whether the impact is temporary or permanent; short-, medium- or long-term; and reasonable quantification of timeframes);
5. Whether the impacts are reversible or irreversible (including the degree of reversibility in practice and a clear identification of any conditions, assumptions and pre-requisites for reversibility);
6. A comprehensive coverage of direct, indirect, secondary and cumulative impacts, including:
    - interactions (e.g. summative, synergistic, antagonistic, and vicious-cycle effects) between impacts;
    - interactions or interference with natural or anthropogenic processes and dynamics;
    - cumulation of the project and its effects with other past, present or reasonably foreseeable developments, activities and land uses and with other relevant baseline situations; and
    - wider impacts and environmental implications arising from consequent demands, implications and commitments associated with the project (including: displacement of existing uses; new or increased pressures on the environment in the surroundings of the project, including pressures which may be exacerbated by the proposal but of which effects may go beyond the area of influence; and impacts of any additional interventions likely to be triggered or necessitated by situations created, induced or exacerbated by the project);
7. Whether the impacts are adverse, neutral or beneficial;
8. The sensitivity and resilience of resources, environmental features and receptors vis-à-vis the impacts;
9. Implications and conflicts vis-à-vis environmentally-relevant plans, policies and regulations;
10. The probability of the impacts occurring; and
11. The techniques, methods, calculations and assumptions used in the analyses and predictions, and the confidence level/limits and uncertainties vis-à-vis impact prediction.

The impacts that need to be addressed are detailed further in the sub-sections below and should be presented in summary chart format.

4.1 Effects on the environmental aspects identified in Section 3

The assessment should thoroughly identify and evaluate the impacts and implications of the project on all the relevant environmental aspects identified in Section 3 above, also taking into account the various considerations outlined in the respective sections.

5.1 Mitigation Measures

A clear identification and explanation of the measures envisaged to prevent, eliminate, reduce or offset (as relevant) any significant adverse effects of the project during all relevant phases including construction, operation and decommissioning [see ***Section 1.2.3*** above]. Such measures could include technological features; operational management techniques; enhanced site-planning and management; aesthetic measures; conservation measures; reduction of magnitude of project; and health and safety measures. Particular attention should be given to mitigation of impacts on the marine resources and of conflicts between the different uses on site.

Mitigation measures for accident/risk scenarios should be packaged as a holistic plan that includes the integration of failsafe systems into the project design as well as well-defined contingency measures.

The recommended measures should be feasible, realistically implementable to the required standards and in a timely manner, effective and reliable, and reasonably exhaustive. They should not be dependent on factors that are beyond the developer's and ERA's control or which would be difficult to monitor, implement or enforce. The actual scope for, and feasibility of, effective prevention or mitigation should also be clearly indicated, also identifying all potentially important pre-requisites, conditionalities and side-effects.

Management plans for the site including measures on how to control biomass, spreading of diseases, etc. These should include a framework for the:

- Environmental Management Plan (including provisions to be taken in case of deterioration of water quality and disruption to the benthos).
- Waste Management Plan
- Risk assessment and contingency planning for disasters and other contingencies (high mortality, oil spills from bunkering area.)
- Risk assessment for accidents by oncoming shipping traffic.

5.2 Residual Impacts

Any residual impacts [*i.e.* impacts that cannot be effectively mitigated, or can only be partly mitigated, or which are expected to remain or recur again following exhaustive implementation of mitigation measures] should also be clearly identified.

5.3 Additional Measures

Compensatory measures (*i.e.* measures intended to offset, in whole or in part, the residual impacts) should also be identified, as reasonably relevant. Such measures should be not considered as an acceptable substitute to impact avoidance or mitigation.

If the assessment also identifies beneficial impacts on the environment, measures to maximise the environmental benefit should also be identified.

In both instances, the same practical considerations as indicated vis-à-vis mitigation measures should also apply.

5.4 Decommissioning Plan

A decommissioning plan (DP) should also be proposed to address the following circumstances, as relevant:

1. Removal of any temporary or defined-lifetime development (or of any structures, infrastructure or land use required temporarily in connection with it) upon the expiry of their permitted duration; and
2. Removal of the development (or of any secondary developments, infrastructure or land use ancillary to it) in the event of redundancy, cessation of operations, serious default from critical mitigation measures, or other overriding situations that may emerge in future.

The DP should also include, as relevant, a phasing-out plan, proposals for site remediation or decontamination, and methodological guidance on site reinstatement or appropriate after-use.

5.5 Monitoring Programme

A realistic and enforceable programme for effective monitoring of those works envisaged to have an adverse or uncertain impact. The monitoring programme should include:

1. Details regarding type and frequency of monitoring and reporting, including spot checks;
2. The parameters that will be monitored, their units of measurement, the monitoring indicators to be used; and standard analytical methods in line with relevant EU policy;
3. An effective indication of the required action to address any exceedances, risks, mitigation failures or non-compliances for each monitoring parameter;
4. An evaluation of forecasts, predictions and measures identified in the EIA; and
5. An indication of the nature and extent of any additional investigations (including EIAs or ad hoc detailed investigations, if relevant) that may be required in the event of any contingencies, unanticipated impacts, or impacts of larger magnitude or extent than predicted.

The programme should address all relevant stages, as follows:

(a) Where relevant, monitoring of preliminary on-site investigations that may entail significant disturbance or damage to site features (*e.g.* marine environment in terms of the benthos;,or any works that require prior site clearance or any significant destructive sampling);
*[**Note:** Official written consent from the competent authorities (e.g. Superintendence of Cultural Heritage) may also be required for such interventions.]*

(b) Monitoring of the construction phase, including the situation before initiation of works (including site clearance), during appropriate stages of progress, and after completion of works;

(c) Monitoring of the operational phase, except where otherwise directed by ERA (*e.g.* where monitoring would be more appropriately integrated into an operating permit) (including monitoring of the marine environment in terms of the benthos, water quality and other sensitive receptors); and

(d) Where relevant, monitoring of the decommissioning phase, including the situation before initiation of works, during appropriate stages of progress, and after completion of works.

5.6 Identification of required authorisations

The assessment should also identify all environmentally-relevant permits, licences, clearances and authorisations (other than the development permit to which this EIA is ancillary) which must be obtained by the applicant in order to effectively implement the project if development permission is granted. Any uncertainty, as to whether any of these pre-requisites is applicable to the project, should be clearly stated.

Note on Sections 5.1 to 5.6 above:
The expected effects, the proposed measures, the residual impacts, the proposed monitoring etc. should also be summarised in a user-friendly itemised table that enables the reader to easily relate the various aspects to each other. An indicative specimen table is attached in ***Appendix 3***.

AREAS OF INFLUENCE

4. The Area of Influence (A of I) for the marine environment (including marine ecology) baseline studies is shown in **Figure 1**.

ASSESSMENT METHODOLOGY

Surveyors

5. The studies will be undertaken as follows:

- Hydrodynamic Modeling: Artelia Eau et Environnement of France: Engineer Franck Mazas BSc (Science), MSc (Fluid Mechanics & Energetics), Grad. Engineer and Dr Anne Levasseur MSc (Earth Sciences), pg Dip. (Ocean Atmosphere & Environment), PhD (Oceanography) ;
- Marine Ecology & Marine Environment: Prof. Joseph A. Borg BSc (Chemistry & Biology), MSc (Biology), PhD (Marine Ecology); and
- Avifauna: Mr John J Borg.

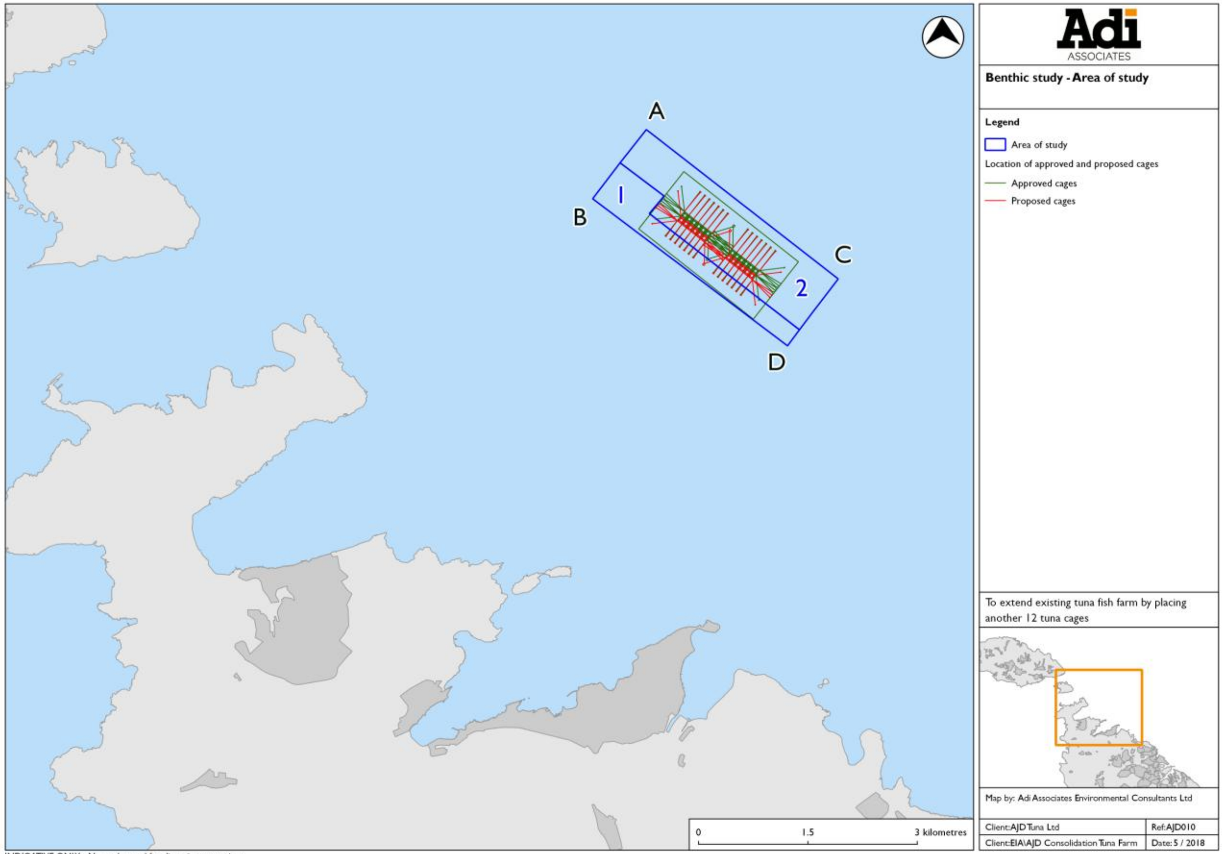
Study methodology

6. The marine environment study will comprise:

- Hydrodynamic modeling as described below;
- A description of the benthic habitats including a description of indicator species relevant to the characterisation of the ecological quality and conservation status of the study area;
- A description of the biotic assemblages and communities present within the Area of Influence, and an indication of their protected status (if any);
- An assessment of populations of other aquatic fauna noted during the surveys, including demersal and pelagic fauna;
- An assessment of the impact of the development of the aquaculture zone on the ecology in the A of I and an evaluation of the significance of these effects;
- A description of mitigation measures designed to minimise adverse impacts on ecology and enhance the ecological features of the site where possible; and
- Preparation of a monitoring framework for the Project, if required.

7. The Study will be undertaken by taking into consideration the Terms of Reference provided by ERA. It is proposed that the ToR will be satisfied as set out in the methodology below.

Figure 1: Area of Study



INDICATIVE ONLY - Not to be used for direct interpretation

BASELINE SURVEY METHODOLOGY

Literature Search

8. A desk-top study will be carried out and a summary of previous survey work undertaken within the study area will be provided as context to the results of the current survey work.

Field Survey

Hydrodynamic modelling

9. The Modelling study will have two tasks:

- Task A: wave study:
  - offshore wave modelling,
  - establishment of local wave climate and extreme waves,
- Task B: hydrodynamic study:
  - set up of the hydrodynamic model,
  - hydrodynamic modelling:
    - current hydrodynamic situation,
    - model for oil slicks and nutrients,
    - settlement of uneaten feed,
    - assessment of the expected impact on water quality,
    - dispersion of a fish oil spill from the fish farm.

10. In order for the model to be produced, the following data will be required: (i) bathymetry, (ii) nature of the seabed, (iii) characteristics of the oil, (iv) characteristics of the uneaten feed (nature, volume, settlement velocity, etc.), (v) location of the farm.

<u>Wave Study</u>

11. ARTELIA has carried out a wave modelling study around the Maltese archipelago spanning the modelling period 1992-2015 (24 years). Several output points have been set around the archipelago. For this study, the closest grid point will be exploited. Its location is illustrated in **Figure 2** below.

Figure 2: Location of wave output point

12. The wave modelling consists of a full wave hindcast study over the Mediterranean Sea. Sea states are modelled through the 3rd-generation, state-of-the-art models Wave Watch III and SWAN. In particular, these codes enable the modelling of the following physical phenomena:

- wave propagation in time and space of the wave spectrum,
- depth-induced refraction;
- bottom friction;
- wave breaking due to depth and steepness;
- diffraction, transmission and reflection by obstacles;

13. Satellite measurements are used for validating and calibrating wind fields used as input of the models and sea states output from the models (see **Figure 3**).

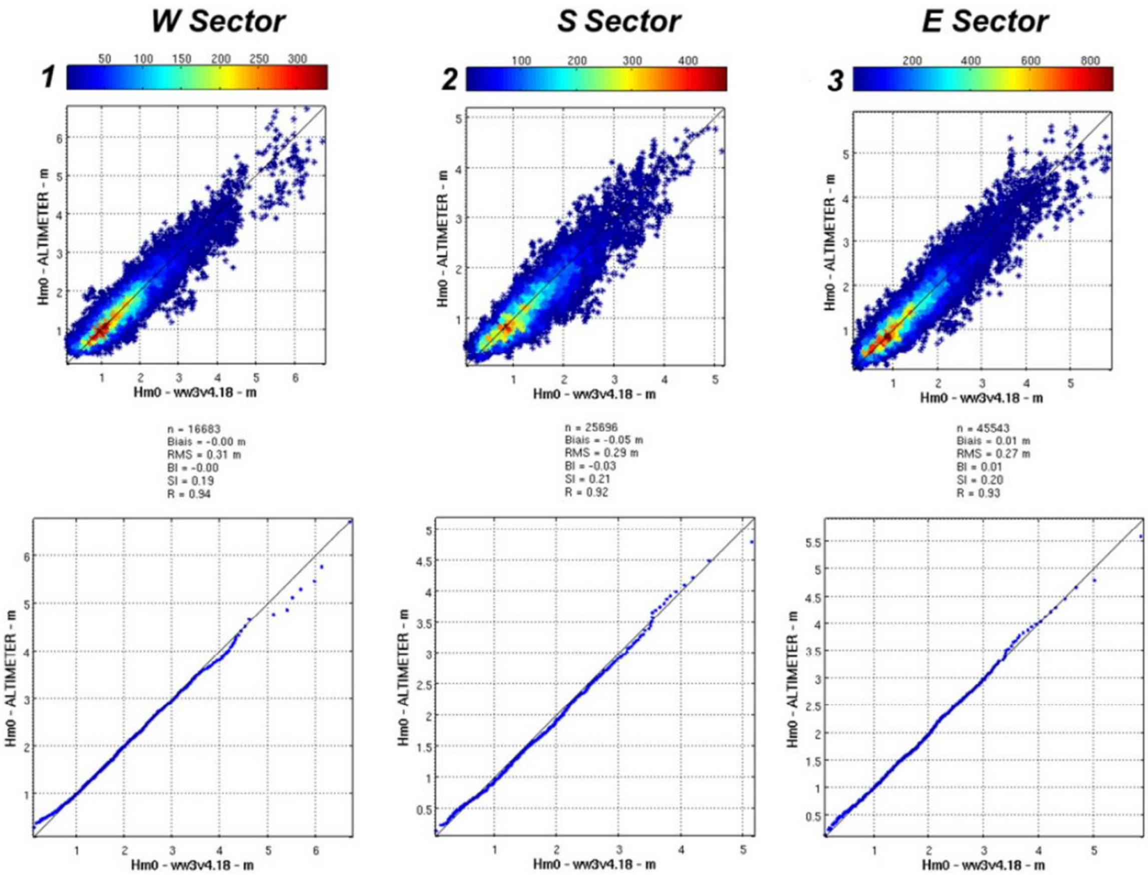
14. At the output point, the wind speed and direction will be interpolated from the CFSR field and the sea state spectra will be processed to get the hourly time series from

January 1992 to December 2015 (24 years) of the wind and spectral wave parameters:

- wind:
    - wind velocity at 10 m, averaged over 10 min (m/s),
    - wind direction (°N),
- sea states:
    - spectral significant wave height H_{m0} (m);
    - peak period T_p (s);
    - peak direction $\varnothing_p$ (°N);
    - directional spreading ∂ (°) or equivalently the spreading parameter (exponent of the cosine function) s (-) ;
    - peak enhancement factor *y* (-) based on the assumption of a JONSWAP-type spectrum.

15. In addition, a spectral partitioning of sea states will be carried out in order to separate the different wave systems (wind waves, swell) and the associated spectral parameters will be provided for each wave system.

Figure 3: Validation of sea states around the Maltese Islands with respect to satellite measurements

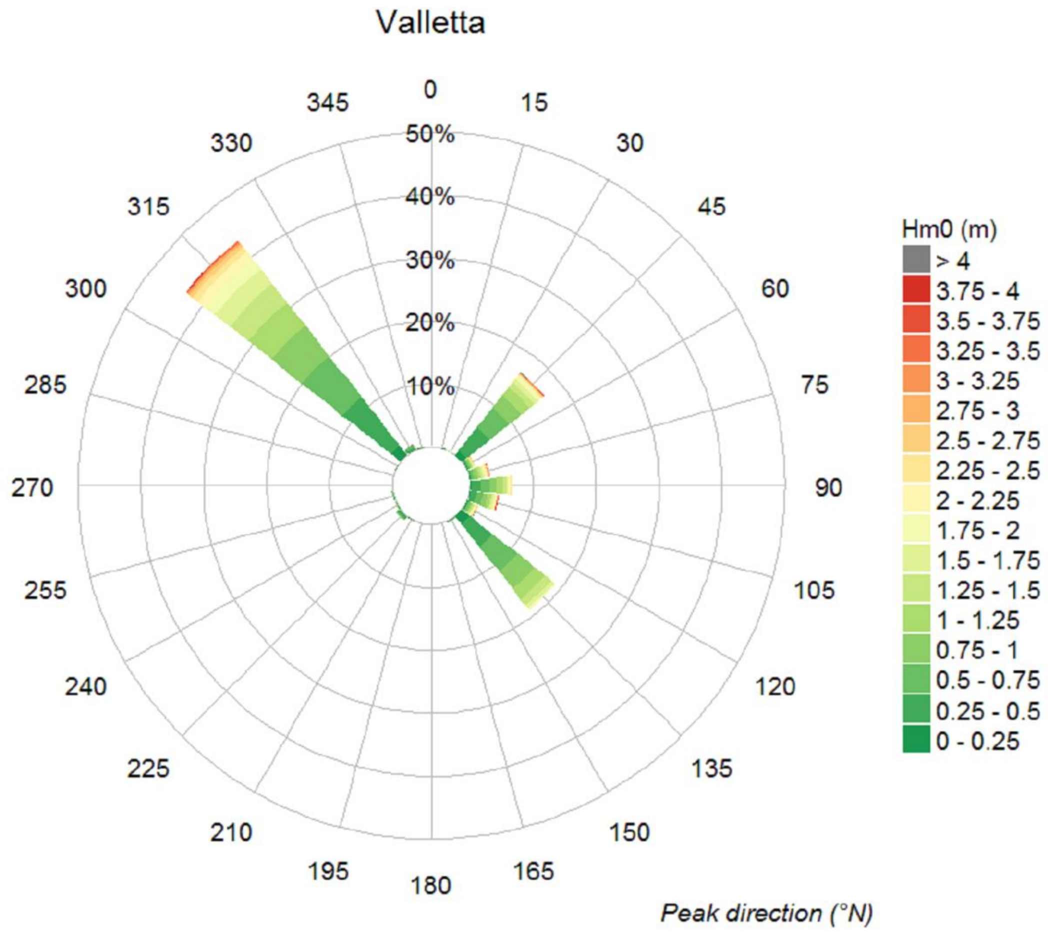


16. The local wave climate will be established with the following plots:

- directional wave roses in H_{m0} and T_p;
- scatter diagrams H_{m0}/ $Ø_p$, H_{m0}/ T_p and T_p/ $Ø_p$;
- exceedance frequency curves for H_{m0} and T_p;
- histogram of the frequency of occurrence of H_{m0} and T_p;
- correlograms H_{m0}/ $Ø_p$, H_{m0}/ T_p and T_p/ $Ø_p$.

17. **Figure 4** below illustrates the wave rose in significant wave height H_{m0} off Valletta.

Figure 4: Wave rose off Valletta (Artelia, 2017)



18. Extreme wave heights will be estimated for the different directional sectors (in particular gregale and majjistral sectors) identified through the assessment of the wind and wave climates. This estimation will be performed through a statistical extrapolation.

Task B: Hydrodynamic modelling

19. The study will be based on the set up of a 3D numerical model using the TELEMAC-MASCARET system (www.opentelemac.org). TELEMAC-3D is part of the TELEMAC-MASCARET system, and is designed to study environmental processes in free surface transient flows.

20. The hydrodynamic model will be set up over the fish farm area and extended far enough offshore to introduce tidal level conditions at the offshore boundary. Adaptation will be made on the existing model of the coastal sea around Malta, available at ARTELIA. The model will comprise between 7 plans to 10 plans on the vertical. Size of the triangular mesh will be adjusted to represent in detail the study area.

21. The bathymetry will be constructed from the available data and from information provided through the remote sensing survey undertaken as part of this EIA.

22. Tidal currents are minimal in this area, so flows are dominated by wind-induced currents and global circulation in the Mediterranean Sea. Consequently, hydrodynamics and flushing simulations will consider typical spring and neap tide conditions, associated to wind conditions typical of calm regimes. It is to be noted that hydrodynamic modelling will not consider extreme water levels, wave conditions and the associated currents that may be generated under storm conditions. It will be based on simulations of typical spring and neap tide conditions and will reproduce operational conditions.

23. A calibration and validation of the hydrodynamics results will be done based on water levels.

24. The calculation period will last 15 days in order to cover the largest tidal range, and two identified prevailing regimes of calm wind conditions will be taken into account per simulation. Results will be presented by means of maps and time-series of the velocity in the water column on the project site.

25. Uneaten feed will be modelled as particles with a specific density and fall velocity. The simulation will represent the settlement of the particles depending on the water circulation in the future fish farm location. The numerical model will be run over a 2 week period. Two scenarios will be simulated, corresponding each to specific wind conditions. Deliverables will include maps of the uneaten feed deposit, and time-series of the thickness of the deposit at several locations in the vicinity of the fish farm.

26. Fall velocity will be determined according to the size of the feed and the literature. Percentage of uneaten feed from the feed supplied will be obtained from fish farm operators. Feed conversion factor will also be estimated from the literature and/or information from the clients.

<u>Assessment of the expected impact on water quality</u>

27. The simplest approach consists of introducing a passive tracer in the tuna fish farm and run the model for a 2-week period, with adequate forcing (tide, currents, wind). The passive tracer represents the release of inorganic nutrients (nitrogen and phosphorus) by metabolic waste from the fishes. The aim is to model the nutrient plume dispersion. Results will give the increase of nutrient concentration generated by the fish farm in its surrounding water, compared to the background level.

28. Nutrient enrichments in the fish farm is influenced by numerous factors like fish numbers, life stage, size, rearing system and diet. To estimate the nutrient loads from the fish farm, assumption will be made on the discharge generated using information provided by the client on the project (fish concentration and characteristics, water quality data sets if available) and the literature.

29. Four scenarios will be simulated, to test two wind conditions and two types of

tracers: nitrogen and phosphorus.

30. Deliverables will include maps and time-series of the phosphorus concentration at several locations within the model domain.

31. Fish oil originated from the feed of the tuna will be modelled using the oil spill dispersion model included in TELEMAC. The oil contained in the fish feed will be modelled as a set of particles released continuously from the feeding cages. The numerical model will be run over a 2 week period. Two scenarios will be simulated, corresponding each to specific wind conditions.

32. Results of the scenarios will be mapped, to assess the area of deposition and the amount of oil deposited.

33. The following inputs will be required for this study:

- volume and density of the fish oil contained in the feed;
- feed consumption of the fish farm; and
- viscosity of the fish oil.

34. In addition to hydrodynamic modeling, the impact of water quality will also be assessed through an analysis of data from monitoring of existing tuna farms.

Ecology – Benthic survey

35. A survey of the seabed within the Area of Study will be undertaken. The survey will be mainly aimed at establishing the gross physical and biological characteristics of the seabed using a remotely operated vehicle (ROV) that will be deployed from a vessel equipped with a full complement of navigational and positioning equipment. A Seaview Systems Raptor ROV will be used.

36. Data will be collected along parallel transects which will have a maximum spacing of 200 m. The video footage will indicate the geographical location of the deployed ROV and water depth throughout the recording to enable easy referencing.

37. The video footage collected from the field will be analysed in the laboratory. Analysis of data will enable determination of the spatial distribution of marine benthic habitats within the area surveyed. The assessment will also identify the main relevant species and assemblages (e.g. protected species or habitats, key species relevant to habitat characterisation) recorded from the survey area. The conservation importance of habitats and species recorded from the survey sites will be identified by reference to appropriate legislation, including EU and Maltese legislation. Special attention will be given to protected species, endemic species, and species that have a conservation and/or ecological importance.

38. A report giving details of the methodology used during the survey, findings and appraisal, together with maps showing the distribution of marine benthic assemblages within the area surveyed, will be submitted. The report will be accompanied by the

video footage collected (on DVD).

Ecology – avifauna

39. The study on avifauna will be based on data accumulated over a 35-year period by the consultant, related to breeding species, as well as migrant and wintering species. Published as well as unpublished records/data will also be consulted and incorporated in the final report.

40. The assessment will include impacts on avifauna including (but not restricted to) disturbance, noise, vibration, loss of habitat, shadow flicker and lighting, collision risks.

41. The impact of the fish pens as barriers/hazards to movement shall be assessed in terms of the seabird colonies and other marine avifauna. The impact on prey availability for breeding and "visiting" seabirds shall also be assessed.

42. The assessment shall analyse the disruption of ecological links between feeding, breeding and roosting areas. An assessment of collision risks for seabirds shall be taken into account.

43. The assessment shall also investigate the annual change in populations of birds if necessary through modelling and the decline in territory occupancy.

IDENTIFICATION OF POTENTIAL IMPACTS

44. The sensitive receptors will be identified as part of the baseline survey. The potential impacts of the Aquaculture Zone on the marine environment are likely to include:

- Potential impacts on the wave climate due to the installations within the zone;
- Impacts from fish oil from fish feed;
- Impacts on avifauna from farm operations including light and noise;
- Direct loss of habitats and decimation of biota through the installation of the mooring system;
- Disturbance to the benthic environment during the farming operations from the loss of materials, the settlement of uneaten baitfish on the seafloor, and settlement of fish faeces. The settlement of organic matter on the seabed would typically attract benthic scavengers to the area, which could affect the natural environment of the seabed; and
- Changes in ecological relationships and trophic linkages to attraction of species to the site.

PREDICTION OF IMPACTS

45. Each of the potential impacts listed above will be examined. The baseline survey information will be entered into a Geographical Information System (GIS). This

system will enable the following analysis to be undertaken (where relevant):

- Map areas of permanent habitat loss;
- Indicate proximity to sensitive habitats; and
- Proximity to areas sensitive to disturbance.

IMPACT SIGNIFICANCE

46. The analysis of the significance of each potential impact identified (positive or negative) will include:

- Description of impact;
- Policy importance of the impact (local, national, international);
- Extent of impact;
- Duration of impact (temporary or permanent);
- Adverse or beneficial effect of impact;
- Reversible and irreversible effects of impact;
- Sensitivity to impacts;
- Probability of impact occurring (certain, likely, uncertain, unlikely, remote); and
- Scope for mitigation/enhancement (very good, good, fair, none).

47. The above criteria will enable the determination of the significance of each impact in respect of the studies described above. The impacts will be described as not significant, of minor or major significance:

- Not significant (e.g. no material change in habitat quality and/or extent);
- Minor significance (e.g. small-scale loss/disturbance of habitat that is unlikely to affect the ecological integrity of the marine environment or); and
- Major significance (e.g. large-scale loss/disturbance of the marine assemblages that is likely to affect the ecological integrity of the A of I).

MITIGATION

48. The Study will describe measures that can be put in place to prevent, minimise, and where possible, offset any significant adverse effects resulting from the project.

49. The Study will also comprise a monitoring programme to monitor any sensitive habitats or species within the A of I and to evaluate the impacts that the project may have on them.

Adi Associates Environmental Consultants Ltd

April 2018

ADi ASSOCIATES

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED EXTENSION OF THE TEMPORARY TUNA FARM OFF IS-SIKKA L-BAJDA, NORTH OF MALTA

MARINE ARCHAEOLOGY METHOD STATEMENT

INTRODUCTION

1. This method statement provides information on the marine archaeology input to the Environmental Impact Assessment (EIA) for the proposed extension of the temporary tuna farm located off is-Sikka l-Bajda (some 5 km offshore) in the North of Malta.

2. The proposal that is being assessed comprises the doubling of the tuna cages (form 12 to 24) without an overall increase in fish numbers; this to decrease the stocking density in the existing cages, which is having a detrimental effect on the fattening of the tuna, and to provide the necessary flexibility to adhere to ICCAT Regulations on caging of tuna.

Terms of Reference

3. The Terms of Reference provided by the Environment and Resources Authority (ERA) are:

3.0 A DESCRIPTION OF THE SITE AND ITS SURROUNDINGS (I.E. ENVIRONMENTAL BASELINE)

The existing environmental features, characteristics and conditions, in and around the proposed development site as well as in all locations likely to be affected by the development or by ancillary interventions and operations, are to be identified and described in sufficient detail, with particular attention to the aspects elaborated further in the next sections.

The consultants should also identify (and justify) wherever relevant:

1. The geographic area (e.g. viewshed or other area of influence) that needs to be covered by each study;
2. The relevant sensitive receptors vis-à-vis the environmental parameter under consideration (e.g. natural ecosystems, specific populations of particular species, or individual physical features);
3. The location of the reference points or stations (e.g. viewpoints, monitoring stations, or sampling points (including depth of multiple sampling points at a single sampling point in the case of water media and sediment, where applicable) to be used in the study; and
4. Other methodological parameters of relevance, also noting that the assessment will normally require both desk-top studies and on-site investigations (including visual observations and sampling, as relevant).

Note: *It is recommended that these details are discussed in advance with the Environment and Resources Authority prior to commencement of the relevant parts of the studies, in order to pre-empt (as much as possible) later-stage issues.*

Wherever relevant to the environmental aspects under discussion, reference to legislation, policies, plans (including programmes and strategies) standards and targets, should also be made, such that the compatibility (or otherwise) of the proposal therewith is also factored into the assessment required by ***Section 4*** below. The discussion should cover the following aspects, in the appropriate level of detail:

- Supra-national (*e.g.* European Union; United Nations; or other international or regional) legislation, directives, policies, conventions, protocols, treaties, charters, plans and obligations;
- National legislation, policies and plans (*e.g.* Structure Plan; National Environment Policy); and
- Sub-national legislation, policies and plans (*e.g.* local plans, site-specific regulations, action plans, management plans, and protective designations such as scheduling or Natura 2000).

Note: *In addition to already in-force legislation, policies and plans, the discussion should also cover any foreseeable future updates (or new legislation, policies and plans) likely to be fulfilled, affected or compromised by the proposed project. Furthermore, it should be noted that some cross-cutting legal/policy instruments (e.g. Water Framework Directive and Marine Strategy Framework Directive) may need to be factored into more than one aspect of the discussion.*

3.3 Marine Archaeology and related Material Assets

Refer to Appendix 2.

4.0 ASSESSMENT OF ENVIRONMENTAL IMPACTS AND ENVIRONMENTAL RISKS

The proposed area is considered to be totally exposed, therefore the level of risk needs to be assessed and the practical feasibility of the project discussed.

All likely significant effects and risks posed by the proposed project on the environment during all relevant phases (including construction, operation and decommissioning) should be assessed in detail, taking into account the information emerging from Sections 1, 2 and 3 above. Apart from considering the project on its own merits (*i.e.* if taken in isolation), the assessment should also take into account the wider surrounding context and should consider the limitations and effects that the surrounding environmental constraints, features and dynamics may exert on the proposed development, thereby identifying any incompatibilities, conflicts, interferences or other relevant implications that may arise if the project is implemented.

In this regard, the assessment should address the following aspects, as applicable for any category of effects or for the overall evaluation of environmental impact, addressing the worst-case scenario wherever relevant:

1. An exhaustive identification and description of the envisaged impacts;
2. The magnitude, severity and significance of the impacts;
3. The geographical extent/range and physical distribution of the impacts, in relation to: site coverage; the features located in the site surroundings; whether the impacts are short-, medium- or long-range; and any transboundary impacts (i.e. impacts affecting other countries);
4. The timing and duration of the impacts (whether the impact is temporary or permanent; short-, medium- or long-term; and reasonable quantification of timeframes);
5. Whether the impacts are reversible or irreversible (including the degree of reversibility in practice and a clear identification of any conditions, assumptions and pre-requisites for reversibility);
6. A comprehensive coverage of direct, indirect, secondary and cumulative impacts, including:

- interactions (e.g. summative, synergistic, antagonistic, and vicious-cycle effects) between impacts;
- interactions or interference with natural or anthropogenic processes and dynamics;
- cumulation of the project and its effects with other past, present or reasonably foreseeable developments, activities and land uses and with other relevant baseline situations; and
- wider impacts and environmental implications arising from consequent demands, implications and commitments associated with the project (including: displacement of existing uses; new or increased pressures on the environment in the surroundings of the project, including pressures which may be exacerbated by the proposal but of which effects may go beyond the area of influence; and impacts of any additional interventions likely to be triggered or necessitated by situations created, induced or exacerbated by the project);

7. Whether the impacts are adverse, neutral or beneficial;
8. The sensitivity and resilience of resources, environmental features and receptors vis-à-vis the impacts;
9. Implications and conflicts vis-à-vis environmentally-relevant plans, policies and regulations;
10. The probability of the impacts occurring; and
11. The techniques, methods, calculations and assumptions used in the analyses and predictions, and the confidence level/limits and uncertainties vis-à-vis impact prediction.

The impacts that need to be addressed are detailed further in the sub-sections below and should be presented in summary chart format.

4.1 Effects on the environmental aspects identified in Section 3

The assessment should thoroughly identify and evaluate the impacts and implications of the project on all the relevant environmental aspects identified in Section 3 above, also taking into account the various considerations outlined in the respective sections.

5.1 Mitigation Measures

A clear identification and explanation of the measures envisaged to prevent, eliminate, reduce or offset (as relevant) any significant adverse effects of the project during all relevant phases including construction, operation and decommissioning [see ***Section 1.2.3*** above]. Such measures could include technological features; operational management techniques; enhanced site-planning and management; aesthetic measures; conservation measures; reduction of magnitude of project; and health and safety measures. Particular attention should be given to mitigation of impacts on the marine resources and of conflicts between the different uses on site.

Mitigation measures for accident/risk scenarios should be packaged as a holistic plan that includes the integration of failsafe systems into the project design as well as well-defined contingency measures.

The recommended measures should be feasible, realistically implementable to the required standards and in a timely manner, effective and reliable, and reasonably exhaustive. They should not be dependent on factors that are beyond the developer's and ERA's control or which would be difficult to monitor, implement or enforce. The actual scope for, and feasibility of, effective prevention or mitigation should also be clearly indicated, also identifying all potentially important pre-requisites, conditionalities and side-effects.

Management plans for the site including measures on how to control biomass, spreading of diseases, etc. These should include a framework for the:

- Environmental Management Plan (including provisions to be taken in case of deterioration of water quality and disruption to the benthos).
- Waste Management Plan
- Risk assessment and contingency planning for disasters and other contingencies (high mortality, oil spills from bunkering area.)
- Risk assessment for accidents by oncoming shipping traffic.

5.2 Residual Impacts

Any residual impacts [*i.e.* impacts that cannot be effectively mitigated, or can only be partly mitigated, or which are expected to remain or recur again following exhaustive implementation of mitigation measures] should also be clearly identified.

5.3 Additional Measures

Compensatory measures (*i.e.* measures intended to offset, in whole or in part, the residual impacts) should also be identified, as reasonably relevant. Such measures should be not considered as an acceptable substitute to impact avoidance or mitigation.

If the assessment also identifies beneficial impacts on the environment, measures to maximise the environmental benefit should also be identified.

In both instances, the same practical considerations as indicated vis-à-vis mitigation measures should also apply.

5.5 Monitoring Programme

A realistic and enforceable programme for effective monitoring of those works envisaged to have an adverse or uncertain impact. The monitoring programme should include:

1. Details regarding type and frequency of monitoring and reporting, including spot checks;
2. The parameters that will be monitored, their units of measurement, the monitoring indicators to be used; and standard analytical methods in line with relevant EU policy;
3. An effective indication of the required action to address any exceedances, risks, mitigation failures or non-compliances for each monitoring parameter;
4. An evaluation of forecasts, predictions and measures identified in the EIA; and
5. An indication of the nature and extent of any additional investigations (including EIAs or ad hoc detailed investigations, if relevant) that may be required in the event of any contingencies, unanticipated impacts, or impacts of larger magnitude or extent than predicted.

The programme should address all relevant stages, as follows:

(a) Where relevant, monitoring of preliminary on-site investigations that may entail significant disturbance or damage to site features (*e.g.* marine environment in terms of the benthos;,or any works that require prior site clearance or any significant destructive sampling);
*[**Note:** Official written consent from the competent authorities (e.g. Superintendence of Cultural Heritage) may also be required for such interventions.]*

(b) Monitoring of the construction phase, including the situation before initiation of works (including site clearance), during appropriate stages of progress, and after completion of works;

(c) Monitoring of the operational phase, except where otherwise directed by ERA (*e.g.* where monitoring would be more appropriately integrated into an operating permit) (including monitoring of the marine environment in terms of the benthos, water quality and other sensitive receptors); and

(d) Where relevant, monitoring of the decommissioning phase, including the situation before initiation of works, during appropriate stages of progress, and after completion of works.

5.6 Identification of required authorisations

The assessment should also identify all environmentally-relevant permits, licences, clearances and authorisations (other than the development permit to which this EIA is ancillary) which must be obtained by the applicant in order to effectively implement the project if development permission is granted. Any uncertainty, as to whether any of these pre-requisites is applicable to the project, should be clearly stated.

Note on Sections 5.1 to 5.6 above:
The expected effects, the proposed measures, the residual impacts, the proposed monitoring etc. should also be summarised in a user-friendly itemised table that enables the reader to easily relate the
various aspects to each other. An indicative specimen table is attached in ***Appendix 3***.

APPENDIX 2: TERMS OF REFERENCE FOR THE MARINE ARCHAEOLOGY (AS PROVIDED BY THE SUPERINTENDENCE OF CULTURAL HERITAGE, AS REVISED IN OCTOBER 2013)

1.0 Preamble

The proposed project would involve development over an extensive area and may lead to intensification of activity over a larger area. Potential impacts may occur within the footprint of the project, in the immediate environs, and along access routes to the site. Potential impacts may include direct and immediate material impacts, as well as subsequent impacts that might arise from the modification of the existing situation.

2.0 Scope and Definitions of the EIA

For the purposes of this document, cultural heritage is defined by Article 2 of the Cultural Heritage Act (2002). This includes movable or immovable objects of artistic, architectural, historical, archaeological, ethnographic, palaeontological and geological importance.

2.1 The study area shall include the total footprint of the proposed development.

2.2 In the context of this particular application, cultural heritage considerations may include features of archaeological value and potential;

The above cultural heritage definitions and considerations are not to be considered as exhaustive. The EIA must consider all other forms of cultural heritage, both known and unknown.

2.3 The Environmental Impact assessment will:

- Describe the Cultural Heritage assets within the study area;
- Assess the physical, spatial and visual impacts of the proposed development on the cultural heritage assets; and
- Propose corrective measures for the protection of the cultural resources.

3.0 Methodology

In quantifying the cultural heritage assets within the study area, and assessing the impacts of the proposed development, the EIA will undertake:

- Description and assessment of the property;
- Desktop and archival research limited to the study area;
- Fieldwork and research, topographic survey and remote sensing as may be necessary within the site. All fieldwork has to be authorised by the Superintendence of Cultural Heritage as defined below under point 4;
- Consultations with any relevant bodies, including the Superintendence of Cultural Heritage, Heritage Malta, the University of Malta, NGOs and Local Councils;
- Compilation of an inventory of the cultural heritage assets identified within the study area. The features of cultural heritage are to be described and plotted with grid references, on Data Capture Sheets, the design of which should be approved in advance by the Superintendence of Cultural Heritage. The Data Capture Sheets will be presented as an appendix to the EIS. The analysis of the features will be included in the main report; and
- A cultural heritage Risk Assessment Map examining the various impacts of the proposed project is to be included in the EIA.

4.0 Authorisation by the Superintendence of Cultural Heritage

As per Cultural Heritage Act 2002, any form of investigation or prospection required for the identification of cultural heritage (including topographic survey and remote sensing) may only be undertaken by the Superintendence of Cultural Heritage or with its written approval.

ADI ASSOCIATES

ERA PTOTECTIVE INVENTORY OF THE MALTESE CULTURAL HERITAGE HERITAGE DATA CAPTURE SHEET			Ref. No.
Location	Category	Type	Site Location (Address)
Eastings	Northings	Feature	Period - Year
S.S. No. 1 S.S. No. 3 Date	S.S. No. 2 S.S. No. 4	Description	
Negative No.	Film No.		
Present Utilization			
Existing Legal Protection		GN. Number	GN. Date
Comments			

Buffer Zone	A	B	C	D	E	Others
Eastings						
Northings						

Site Map Scale 1 : 2500	
Archaeological Characteristics – Sketch/Scaled drawings:	
Condition:	Degree of Protection (Structure Plan policies UCO7 or ARC 2):
State of Security:	Proposed Utilization:
Basic Bibliography:	
Compiled by: Checked by: Date:	Revised by: Checked by: Date:

4. The Terms of Reference have been taken into consideration in formulating this Method Statement.

5. In meeting these ToR the Marine Archaeology Study will comprise:

- A desk-top review of existing data / information on the marine archaeology of the site;
- A Side Scan Sonar survey of the entire study area to identify and map possible archaeological / cultural heritage artefacts;
- Review of video footage undertaken for the marine ecology surveys for any presence of archaeological / cultural heritage artefacts encountered;
- A description of any archaeological / cultural heritage artefacts encountered;
- An assessment of the impacts resulting from the proposed aquaculture zone and the increased human activity in the area on the archaeological / cultural heritage artefacts and an evaluation of the significance of these effects; and
- Description of mitigation measures designed to minimise adverse impacts on potential archaeological / cultural heritage artefacts.

6. The Study will be undertaken in accordance with the Terms of Reference provided by ERA. It is proposed that the ToR will be satisfied as set out in the methodology below.

BASELINE SURVEY METHODOLOGY

7. The surveys described above will be undertaken between February and April 2018, depending on weather / sea conditions.

Survey Area

8. The area of survey is as shown in **Figure 1**.

Potential Impacts

9. Potential impacts on marine archaeology are:

- Direct loss of artefacts through placement of mooring blocks or anchors;
- Disturbance of single artefacts through sediment scouring or accumulation resulting from the presence of the structures; and
- Disturbance to artefacts from increased activity in the area (e.g. anchoring).

Field Survey Methodology

Literature Search

10. Based on literature searches and the consultants' knowledge of the area, a summary of previous survey work undertaken within the study area will be provided as

context to the results of the current survey work. This will include review of existing literature, old manuscripts, and reports of earlier discoveries.

Field Surveys

11. The remote sensing survey of the area of study will consist of a side scan sonar and multibeam survey of the area coupled with the video footage that will be taken for the marine ecology survey.

12. The remote sensing surveys will be undertaken by Geomara Limited of Ireland under license from the Continental Shelf Department. The main aims of the remote sensing survey are:

- To map the seabed within the area of study;
- Produce a bathymetric map of the area of study; and
- To locate and map possible objects on the seabed.

13. This survey will assist in the baseline study of both the marine ecology and marine archaeology for the area and will provide:

- Offshore Bathymetry data;
- Location and nature of any subsea obstructions;
- Seabed ecology;
- Seabed Morphology;
- Sediment characteristics; and
- Archaeological Remote sensing.

14. **Table 1** lists the software that will be used for the data capture and analysis.

Table 1: Software

Technique	*Proposed Software*
Multibeam Acquisition & Processing	***Teledyne PDS (2000)***
Side Scan Sonar Acquisition	***Sonar Pro***
Side Scan Sonar Processing	***Sonarwiz 7***
Sound Velocity Profiler Acquisition & Processing	***Data Link***

15. The survey will be undertaken onboard a suitable local commercial vessel with ample deck space for operations and a dry cabin to house all sensitive electronic equipment being used. The vessel will be fully licensed and insured with all appropriate safety and navigational equipment.

16. The sidescan sonar will be towed from the stern of the vessel with appropriate layback for sea conditions and water depth. The Reson T50R multibeam sonar shall be mounted midships on the vessel using a bespoke over the side scan sonar mount and pole. The sonar pole is specifically manufactured to contain the sonar head, the system motion reference unit and positional antenna. This specific design reduced the potential for offset measurement errors created by non co-located devices.

17. For Multibeam survey line spacing will be arranged in such a manner that 25% overlap will be recorded for all survey lines and object detection shall be in line with IHO Special Order. During mobilisation, system calibrations will be completed. These will be undertaken in accordance with the manufacturer's specifications.

18. Teledyne Reson PDS2000 software will be used to provide helmsman's displays to the vessel skipper. The displays will include real-time positional updates as well as any cross track error distances. It will also provide the on-line surveyor with real time information relating to the ping density of the survey.

19. For Side Scan Sonar survey, line spacing will be arranged in such a manner that 50% overlap will be recorded for all survey lines. The side scan sonar transducer settings (beam width and depression) will be optimum for the operating water depth and range settings used. During mobilisation, system calibrations will be completed. These will be undertaken in accordance with manufacturer specifications.

20. A GPS Position Check will be carried out prior to the commencement of the survey. The position check will be recorded as a scatterplot over a period of 5 minutes recording positional variations over a fixed location.

21. Preliminary interpretation and processing of the data collected is anticipated to be undertaken on-board the survey vessel.

22. All raw data will be stored in its raw state by the survey software. Filtering, damping, prediction or gating of raw data may only take place with the prior consent of the Engineer and then only in the post-processing.

23. For all surveys, the 'raw' soundings will be selected, no depth averaging or bias will be applied during field operations. Processing of depth data will include all of the raw soundings; they will not be averaged, gated or thinned in any way.

24. The survey data will be processed in a variety of post processing software packages.

25. The foremost aim of this survey is to gather data that will enable to produce the following:

- A bathymetric chart of area of study; and
- Target location within the sediments in the survey area c/w geo-referenced target list.

26. Any objects captured by the Side Scan Sonar will be recorded and plotted on a digital map (location will include x and y coordinates). No archaeological / cultural heritage material shall be removed from the seabed or in any way disturbed. A detailed report of survey (complete with photographs, maps and other notes) will be compiled and included as a Technical Appendix to the EIA.

27. The report of survey will include details on the methodology used during the survey, data cards, findings, and interpretation, together with a map showing the distribution of any archaeological artefacts or deposits in the survey area as described hereunder

Evaluation

28. Archaeological or cultural heritage artefacts recorded will be identified as far as possible and their conservation importance given with reference to appropriate legislation, standards and guidance. These will include the Structure Plan for the Maltese Islands, the Cultural Heritage Act, 2002, as well as international conventions / treaties / standards applicable in Malta.

29. The results of the survey will be mapped in a GIS and catalogued following ERA's standard system.

30. Copies of all documents and photographs related to this survey as well as the final report will also be deposited at the Superintendence of Cultural Heritage.

IDENTIFICATION OF POTENTIAL IMPACTS

31. The sensitive archaeological / cultural heritage receptors will be identified as part of the baseline survey. An assessment of the potential impact will be made in accordance with the Terms of Reference. The potential impacts of the Scheme on these sensitive receptors are likely to include:

During construction	○ loss of artefacts through removal of sediment during works; ○ loss of or damage to artefacts during operation
During operation	○ covering of artefacts due to alterations to currents and sediment movement around the structures; ○ disturbance to artefacts from increased activity.

PREDICTION OF IMPACTS

32. Each of the potential impacts listed above will be examined. The marine archaeology baseline survey information will be entered into a Geographical Information System (GIS). This system will enable the following analysis to be undertaken:

- Map cultural heritage or archaeological features within the Area of Influence;
- Map identified targets within the Area of Influence; and
- Indicate proximity of these features to any structures likely to be a source of disturbance.

IMPACT SIGNIFICANCE

33. This section will include, for each potential impact, the following information:

- Description of impact;
- Policy importance of impact (Local, National, International);
- Extent of effect (Parts of site, whole site, site plus adjacent areas, site plus wide area);
- Duration of impact (temporary/permanent);
- Adverse or beneficial impact;
- Reversible/irreversible impact;
- Sensitivity of receptor (Protected species, rare/endemic species, conservation importance etc);
- Probability of impact occurring (certain, likely, uncertain, unlikely, remote); and
- Scope for mitigation/enhancement (very good, good, none).

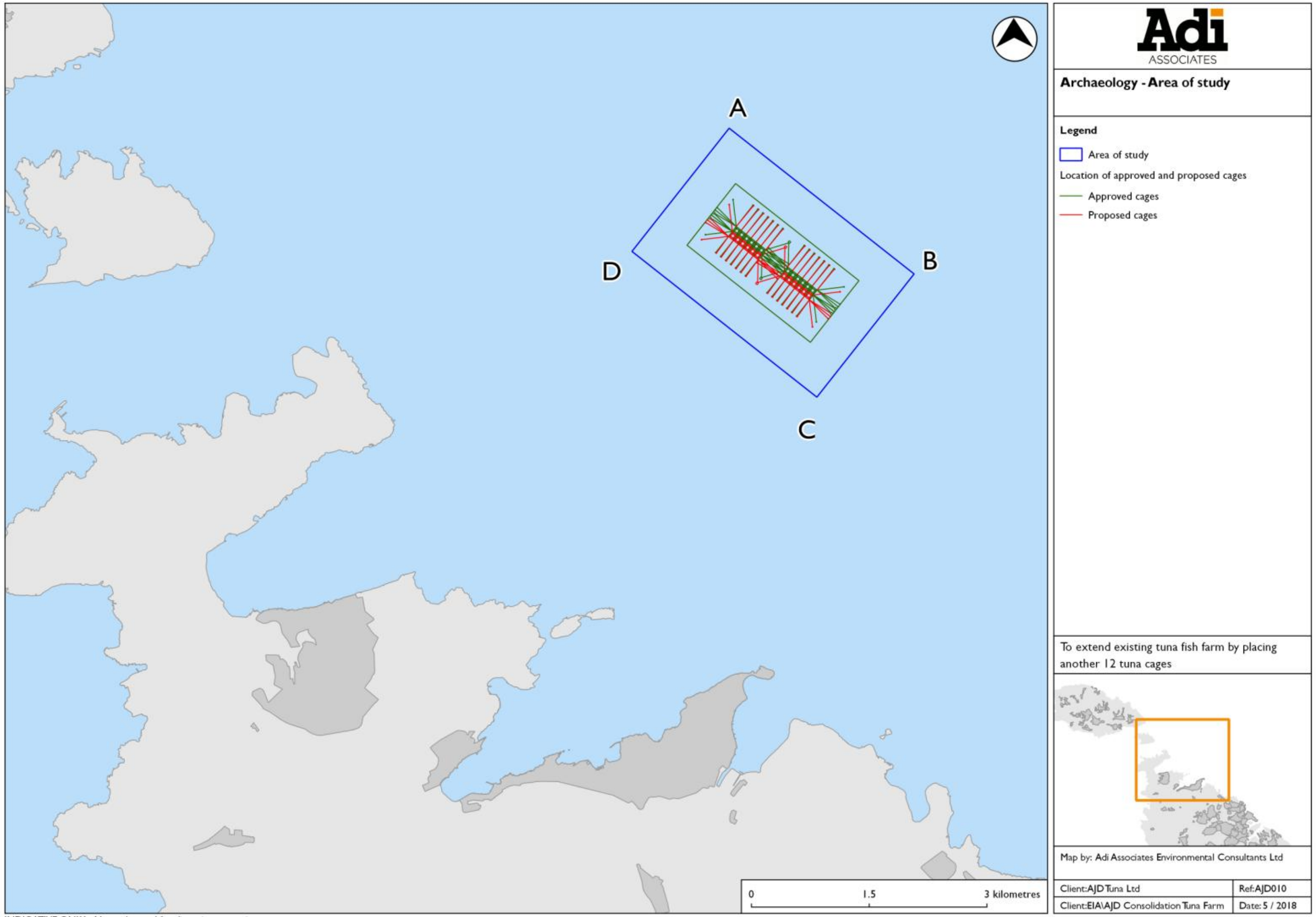
34. Based on the above criteria, a summary of the significance of the impact will be judged in terms of whether the impact is considered not significant, of minor significance, or of major significance.

MITIGATION

35. The GIS will be used to map any archaeological artefacts or deposits recorded in the area of study. The study will describe measures that can be put in place to prevent, minimise and, where possible, offset any significant adverse effects resulting from the Project.

Adi Associates Environmental Consultants Ltd
April 2018

Figure 1: Area of Study



INDICATIVE ONLY - Not to be used for direct interpretation

PA 02175/18

Proposal to consolidate temporary tuna farming area at a parcel of sea approximately 5 kilometers from the shore (in general area approved for PA/03072/17 and PA/05858/17) for a total biomass of 3,300 tonnes of fish

Technical Appendix 2A

SIDE SCAN SONAR SURVEY REPORT 2017

Prepared by Geomara Ltd (Ireland)

Supporting Documents for

Environmental Impact Assessment Report

FIELD REPORT

Side Scan Sonar Survey

Offshore Is-Sikka il-Bajda, Malta

On Behalf of

Geomara Job Number: G16032

Author: Eoghan Kieran

Reviewed By: Finn Delaney

Date: 01 August 2017

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1 Introduction

1.1 Background

Geomara were commissioned by Adi Associates Environmental Consultants Ltd to undertake a side scan sonar survey of a proposed fish farm relocation in an area offshore is-Sikka il-Bajda, Malta.

1.2 Survey Location

The survey area comprised two adjoining survey blocks which extended from the southern and eastern sides of an existing tuna farm (recently relocated from the South Comino Channel). Survey Area 1 was partially located in the northeastern corner of is-Sikka il-Bajda bunkering area. The second survey area was entirely located in the Sikka il-Bajda bunkering area, immediately to the west of Area 1. Water depths in the area are charted as between 42 m and 53 m (Figure 1). Co-ordinates for the two survey areas are given in Tables 1 and 2.

Easting	Northing
449079.8	3985191
448630.8	3983957
449172.6	3983551
450235.8	3984823

Table 1. WGS84 UTM 33N co-ordinates for Area 1

The perimeter of Area 1 measured 4861.7m and it encompassed an area of 1,356,618.2 m^2

Northing	Easting
47262.11	3985016
447194.6	3984894
448637.6	3983932
448808	3984450

Table 2. WGS84 UTM 33N co-ordinates for Area 2

The perimeter of Area 2 measured 4064.7m and it encompassed an area of 568,811.8 m^2

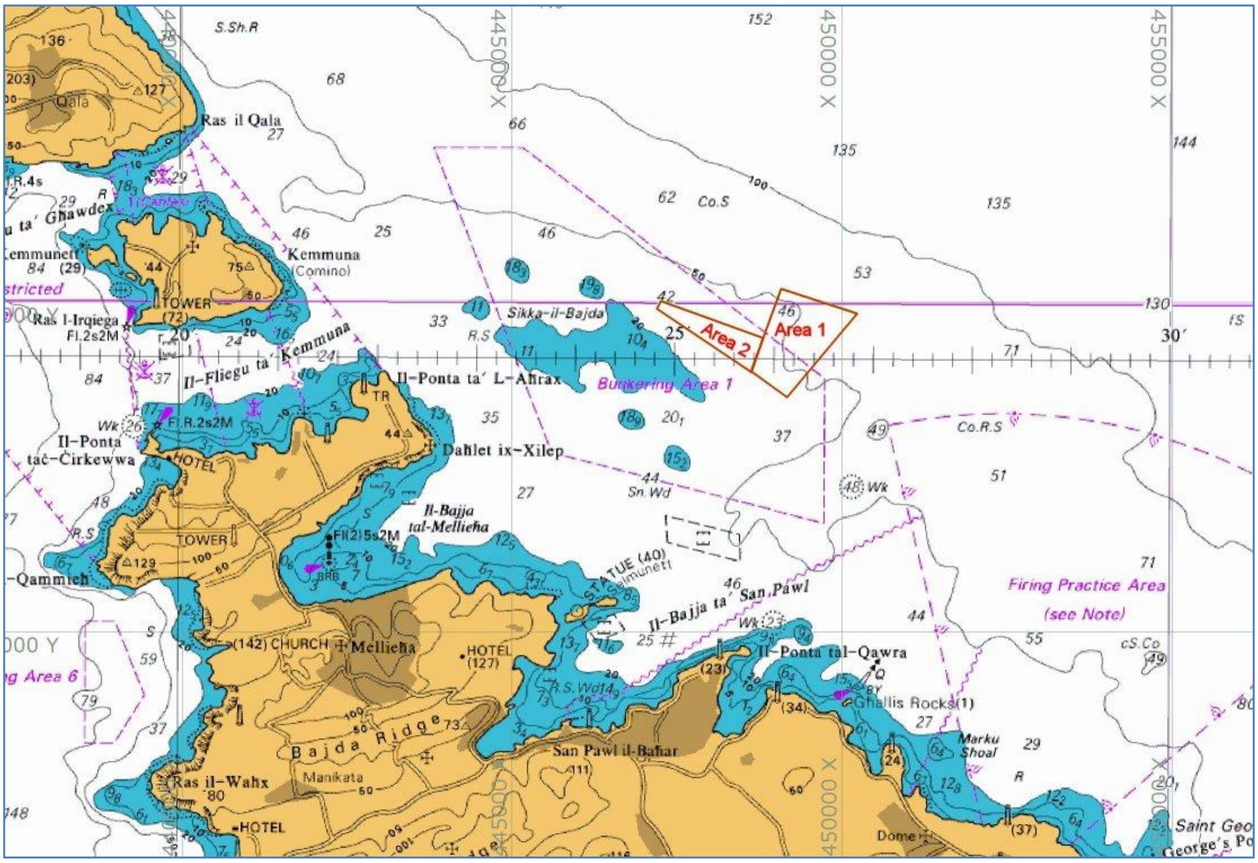

Figure 1. Survey Area Location

1.3 Ground Conditions

As previously detailed, the survey areas were situated around the southern and eastern perimeters of the existing Tuna farm. Although there was a working fish farm immediately adjacent, the survey areas (Figure 1) were generally free from obstacles such as vessel traffic and fishing gear.

2 Survey Design

The survey design ensured that all of the survey area that could be accessed was ensonified to a high standard. In Area 1, all survey lines were orientated in a North – South orientation whilst in Area 2 they were orientated East – West. These line orientation plans were required to ensure that the survey vessel and equipment did not encounter any of the existing fish farm equipment such as net anchors and moorings. Lines were planned and run in order to obtain 10% – 20% overlap (Figure 2).

The Project geodetic parameters were WGS84 UTM 33N.

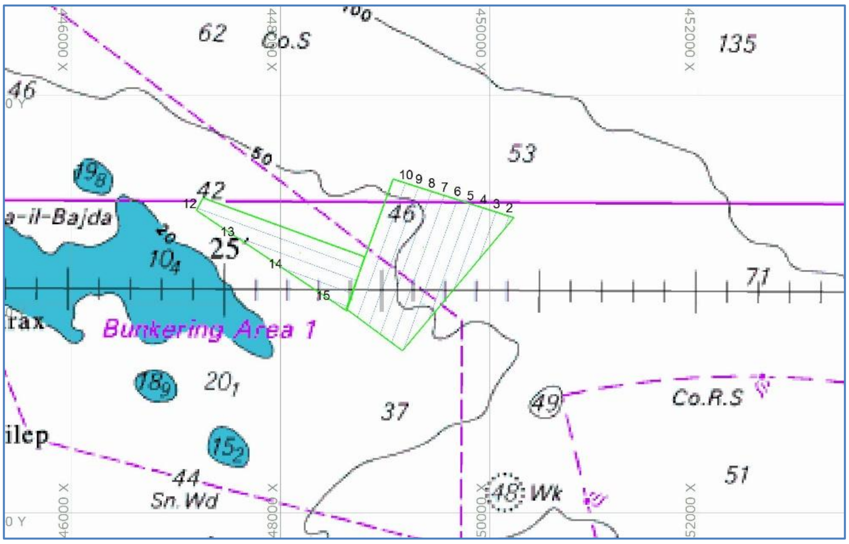

Figure 2. Planned Survey Lines

3 Field Survey

3.1 General

The side scan sonar survey was undertaken on Thursday 3rd August 2017. Weather conditions during the survey were moderate with light winds and a negligible swell was encountered. A total of 17 survey lines were recorded which amounted to 19.533 linear km of side scan sonar data.

Depths encountered in the survey area ranged from 42 to 55 m. In general the prepared line plans were adhered to, but in areas where a large depth variation was encountered, a variation to the line spacing was required in order to obtain a 10% - 15% overlap. 100% ensonification was achieved in all surveyed areas.

3.2 Survey Vessel

The survey vessel was the working vessel Awrata (Figure 3). The layout of the vessel provided ample deck space for operations and a dry cabin to house all sensitive electronic equipment being used. The vessel was fully licensed and insured, had all necessary safety and navigational equipment.

The side scan sonar system was deployed from the stern of the vessel. The sonar winch was situated at the centre of the back deck. A tow cable pulley sheave was mounted on an elevated hiab arm at the stern of the vessel. This sheave ensured that the tow cable was sufficiently elevated so that it did not catch on the vessel stern. The vessel was skippered by a local. His experience and advice was taken into account at all times during the survey.

Figure 3. Survey Vessel

3.3 Positioning and Heading

Vessel and equipment positioning was provide by a Trimble SPS 461 GPS Heading and positioning antennas (Figure 4). The Trimble SPS 461 is a dual frequency receiver which provides DGPS accuracy position from SBAS, OmniSTAR VBS, and or an external RTCM DGPS correction. The SPS461 computes the precise vector between the two antennas to provide a highly accurate heading and positioning values. The positional antenna was placed at a height with clear views of the sky, directly over the sonar transducer. The vertical offset height from the positional antenna to the transducer was measured and inputted in the acquisition software.

A second antenna, the heading reference antenna, was placed 2.1 m from the positional antenna. This separation was required to ensure accurate heading referencing throughout the survey. The mounting of the GPS antenna and offset calculations ensured the most accurate heading and position.

Figure 4. Trimble SPS461 Heading and Position GPS system

3.4 Vessel Navigation

Vessel navigation was provided by the Trimble SPS461 receivers through the Hypack 2017 software. A helmsman's display monitor provided the vessel skipper with navigation and a coverage map. This allowed for the vessel to stay on course throughout the duration of the survey and provided the required accuracy of coverage.

3.5 Side Scan Sonar

The side scan sonar system used for the survey was the Edgetech 4125 (Figure 5). EdgeTech's 4125 Side Scan Sonar System was designed with both the Search & Recovery (SAR) and shallow water survey communities in mind. The 4125 utilizes EdgeTech's Full Spectrum CHIRP technology, which provides higher resolution imagery at ranges up to 50% greater than non CHIRP systems operating at the same frequency.

This translates into more accurate results and faster surveys, thus cutting down on costs. Dual simultaneous frequency sets of 400/900 kHz are the transducer sets used in our system. This is the perfect tool for shallow water survey applications, providing an ideal combination of range and resolution.

Figure 5. Edgetech 4125 Side scan sonar

The 4125 system can be powered by both AC and DC for added versatility and is delivered in portable rugged cases for ease of transport from site-to-site. As is standard with all of EdgeTech's towed side scan systems, the 4125 comes with a safety recovery system which will prevent the loss of a towfish if it becomes snagged on an obstacle during a survey.

A standard 4125 System comes with a choice of towfish and a portable water resistant topside processor with a splash-proof, drop & shock resistant laptop computer including EdgeTech's easy-to-use Discover acquisition software.

3.6 Sonar Winch

To ensure that the side scan sonar reached appropriate depths to enable proper ensonification of the seafloor, a sonar winch was required. Geomara used their DT Marine 1020 Electro Hydraulic sonar winch (Figure 6). The winch was situated in the central stern section of the survey vessel. Offset measurements were then taken from the winch location to the GPS, thereby enabling offset measurements to be imputed into the survey software.

Figure 6. DT Marine, 1020 Electro-hydraulic sonar winch

3.7 Data Acquisition and Processing

Edgetech's Discover proprietary software was used to set the survey parameters and record the resultant data. All side scan sonar data was recorded using Edgetech's .jsf proprietary format and standard industry XTF format. Simultaneous dual frequency of 445 and 900 kHz were recorded during the survey. The gains and frequency were not subjected to any change during the survey.

Subsea positioning was also provided by catenary calculations in the Discover software. The Remontec T- Count sheave counter system recorded that amount of tow cable paid out by the sonar winch. This data was then transmitted to the Discover software where it was used in conjunction with the recorded height of the side scan towfish above the seafloor to calculate the position. Secondary positional checks were later undertaken to ensure correct subsea positioning.

All side scan sonar data was processed using Chesapeake Technology, Sonarwiz 7 software. Geomara have a defined side scan sonar process which has been developed in conjunction with the Sonarwiz 7 software manufacturer. This process ensures that all data is processed to the highest quality and that the maximum data is recovered from each sonar trace. Details of this staged process are explained in Figure 7 below.

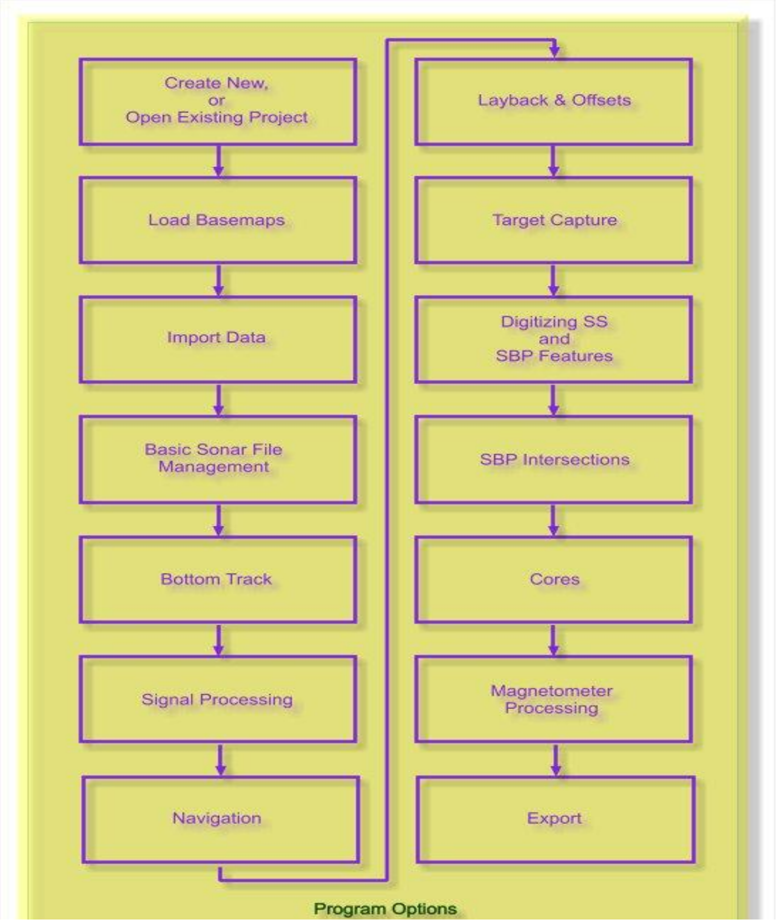

Figure 7. Side scan sonar data processing flowchart

4 Results

The side scan sonar survey was undertaken on Thursday 3rd August 2017. A total of 17 survey lines were recorded which amounted to 19.533 linear km of side scan sonar data (Figure 8. The data indicated that the seabed in the subject site comprised mainly of flat homogenous rippled sand (Figure 9). Two disparate areas of change were noted on the sonar data (Figure 10). These were; the southeastern corner of Area 1 and the southern and western ends of Area 2.

The seafloor in the southeastern corner of Area 1 appeared to comprise of the same shallow rippled sand as the adjoining area but this was interspersed with areas of less dense acoustic reflection (Figure 11). It was not possible to discern the exact composition of the varying seafloor material from the sonar data. However it was considered that these areas of less dense reflection could represent the terminus of the nearby maerl beds or a low reflectivity silty seabed substrate.

The seafloor variation noted in the southern and western ends of Area 2 appeared to comprise reef outcrop (Figure 12). This outcrop feature was clearly discernible and it had visible rippled sand pockets interspersed.

The side scan sonar survey did not record the presence of any potential cultural heritage.

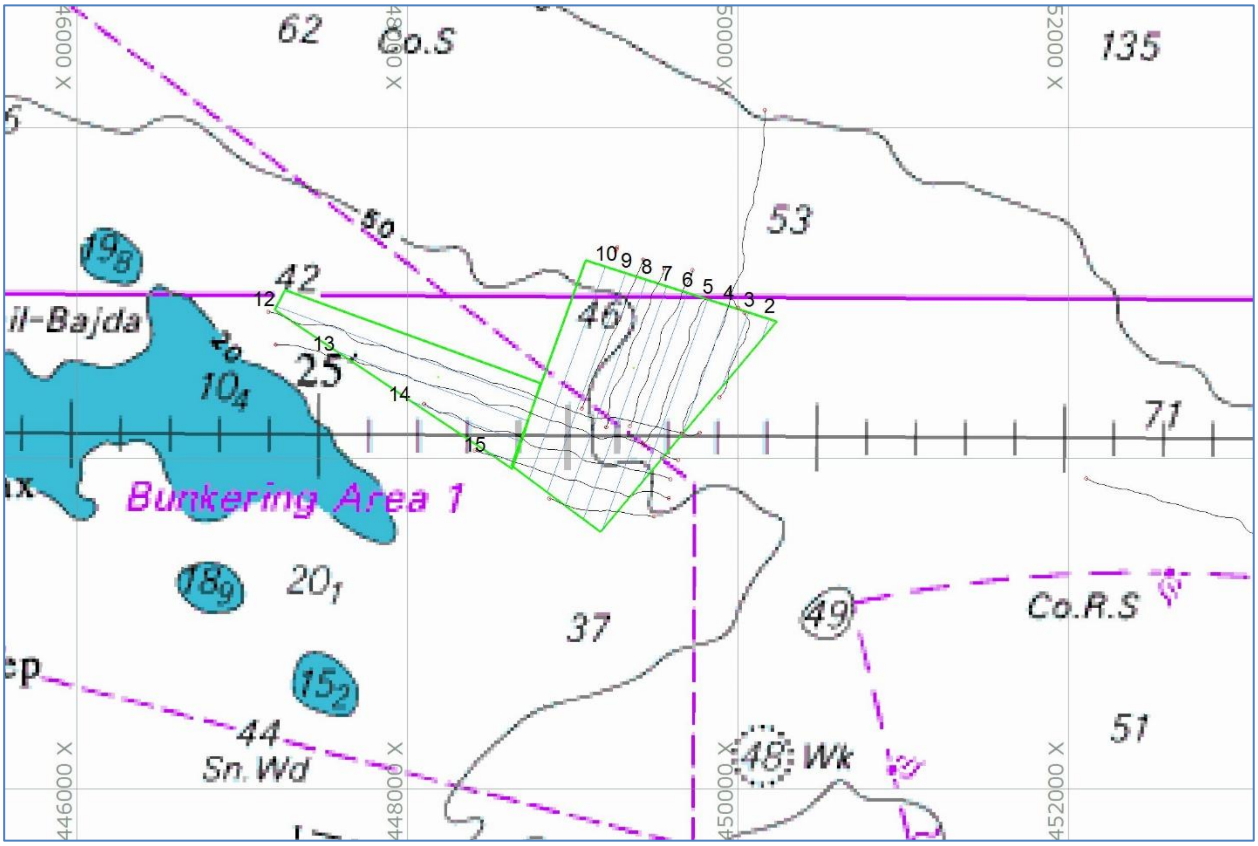

Figure 8. Survey track line

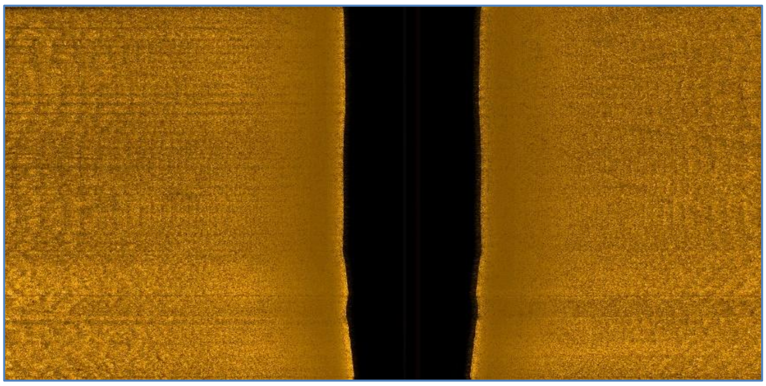

Figure 9. Typical sonar data from main rippled sand area

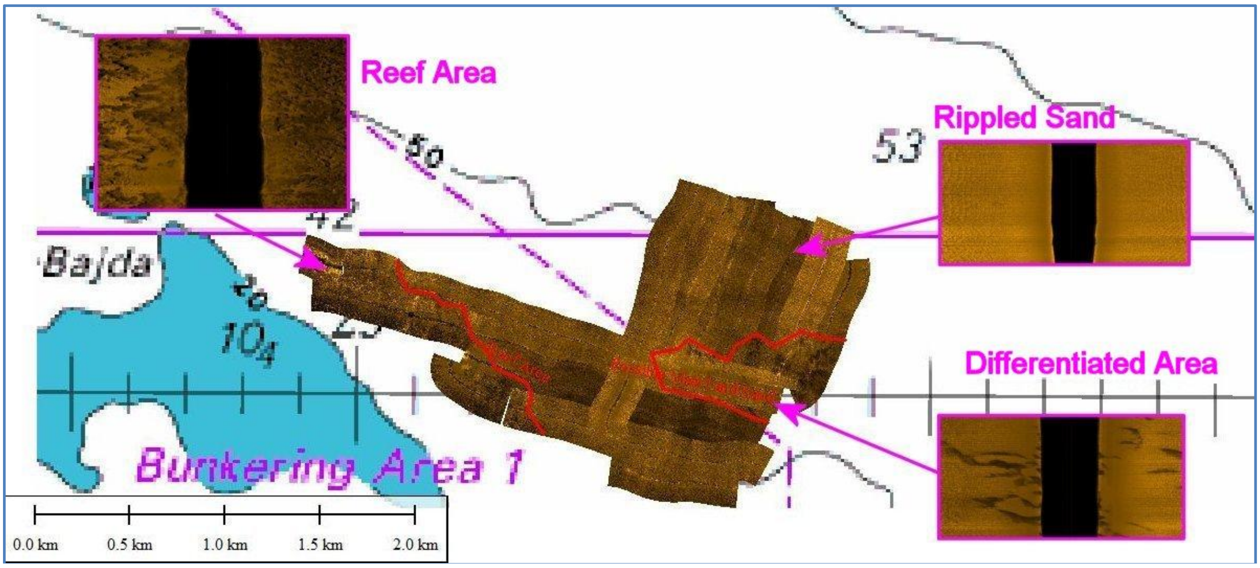

Figure 10. Mosaic of SSS data

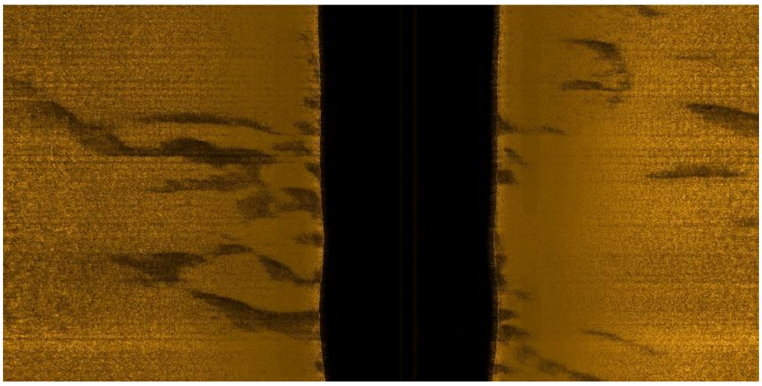

Figure 11. Sonar data from Area 1, differentiated area

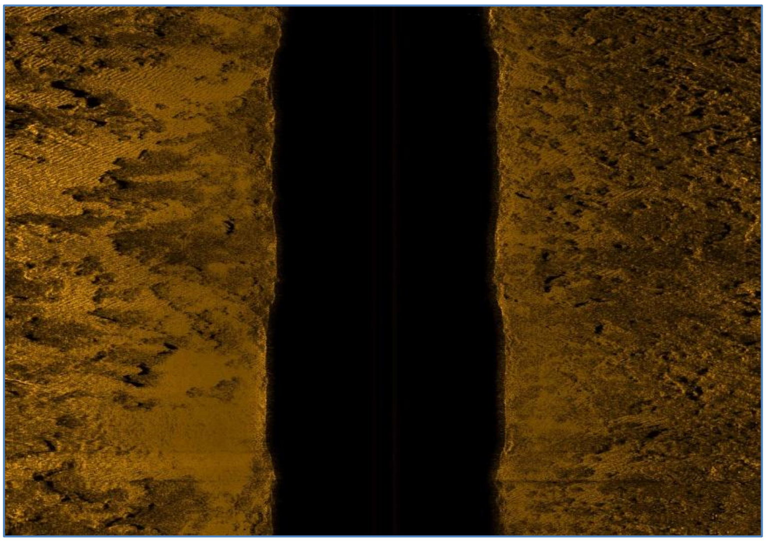

Figure 12. Sonar data in reef area

PA 02175/18

Proposal to consolidate temporary tuna farming area at a parcel of sea approximately 5 kilometers from the shore (in general area approved for PA/03072/17 and PA/05858/17) for a total biomass of 3,300 tonnes of fish

Technical Appendix 2B

REMOTE SENSING SURVEY REPORT 2018

Prepared by Seastar Surveys Ltd (UK)

Supporting Documents for

Environmental Impact Assessment Report

ADI Associates – Environmental Consultants Ltd

Malta Environmental Baseline: Acoustic and Camera Surveys April / May 2018

Survey Report

19th June 2018

Seastar Survey Ltd. Project Number – J/18/516

For further information please contact Steven Dewey
Seastar Survey Ltd., Ocean Quay, Belvidere Road, Southampton, SO14 5QY
Email: sdewey@seastarsurvey.co.uk

Please cite this report as:

MacMillan, A., O'Dell, J., and Dewey, S. (2018). Malta Environmental Baseline: Acoustic and Camera Surveys. A report to ADI Associates by Seastar Survey Ltd., 15 pages.

Signed Declaration

Attn: Director of Environment and Resources
Environment and Resources Authority
Malta

I, Steven Dewey, who carried out the remote sensing surveys (or part thereof) for the marine environment study for the EIA for the proposed extension to an existing tuna farm operation off the Northeast coast of Malta, hereby declare that such study was solely carried out by me on behalf of Seastar Surveys Ltd and the company takes responsibility for any statement and conclusion contained therein.

19 June 2018
Date

Signature

Signed Declaration

Attn: Director of Environment and Resources
Environment and Resources Authority
Malta

I, Abigail MacMillan, who carried out the remote sensing surveys (or part thereof) for the marine environment study for the EIA for the proposed extension to an existing tuna farm operation off the Northeast coast of Malta, hereby declare that such study was solely carried out by me on behalf of Seastar Surveys Ltd and the company takes responsibility for any statement and conclusion contained therein.

19 June 2018

Date

Signature

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1 INTRODUCTION

Seastar Survey Ltd ('Seastar') were contracted by Adi Associates – Environmental Consultants Ltd ('ADI') to undertake hydrographic and environmental survey work in an area of seabed located approximately 5 km off St Pauls Bay, on the northeast coast of Malta.

The objectives of the surveys were to collect bathymetric data to inform a numerical model and to collect sidescan sonar data to identify seabed features and sediment types, which would be ground-truthed during a subsequent environmental survey using a drop-down camera system.

For the bathymetric survey work two areas were to be surveyed; an offshore area (area 1) indicated by the red box in Figure 1.1, and an area close to an existing fish farm (area 2), which is indicated by a green box in Figure 1.1.

Existing sidescan sonar data was available courtesy of Professor T. Gambin from the University of Malta for the majority of area 1, and therefore, during this survey, data was only collected to infill 2 gaps in the existing coverage for area 1, and to collect data from area 2.

The survey area for the drop-down camera work was slightly different, with the offshore area (area 1) being larger and covering both the red and some of the blue box shown in Figure 1.1, as well as all of area 2.

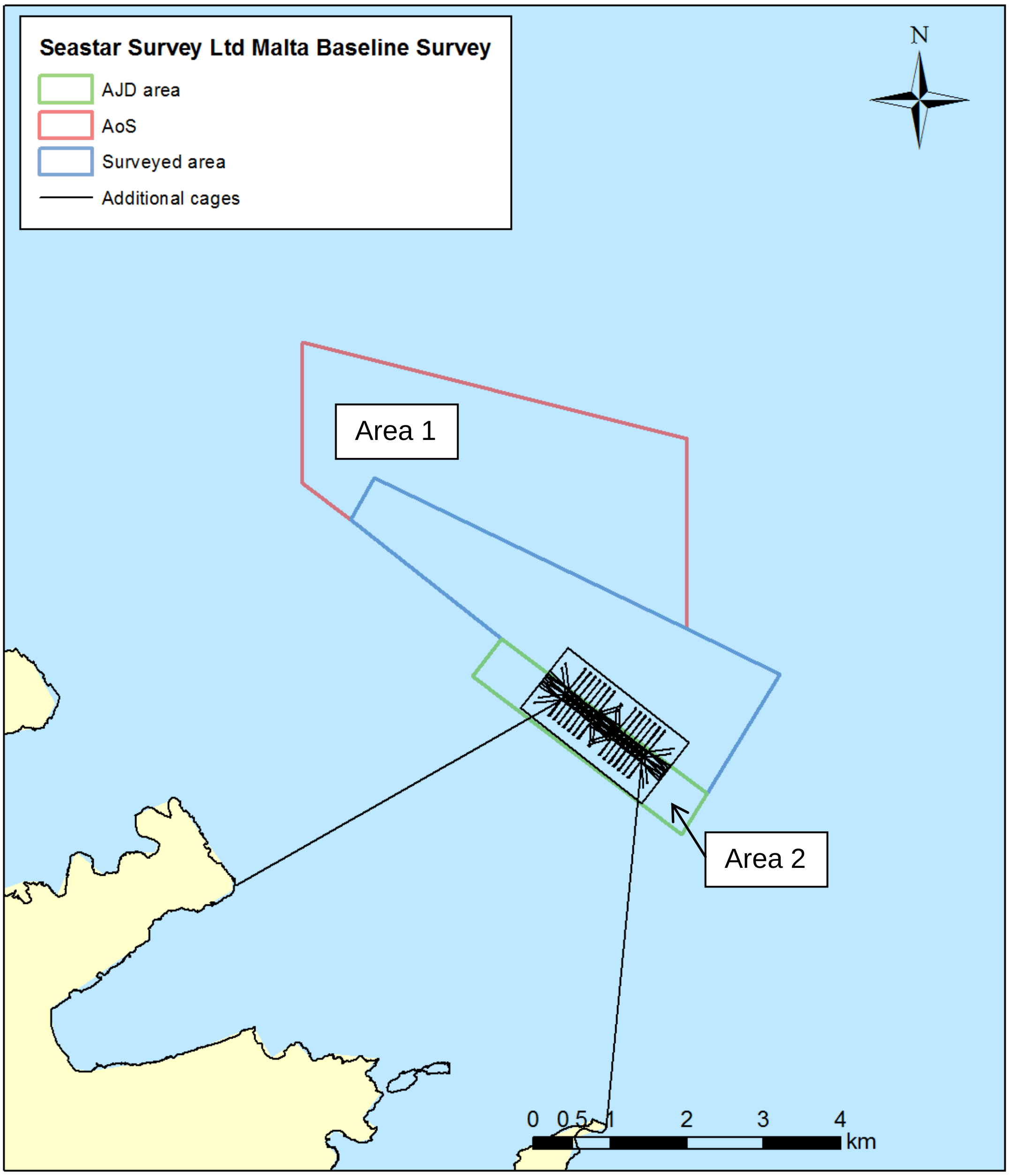


Figure 1.1: Areas surveyed by Seastar as part of the 2018 baseline survey: Area 1 - offshore area (red box) and Area 2 – area inshore of existing fish farm (green box). The area in blue was surveyed previously. Existing fish farm indicated in black box.

2 ACOUSTIC SURVEY

2.1 Mobilisation

Seastar transported all equipment and personnel from Southampton to Malta by road between Thursday 19th and Monday 23rd April 2018. All survey operations were conducted from MV *Awrata*, a 14 m, steel workboat owned and operated by Azzopardi Fisheries. Throughout the project the vessel worked out of Fekruna Quay, Xemxija.

The acoustic survey equipment was mobilised and tested on MV *Awrata* on Monday 23rd April 2018.

2.2 Survey Equipment

The following equipment was used during the acoustic surveys;

- Hemisphere GNSS V320 GPS and vector compass
- Marimatech E-Sea Sound 206 single-beam echosounder (33 & 200 kHz)
- TSS motion reference unit (MRU)
- Valeport 606 CTD
- Edgetech 4125 dual frequency sidescan sonar (400 and 700 kHz)
- Cable counter and block
- DT Marine Products Inc. hydro-electric winch
- Co-axial armoured cable
- Helmsman display
- Hypack survey management software
- Edgetech Discover software

2.3 Survey Plan

Prior to the fieldwork, line plans were created in the two survey areas shown in Figure 1.1 using the survey management software Hypack.

2.3.1 Bathymetric Survey

For the bathymetric survey of area 1, 62 main survey lines were planned at 100 m line spacing, in a NE-SW direction. These were intersected by 13 perpendicular cross-lines; 8 were at a line spacing of 300 m and 5 lines were run at 150 m line spacing within the south-west corner of the survey area. The 150 m cross-line spacing was used in order to obtain higher resolution data of a sub-sea channel identified from sidescan sonar data collected previously by Professor Gambin from the University of Malta.

For area 2, 34 main lines were planned at 100 m line spacing in a NE-SW direction. These were intersected by 10 perpendicular cross-lines at 75 m line spacing. The bathymetry line plans for both survey areas are shown in Figure 2.1.

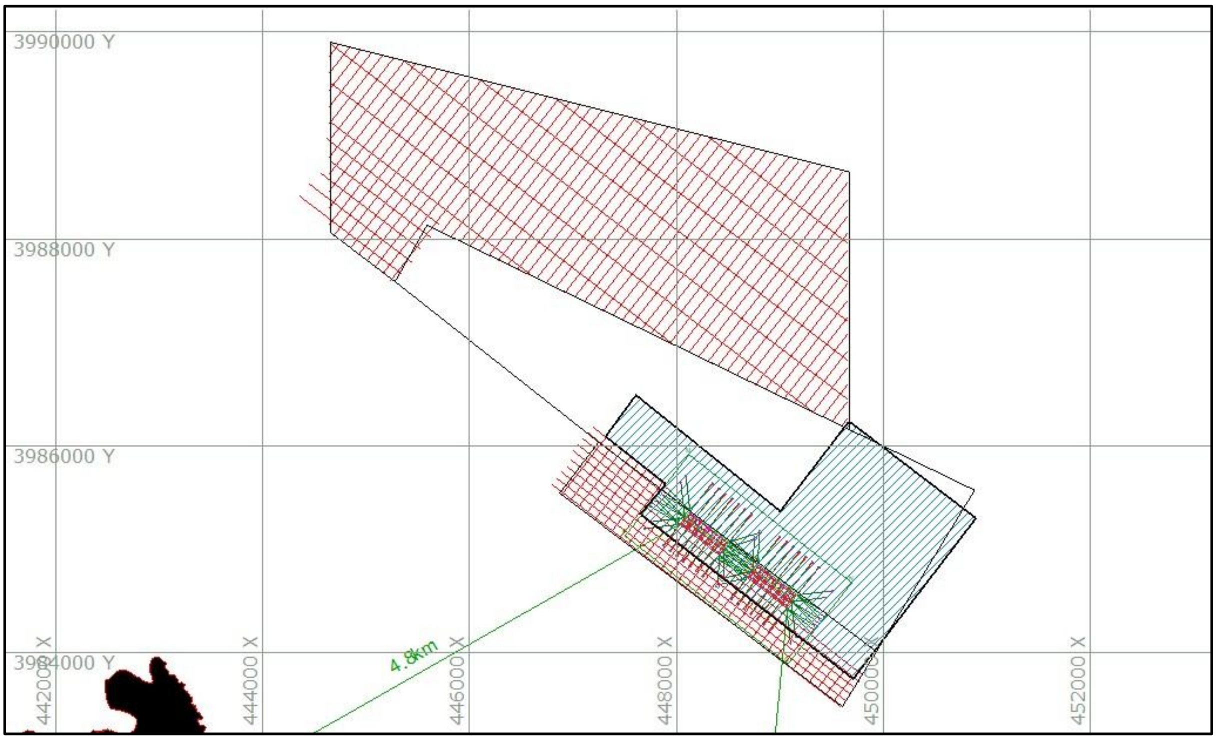


Figure 2.1: Proposed bathymetry line plans for the two survey areas. Fish farm indicated in green and red. Blue hashed area and white area surveyed previously.

2.3.2 Sidescan Sonar Survey

As sidescan sonar data had already been collected for the majority of area 1, and only two lines were required as infill, no line plan was created during the initial planning stage.

For area 2, the sidescan sonar survey was restricted by the anchors and ropes that hold the current fish farm cages in place. As a result, only 2 of the bathymetry survey lines on the south west of the area were run using the sidescan sonar.

2.4 Deployment

The echosounder transducer was pole mounted and secured to the port side of MV *Awrata*. To create a rigid fixing point two horizontal scaffold poles where welded to the boat and the transducer pole was attached to these using scaffold clamps. In addition, fore and aft guy ropes were used to secure the transducer head to the boat to prevent any vibration.

The transducer was positioned 0.5 m below the water line this point then acted as the 0,0-reference point from which all offsets were measured.

The Hemisphere GPS was mounted on the roof of the wheel house, inboard and forward of the echosounder transducer. The GPS offsets were entered into Hypack so that recorded positions were for the location of the echosounder transducer.

The winch and block for the sidescan sonar were aft of the echosounder transducer and the block was suspended from the vessel's crane; once the offsets to the block were measured and entered into Hypack, the crane remained in the same position throughout the duration of the sidescan sonar survey.

A helmsman's display feed from Hypack, showing the survey lines and vessel position, was set up to assist the vessel skipper in driving the survey lines.

During the bathymetry survey the vessel skipper set up on the bearing of the chosen line and vessel speed was reduced to 4.5 knots. The echosounder was used in dual frequency mode and recorded soundings at both 33 and 200 Hz. This ensured best quality data was achieved when moving between shallow and deep water in area 1.

For the sidescan survey the vessel set up on the bearing of the chosen line approximately 500 m before the start of line and speed was reduced to approximately 3 knots. The Edgetech 4125 was deployed from the stern of the vessel and winch wire was paid out until the fish altitude (height above seabed) was approximately 10 m.

2.5 Horizontal control

Survey navigation was achieved through the use of a Hemisphere GNSS V320 GPS and vector compass, which has a positional accuracy of ± 0.3 m.

Raw data from the GPS was input into Hypack and positions were recorded in WGS84 latitude and longitude and converted to UTM grid (UTM North, zone 33 (12 - 18° E)).

For the sidescan sonar the amount of winch wire payed-out was recorded using a cable counter block. The amount of cable out was then entered into Hypack, which used a catenary factor, along with the vessel speed, heading, fish altitude, water depth and the measured offset for the block, to calculate a layback position of the tow-fish relative to the echosounder transducer. The layback was checked by comparing the position of an obvious target within the survey area and adjustment made to the catenary factor.

Navigation checks were performed daily throughout the acoustic surveys against a known location alongside the quay in Xemxija (Figure 2.2).

2.6 Vertical control

2.6.1 Tides

Raw soundings were reduced to local chart datum using tide corrections applied during post-processing. Tidal data from a gauge in the Port of Marsaxlokk were downloaded from https://malta.port-log.net/live/Display.php at the end of the survey period. Tide times were converted from local time to GMT and tidal curves were created, which were then imported into Hypack.

2.6.2 Speed of Sound Profiles

A Valeport 606 CTD was used to measure the speed of sound through the water column at various locations within both area 1 and area 2. The raw bathymetric data was recorded with a default setting of 1500 m/s and corrections for speed of sound were applied to the raw data during post-processing.

2.6.3 Vessel Motion Reference

The heave, pitch, and roll of the vessel were measured using a TSS motion reference unit (MRU) and these data were input directly into the Marimatech echosounder. The raw data was then corrected in real time for vessel motion within the echosounder and the corrected depth, along with the raw data from the MRU, were recorded within Hypack.

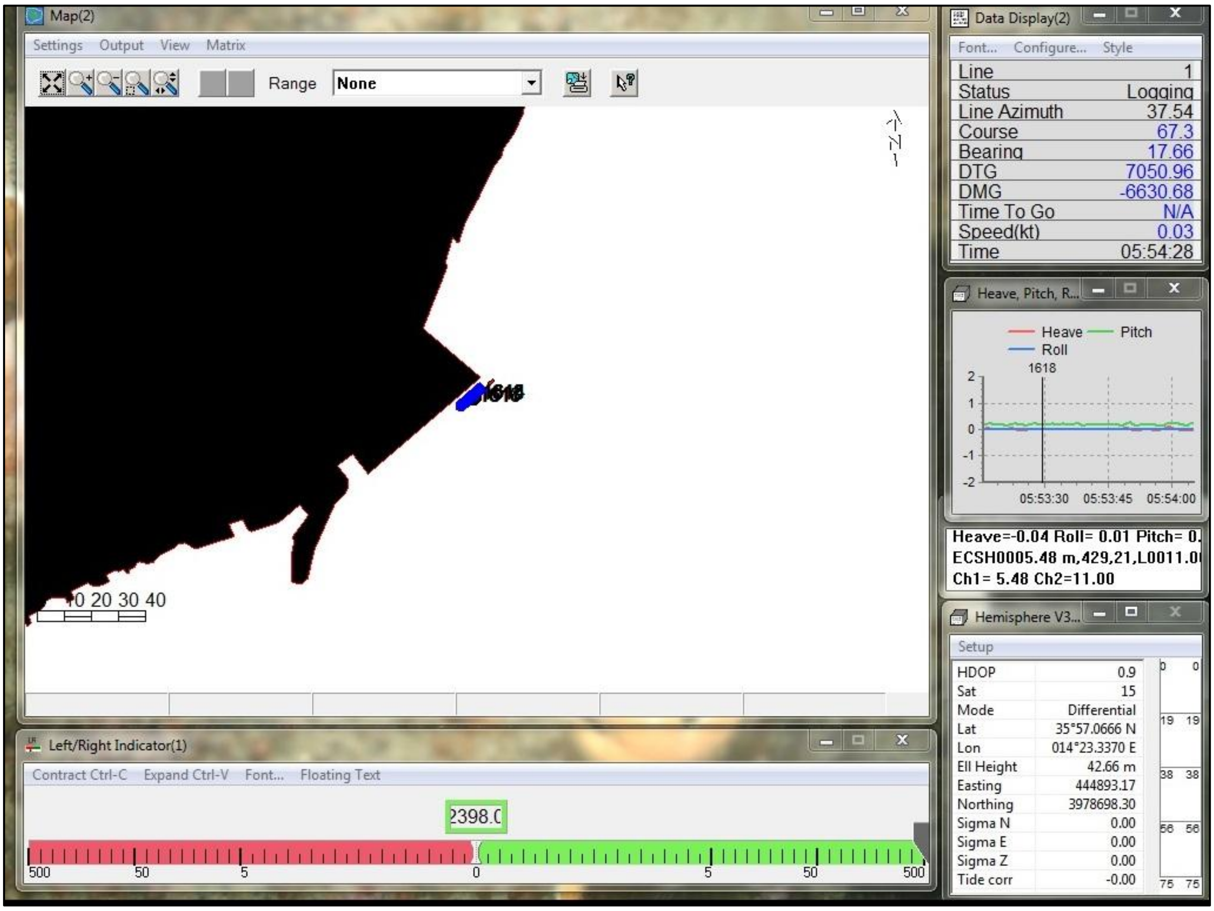


Figure 2.2: Navigation check being performed alongside Fekruna Quay

2.7 Processing

2.7.1 Bathymetric Survey

The raw bathymetry data were processed in Hypack using the Single Beam Editor tool. All spikes, multiple returns, and other erroneous data were removed before applying draught, sound velocity, and tidal corrections. Edit soundings, relative to local chart datum, were then saved before being sorted to a 2 m grid.

Data quality control checks were made against the paper trace, and by comparing edited depths at all of the main survey lines and cross lines "crossover points". In total there were 339 intersections checked with a mean difference between main lines and cross lines of 0.13 m.

2.7.2 Sidescan Sonar Survey

The raw sidescan data were recorded in the Discover software and saved as .jsf files. These were converted into a Hypack compatible format (.hsx files) and processed in Hypack.

The recorded layback was checked by identifying targets on adjacent lines and cross checking their position.

2.8 Survey Success and Weather

Table 2.1 provides a summary of the survey success and weather for the acoustic surveys.

Table 2.1: Daily progress during the acoustic surveys

Date	Survey Type	Survey Success
24/04/2018	Bathymetry	21 lines
25/04/2018	Bathymetry	28 lines
26/04/2018	Bathymetry	27 lines
27/04/2018		WEATHER DAY
28/04/2018		WEATHER DAY
29/04/2018		WEATHER DAY
30/04/2018	Bathymetry	27 lines
01/05/2018	Sidescan sonar	TECHNICAL DAY
02/05/2018		WEATHER DAY
03/05/2018		WEATHER DAY
04/05/2018	Sidescan sonar	WEATHER DAY
05/05/2018		STAND-DOWN DAY
06/05/2018	Sidescan sonar	3 lines

2.8.1 Bathymetric Survey

The bathymetry survey was carried out on the 24th, 25th, 26th, and 30th April 2018. Strong winds and unfavourable sea conditions at the survey site prevented working between Friday 27th and Sunday 29th of April 2018.

In total, across the two sites, 103 bathymetry lines were run, including lines that were re-run due to poor data quality. In area 1 a total of 74 lines of good quality data were achieved, with one less cross line surveyed than originally planned. Figure 2.3 shows the track plot for all achieved survey lines in area 1.

In area 2 a total of 23 lines of good quality data were achieved. The survey plan for this area had to be altered during the fieldwork due to the prevailing wind and sea conditions. This meant fewer NE-SW main lines were run, but additional cross lines were added. Figure 2.4 shows the track plot for the achieved bathymetric survey lines in area 2.

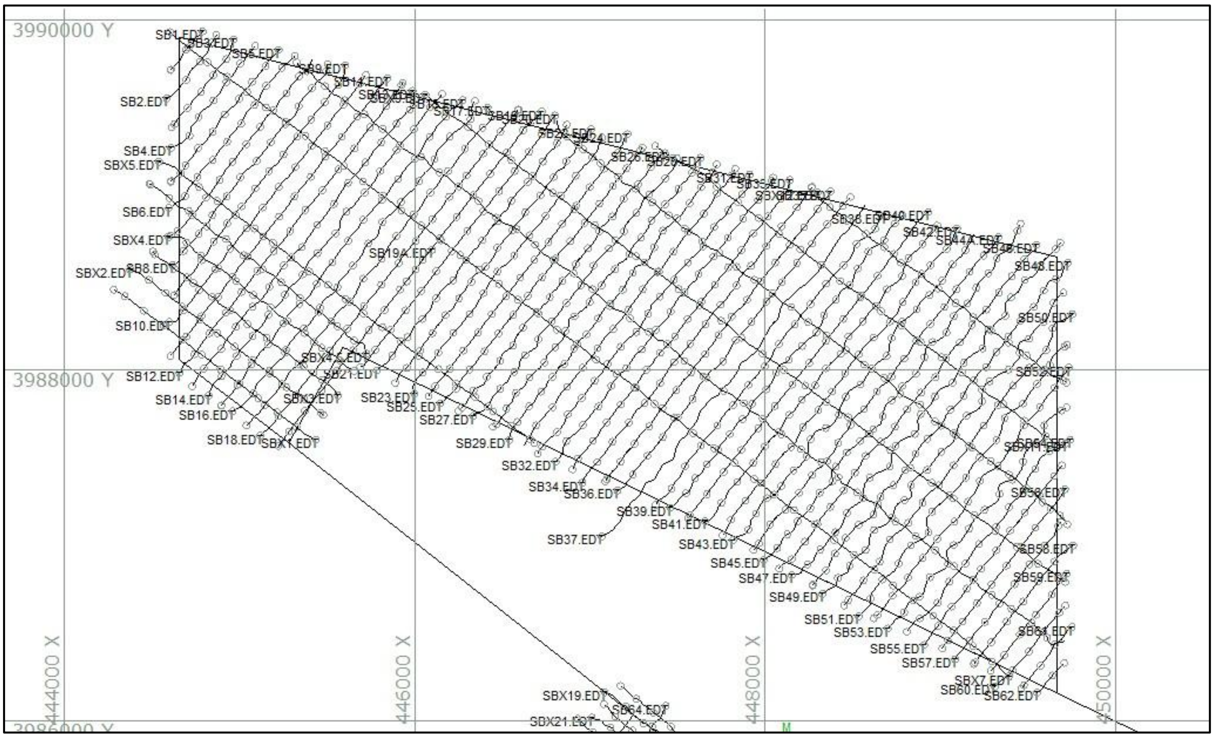


Figure 2.3: Bathymetric survey track plots for all successful survey lines in area 1

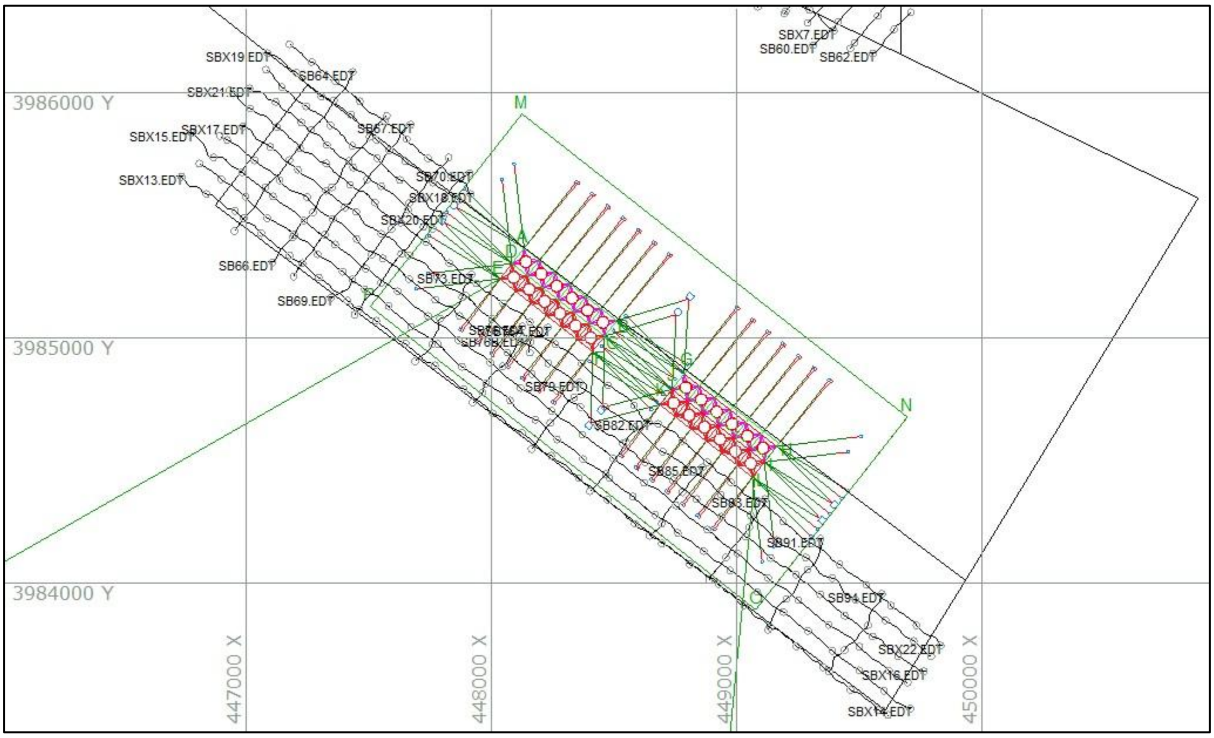


Figure 2.4: Bathymetric survey track plots for all successful survey lines in area 2

2.8.2 Sidescan Sonar Survey

The sidescan sonar survey was attempted on the 1st May 2018 but work was prevented by a power supply issue between the vessel's generator and the winch. Strong winds and rough seas then prevented survey working between Wednesday 2nd and Friday 4th May 2018; survey work was attempted on the 4th May 2018 but once on site the residual swell was too large to collect good data (2 – 3 m swell with intermittent wave heights of > 3 m). Sidescan sonar survey work was carried out on the 6th May 2018 (See Table 2.1).

During the sidescan sonar survey three lines were run in area 1 (two lines of infill, one of which was run in two directions to check layback) and two survey lines were run in area 2.

Due to the location of the anchors and anchor lines for the existing fish farm, only two sidescan sonar lines were run in area 2 (lines SBX13 and SBX14). It was deemed too dangerous to run the sidescan over these anchor lines due to the high risk of snagging the tow-fish.

3 CAMERA SURVEY

3.1 Mobilisation

Following the completion of the acoustic surveys, the sidescan sonar equipment was demobilised on Monday 7th May 2018 and the camera system was mobilised and tested.

3.2 Survey Equipment

- Kongsberg 14-208 camera and flash
- Four video LED lights
- Seastar Survey camera frame
- EdgeDVR Digital video recorder with overlay
- 300 m umbilical

3.3 Camera Survey Plan

The sidescan data collected by Seastar along with the data supplied by Professor Gambin were analysed in order to identify potential features of interest; in total 26 features of interest were identified. Target positions for these were plotted in Hypack (Figure 3.1).

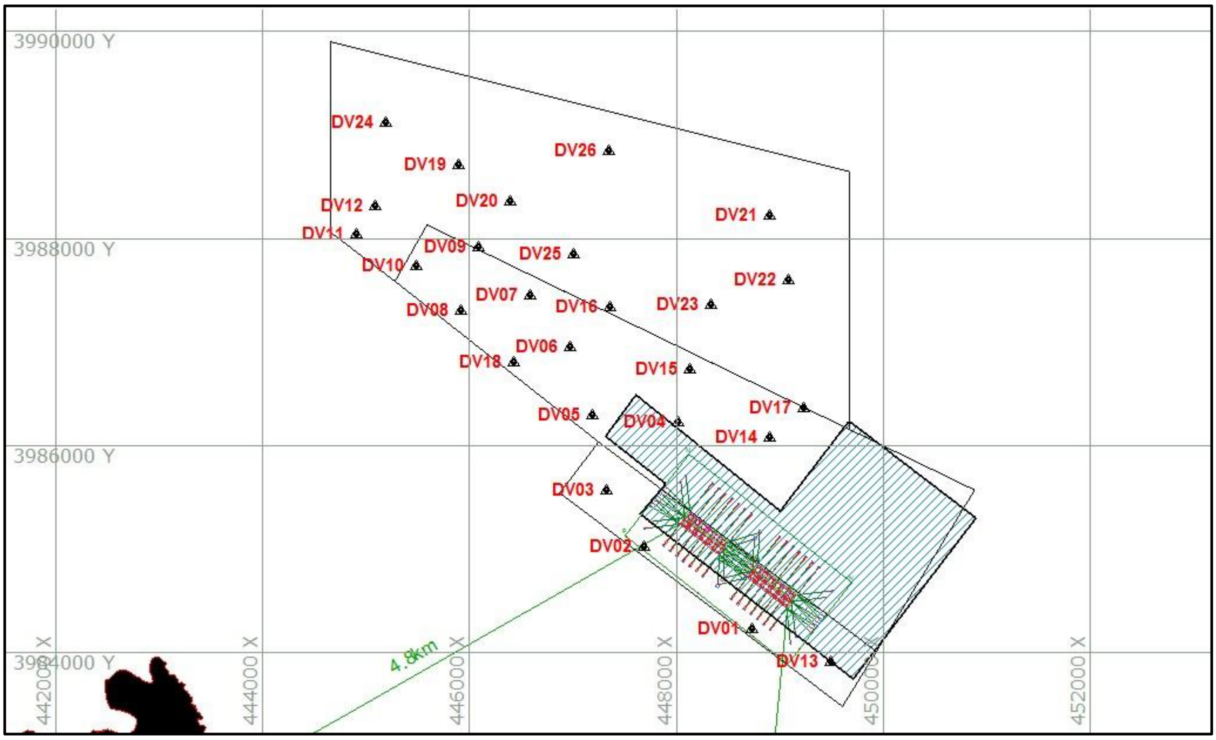


Figure 3.1: Targets of potential features of interest identified from the sidescan sonar data. The blue hashed area was surveyed during a previous drop-down camera survey.

3.3.1 Deployment

The camera and lights were set up on the camera frame so as to optimise field of view and video lighting. The field of view was measured using a calibrated field survey tape measure when the camera frame was on deck and this information assisted with the analysis of the video and stills data acquired.

At each site the vessel set up on the target location and was taken out of gear so as to determine the direction and speed of drift. Once the drift direction was determined the vessel moved ~ 300 m from the target location in the direction of drift, and turned so that the camera transect was driven into the current. Figure 3.2 shows the vessel track for each of the camera deployments.

At the start of line the vessel slowed to between 0.5 and 1.0 knot. The camera frame was deployed using the DT winch and the vessel's crane. The camera frame was attached to the winch wire used during the sidescan sonar survey. The vessel's crane was used to lift the camera frame off the deck and slew it outboard over the stern. Once the cable counter block was in position at the stern of the vessel the camera frame was lowered by paying out on the winch.

The camera umbilical was bulldog taped to the winch wire at regular intervals to prevent it streaming out in the water column, as this could affect how the camera frame flew through the water and result in poor quality data.

As with the sidescan sonar a layback position was calculated and recorded in Hypack, and an output of layback position and GPS time (GMT) was sent to the video overlay and recorded along with the video using the EdgeDVR software. At regular intervals (approximately every minute) the camera frame was landed on the seabed and a high resolution still image was taken of the seabed. These still images were saved on the camera and uploaded at the end of each survey day.

The position of the still images was recorded by noting the time of the photograph with the layback position from the navigation log for the same time.

3.3.2 Survey Success and Weather

The camera survey took place on the 8th, 10th, 15th and 16th of May 2018. The Seastar survey team stood down between the 11th and 14th May 2018 due to the poor weather forecast and restarted when the weather had improved, on the 15th May 2018. Table 3.1 provides a summary of the survey success and weather for the camera survey.

Table 3.1: Daily progress and weather during the camera survey

Date	Survey Success	Weather
07/05/2018	CAMERA MOBILISATION	
08/05/2018	10 Deployments 11 Lines	Light breeze (Force 2) from W, sea state calm
09/05/2018	WEATHER DAY	Sea state too rough to work; 1 - 2 m wave heights, long period swell
10/05/2018	3 Deployments	Survey day cut short as sea state worsened; 1 - 2 m wave heights, increasing white caps
11/05/2018	STANDBY PERIOD	*Poor weather forecast for these days so Seastar's survey team stood down*
12/05/2018		
13/05/2018		
14/05/2018		
15/05/2018	6 Deployments	Cool light breeze (Force 2 - 3) from NE, sea state smooth
16/05/2018	6 Deployments 8 Lines	Gentle breeze (Force 3) and moderate sea state in morning, improved throughout day

A total of 25 deployments were completed; all 26 targets were surveyed (at some locations two targets were surveyed during the same deployment) and an additional transect running along the length of the fish farm within area 2 was also undertaken.

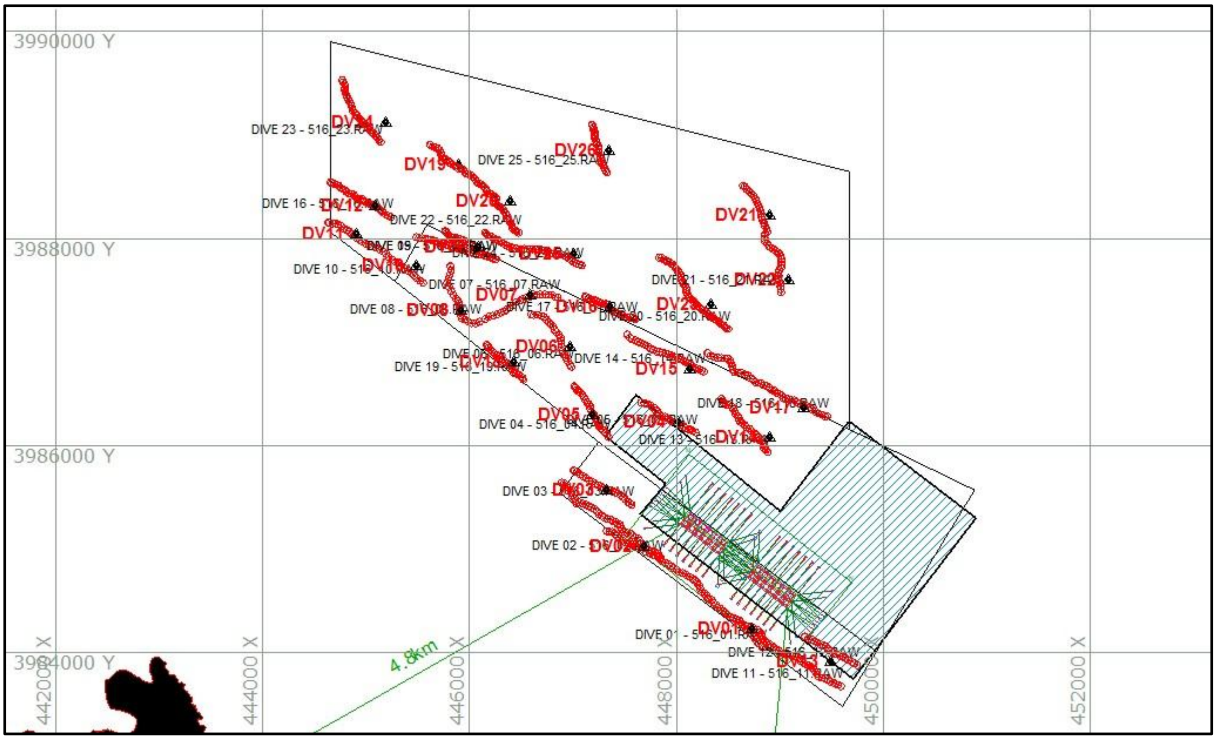


Figure 3.2: Track plots of the camera transects across all the identified target locations of interest and along the length of the existing fish farm

ADI ASSOCIATES

PA 02175/18

Proposal to consolidate temporary tuna farming area at a parcel of sea approximately 5 kilometers from the shore (in general area approved for PA/03072/17 and PA/05858/17) for a total biomass of 3,300 tonnes of fish

Technical Appendix 3

WAVE STUDY, HYDRODYNAMICS AND ENVIRONMENTAL MODELLING REPORT

Prepared by Artelia Eau et Environnement (France)

Supporting Documents for

Environmental Impact Assessment Report

Relocation of the AJD Tuna Farm in the North of Malta

Wave Study, Hydrodynamic and Environmental modelling for the EIA

Rev. 2

ARTELIA Eau & Environnement
6 rue de Lorraine
38130 - Echirolles
Tel. : +33 (0) 4 76 33 40 00
Fax : +33 (0) 4 76 33 43 33

DATE : JUNE 2018 **REF :** 871 4641

Signed Declaration

Attn: Director of Environment and Resources
Environment and Resources Authority
Malta

I, Dr Franck Mazas, who carried out the study (or part thereof) on wave studies, hydrodynamic and environmental modelling for the EIA for the proposed extension to an existing tuna farm operation off the Northeast coast of Malta, hereby declare that such study was solely carried out by me on behalf of Artelia Eau et Environnement, and the company takes responsibility for any statement and conclusion contained therein.

25 May 2018

Date

Signature

Signed Declaration

Attn: Director of Environment and Resources
Environment and Resources Authority
Malta

I, Dr Anne Levasseur, who carried out the study (or part thereof) on wave studies, hydrodynamic and environmental modelling for the EIA for the proposed extension to an existing tuna farm operation off the Northeast coast of Malta, hereby declare that such study was solely carried out by me on behalf of Artelia Eau et Environnement, and the company takes responsibility for any statement and conclusion contained therein.

25 May 2018
Date

Signature

N° 871 4641 - Relocation of the AJD Tuna Farm in the North of Malta – Rev. 2					
2	After comments from Client	FMS/DLS/PCU	ALR	FMS	28/06/2018
1	Final Report	FMS/DLS/PCU	ALR	FMS	26/06/2018
0	Interim report	FMS/DLS/PCU	ALR	FMS	20/06/2018
Version	Description	Redaction	Checked	Approved	Date

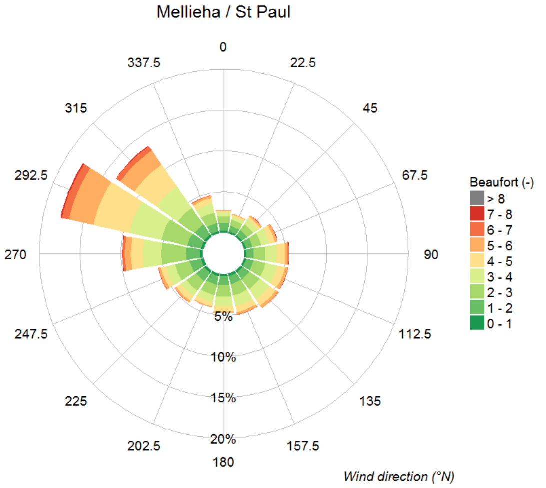
EXECUTIVE SUMMARY

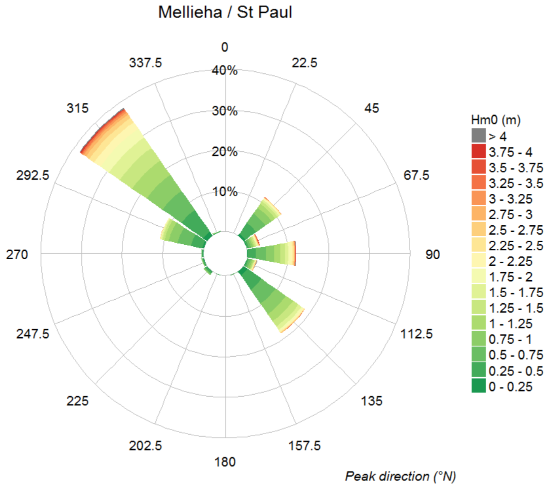
Task A: Wind and wave modelling

A numerical model of wave generation and propagation was set up over the Mediterranean Sea to produce sea states off Malta in the study area. The model was forced by wind fields from the global reanalysis CFSR, calibrated and validated by satellite wind speed measurements in the wave generation zone.

Sea states were simulated from January 1992 to December 2015 (24 years). Satellite measurements of wave height were used for calibration and validation of the model, granting a very high level of reliability of the final data (negligible bias and correlation coefficient in the range 0.92-0.95 around the Maltese archipelago).

Sea states and wind were analysed at an output point located offshore St-Paul's Bay and Mellieha Bay, approximately 56 m deep, close to the temporary tuna farms location. The wind and wave roses are illustrated below.

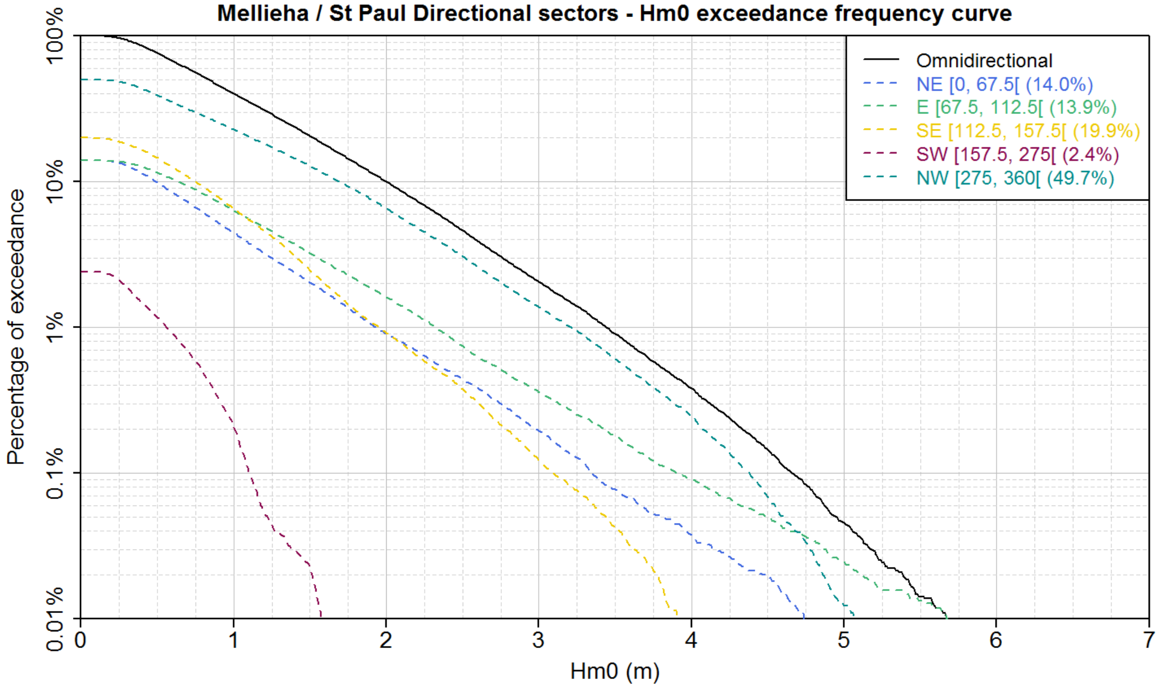




The wind and wave climate can be described as follows:

- **wind:** the NW sector (*majjistral*) is predominant. However the largest wind speeds (more than 20 m/s) may occur not only from this sector but also from a wide NE (*gregale*) to SE (sirocco or *xlokk*) sector. Two directional sectors may then be defined:
  - ESE sector [0°N, 202.5°N[: 39.8% of occurrences (the wind rose and the wind velocity / direction scatterplot do not allow to distinguish the NE and SE winds),
  - NW sector [202.5°N, 360°N[: 60.2% of occurrences,
- **sea states**: the NW sector (*majjistral*) is still predominant (around 45% of sea states). However, it is seen that a significant part of the sea states come from NE, E and SE directions. The following sectors can be distinguished:
  - NE sector [0°N, 67.5°N[: 14.0% of sea states;
  - E sector [67.5°N, 112.5°N[: 13.9% of sea states;
  - SE sector [112.5°N, 157.5°N[: 19.9% of sea states;
  - SW sector [180°N, 275°N[: 2.4% of sea states;
  - NW sector [275°N, 360°N[: 49.7% of sea states.

The following figure splits the exceedance frequency curve in H_{m0} according to these sectors.



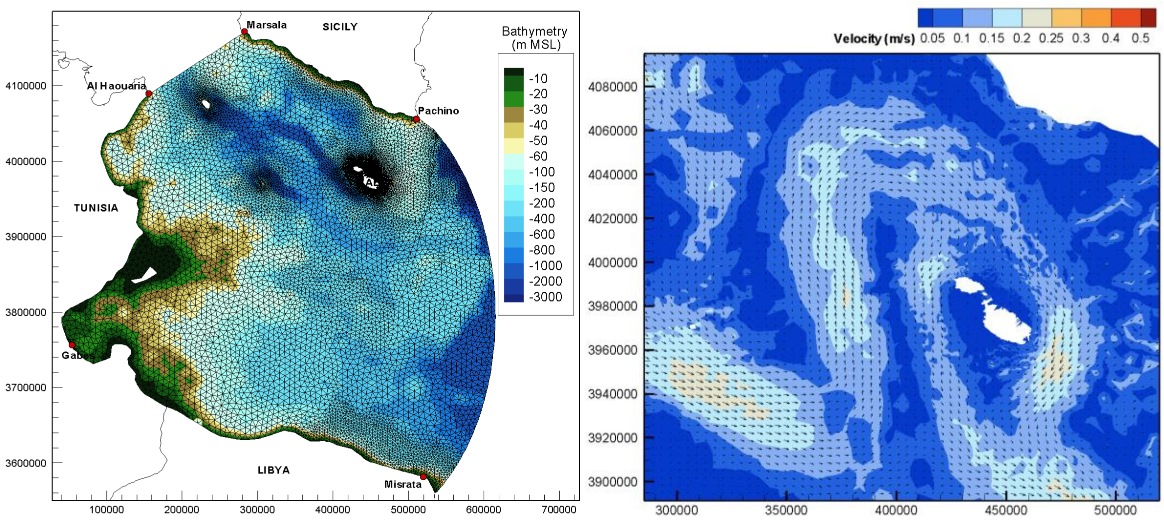
Extreme wind speeds and significant wave heights are as per the tables below.

Sector	Return period (year)	Wind speed (m/s)	
		Best estimation	90% confidence interval
ESE [0°N, 202.5°N[	1	17.4	*17.1 - 17.8*
	5	19.4	*18.7 - 20.0*
	10	20.1	*19.3 - 20.9*
	50	21.6	*20.5 - 23.0*
	100	22.3	*20.9 - 23.8*
NW [202.5°N, 360°N[	1	19.4	*19.1 - 19.8*
	5	21.5	*20.8 - 22.2*
	10	22.3	*21.5 - 23.2*
	50	24.2	*22.9 - 25.6*
	100	24.9	*23.5 - 26.6*

Sector	Return period (year)	H_{m0} (m)		T_p (s)
		Best estimation	90% confidence interval	
NE [0°N, 67.5°N[	1	3.41	*3.24 - 3.59*	*7.0 - 10.0*
	5	4.54	*4.16 - 4.95*	*8.0 - 11.5*
	10	5.01	*4.51 - 5.55*	*8.5 - 12.0*
	50	6.07	*5.27 - 6.98*	*9.5 - 13.0*
	100	6.51	*5.57 - 7.61*	*9.5 - 13.0*
E [67.5°N, 112.5°N[	1	3.66	*3.45 - 3.90*	*7.5 - 11.5*
	5	5.16	*4.70 - 5.67*	*9.0 - 13.0*
	10	5.75	*5.11 - 6.45*	*9.5 - 14.0*
	50	6.99	*5.70 - 8.50*	*10.5 - 15.0*
	100	7.47	*5.82 - 9.53*	*10.5 - 15.5*
NW [275°N, 360°N[	1	4.47	*4.36 - 4.58*	*8.5 - 11.5*
	5	5.12	*4.91 - 5.33*	*9.0 - 12.5*
	10	5.35	*5.09 - 5.63*	*9.5 - 12.5*
	50	5.85	*5.45 - 6.30*	*9.5 - 13.0*
	100	6.05	*5.59 - 6.57*	*10.0 - 13.5*

Task B: Hydrodynamic modelling

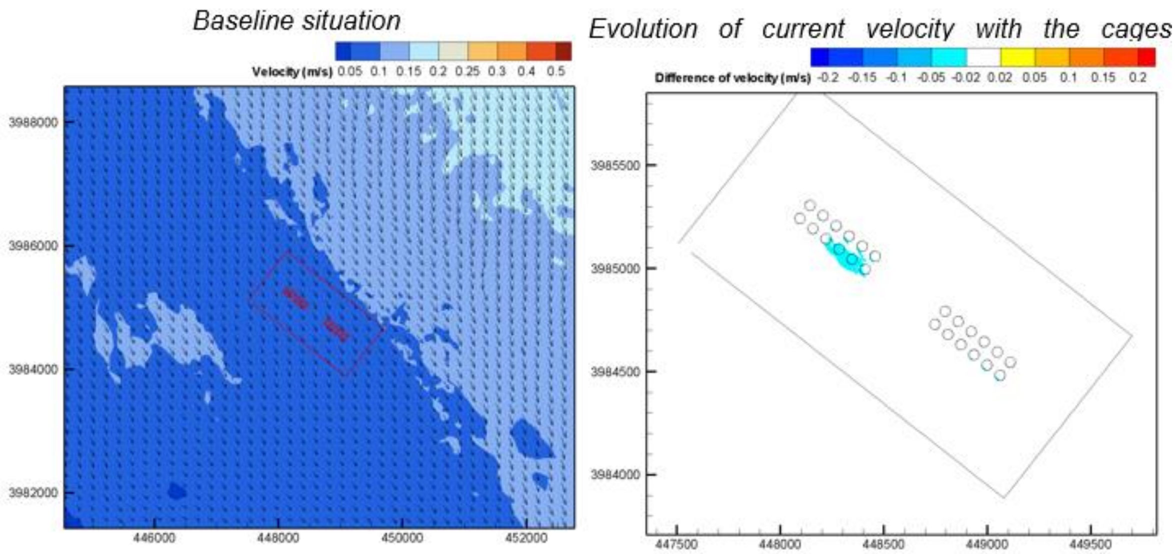
In a first stage, a hydrodynamic numerical model covering the Sicily Channel is constructed. This numerical model aims at simulating the water circulation around the Maltese Islands and more specifically currents in the Malta channel. Results from the model represent the specific features of the water circulation, in particular the Atlantic Ionian Stream flowing from the Northwest to the Southeast in the Malta Channel. The numerical model also reproduces the water level variations.



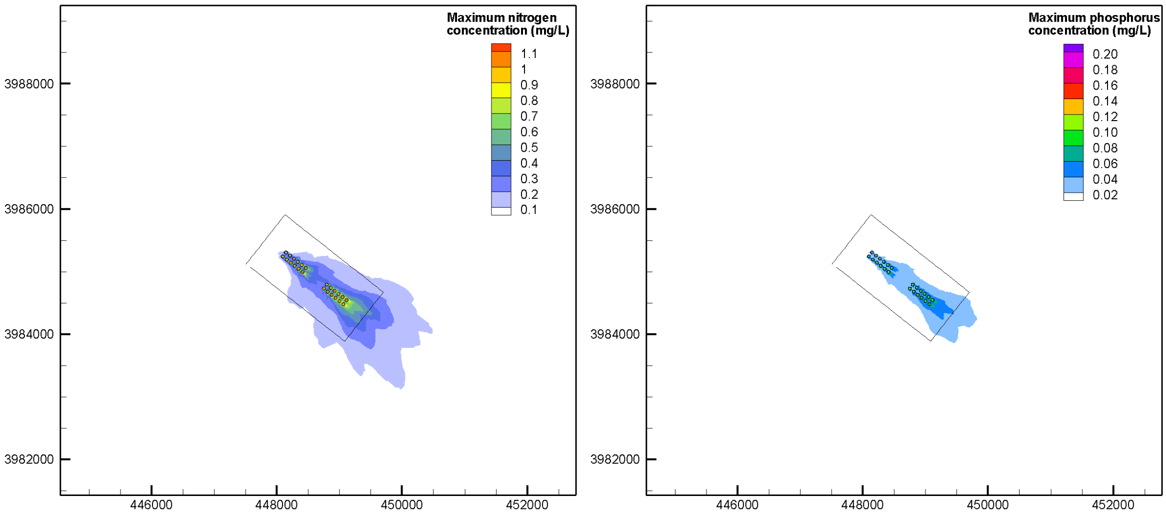
In a second stage, a set of environmental simulations is carried out to assess the impact of the AJD/MML fish farms. Meteorological conditions and ocean hydrodynamics is representative of August 2015, which is periods with light to moderate wind, always below 10 m/s, and varying wind directions.

The impact of the fish cages on the currents is taken into account by a drag force exerted along the netting, from surface to -35 m depth. The cages act as obstacles and reduce the velocity field by approximately 15% after each cage. A cumulative effect is observed due to the presence of several cages in series. On the location of the AJD/MML farms, currents are very low, always below 10 cm/s during the simulation period. Therefore, the impact of the flow reduction ranges from 5 cm/s to 2 cm/s and is limited to the vicinity of the cages.

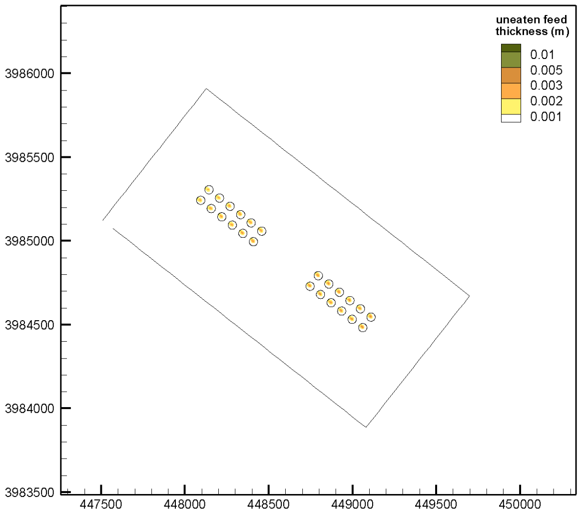
11 August 2015, 19h



Nutrients (phosphorus and nitrogen) are modelled as passive tracers using the same period. Currents towards the southeast are predominant during the simulation period, and therefore the nutrients plumes are orientated towards the Southeast. The threshold of 0.1 mg/L of total nitrogen is obtained about 1.5 km southeast of the last cages. The threshold of 0.02 mg/L of total nitrogen is obtained less than 1 km southeast of the last cages.



Uneaten baitfish are not transported offshore, and are deposited below the cages. The deposit of uneaten feed reaches at maximum 0.1 m after 30 days of simulation, under the assumption that no biodegradation or consumption by small scavengers occurs.

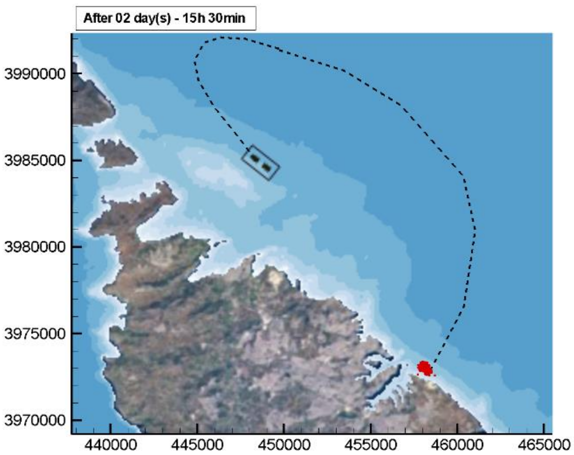


Two scenarios of dispersion of fish oil are simulated, corresponding to various wind conditions:

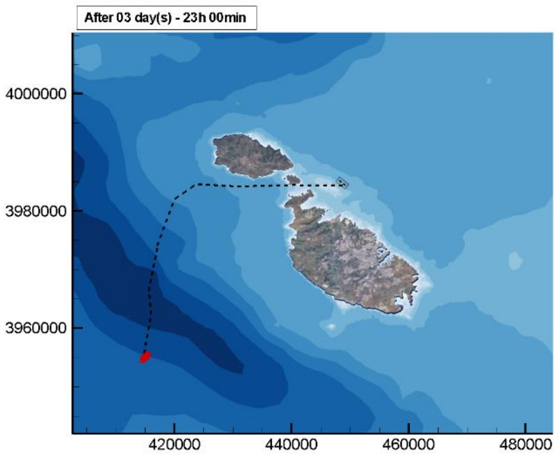
- Scenario 1: starting on 2 August 2015 (wind initially from the South and then predominantly from the North-West);
- Scenario 2: starting on 27 August 2015 (wind predominantly from the East).

The fish oil slick drift intensity is in the range of 5 cm/s to 15 cm/s in the scenarios simulated. It can be inferred from the two scenarios that the oil slicks are subject to a wide range of trajectories, depending on the hydro meteorological conditions prevailing on site. Wind significantly influences the trajectories near the fish farm**.**

Scenario 1



Scenario2



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PURPOSE OF THE STUDY

In 2016, the Planning Authority revoked all licenses of inshore tuna farms and requested that these operations be relocated to aquaculture zones further offshore.

The two tuna farms in the north of Malta - Malta Mariculture Limited (originally operating south of Comino), and AJD Tuna Ltd (originally operating off St Paul's Bay), were required to relocate further offshore but an aquaculture zone in the north of the island did not exist. For this reason, the Department of Fisheries has applied to the Planning Authority for the establishment of a North Aquaculture Zone (similar to the SE Aquaculture Zone off Marsaskala). This application is subject to an EIA process.

In the meantime, AJD Tuna Ltd and MML Ltd applied to the Planning Authority to relocate their operations to an area approximately 5 km from the shore off Mellieha / St Paul's Bay. Temporary permissions for these relocations were approved in 2017. The two farms are operating from the area shown in Figure 1 below. Each farm has a total of six cages.

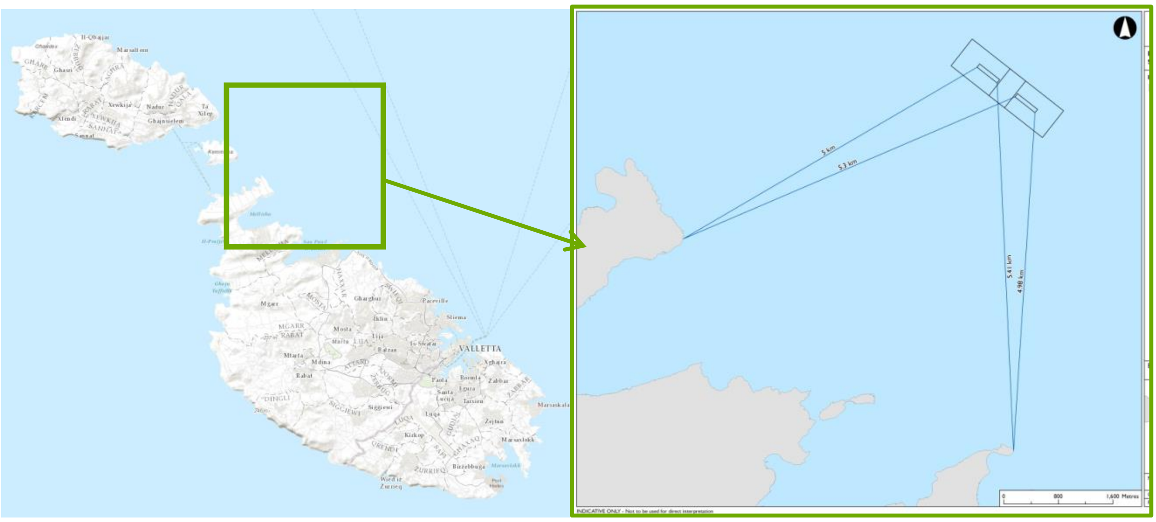

Figure 1. Location of the temporary tuna farming area for AJD & MML (source: ESRI World Topographic Map, Adi Associates)

The owner of the tuna farms has now applied to the Planning Authority to increase the number of cages from 12 to 24. Although the number of cages will be doubled, the overall amount of Bluefin tunas will remain unchanged so that the stocking density will be divided by two in the future configuration. The stocking density at caging is regulated by the International Commission for the Conservation of Atlantic Tunas (ICCAT). These two farms together have a total quota of 3,300 tonnes of fish.

In this context, Malta’s Environment & Resources Authority (ERA) has required a set of studies constituting an Appropriate Assessment and an Environmental Impact Assessment regarding the activities of the farm. The location of the farm and the layout showing the increased number of cages is illustrated in Figure 2.

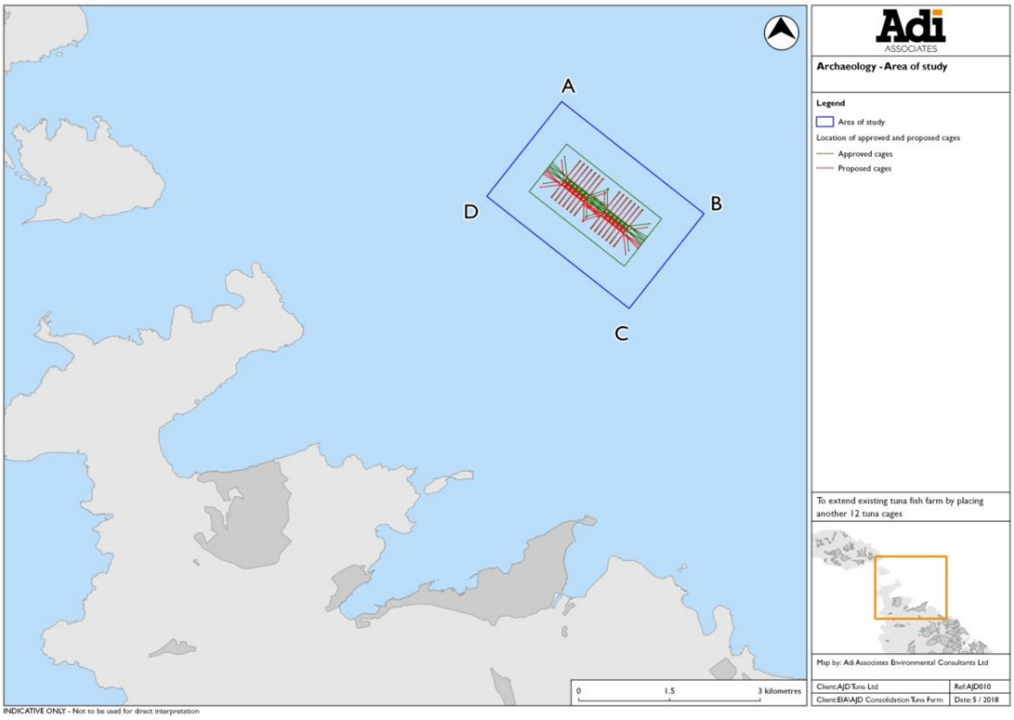

Figure 2. Location of the AJD & MML Tuna Farms (source: Client)

Adi Associates, hereinafter referred to as the Client, has been awarded the Environmental Impact Assessment and has requested ARTELIA to carry out the wave and hydrodynamic modelling studies, in particular the following tasks:

- Task A: wave study:
  - offshore wave modelling,
  - establishment of local wave climate and extreme waves,
- Task B: hydrodynamic study:
  - set up of the hydrodynamic model,
  - hydrodynamic modelling:
    - baseline hydrodynamic situation,
    - settlement of uneaten feed,
    - dispersion of dissolved nutrients,
    - dispersion of a fish oil spill from the fish farm.

The present document is the report of the study. It presents the methodologies and the results of the analyses and models carried out to meet the above requests.

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DEFINITIONS AND CONVENTIONS

The following definitions are used in the study:

- sea states:
  - H_{m0} or H_s (m): spectral significant wave height, defined as $H_{m0} = 4\sqrt{m_0}$, where m_0 is the 0th moment of spectral density,
  - T_p (s): peak period, defined as the reciprocal of the most energetic frequency of the wave spectrum after directional summing,
  - θ_p or Dir_p (°N): peak direction, defined as the most energetic direction of the frequency bin corresponding to T_p,
  - σ (°): directional spreading or, equivalently, spreading parameter (exponent of the cosine function) s (-),
  - γ (-): peak enhancement factor of the frequency spectrum, calculated assuming a JONSWAP-type spectrum,
- wind:
  - W_s (m/s): wind velocity at 10 m height, averaged over 10 minutes,
  - W_{dir} (°N): wind direction associated to W_s,
- current:
  - V_{cur} (m/s): current velocity,
  - Dir_{cur} (°N): current direction.

Following the nautical convention, the directions are:

- direction **from which** waves come;
- direction **from which** the wind blows;
- direction **to which** the current goes.

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1. TASK A: WAVE STUDY

1.1. WIND AND WAVE MODELLING

1.1.1. Methodology

The main stages of the methodology used to produce sea states and wind off Malta are summarized as follows:

- model construction:
  - definition of computational domains,
  - collection of bathymetric data and construction of model bathymetry,
- wind:
  - extraction of wind fields over the wave generation area from the global reanalysis CFSR[1] (NCEP[2]) from January 1992 to December 2015,
  - calibration and validation of the wind fields by satellite wind speed measurements in the wave generation zone,
- offshore sea states:
  - construction of the third generation wave model WaveWatch III (v4.18) in order to simulate the generation and propagation of offshore sea states,
  - simulation of offshore sea states from January 1992 to December 2015, over the Mediterranean Sea,
  - validation of sea states at the borders of the propagation domains by satellite wave height measurements,
- nearshore sea states:
  - construction of the third generation model SWAN (v40.91) at regional scale in order to propagate the offshore sea states generated,
  - simulation of the generation and propagation of sea states around the Maltese archipelago.

Four computational nested domains are set up from a regional scale (Mediterranean Sea) to local scale with a spatial resolution progressively refined. Their footprints are illustrated in Figure 3 below.

[1] Climate Forecast System Reanalysis

[2] National Centers for Environmental Prediction

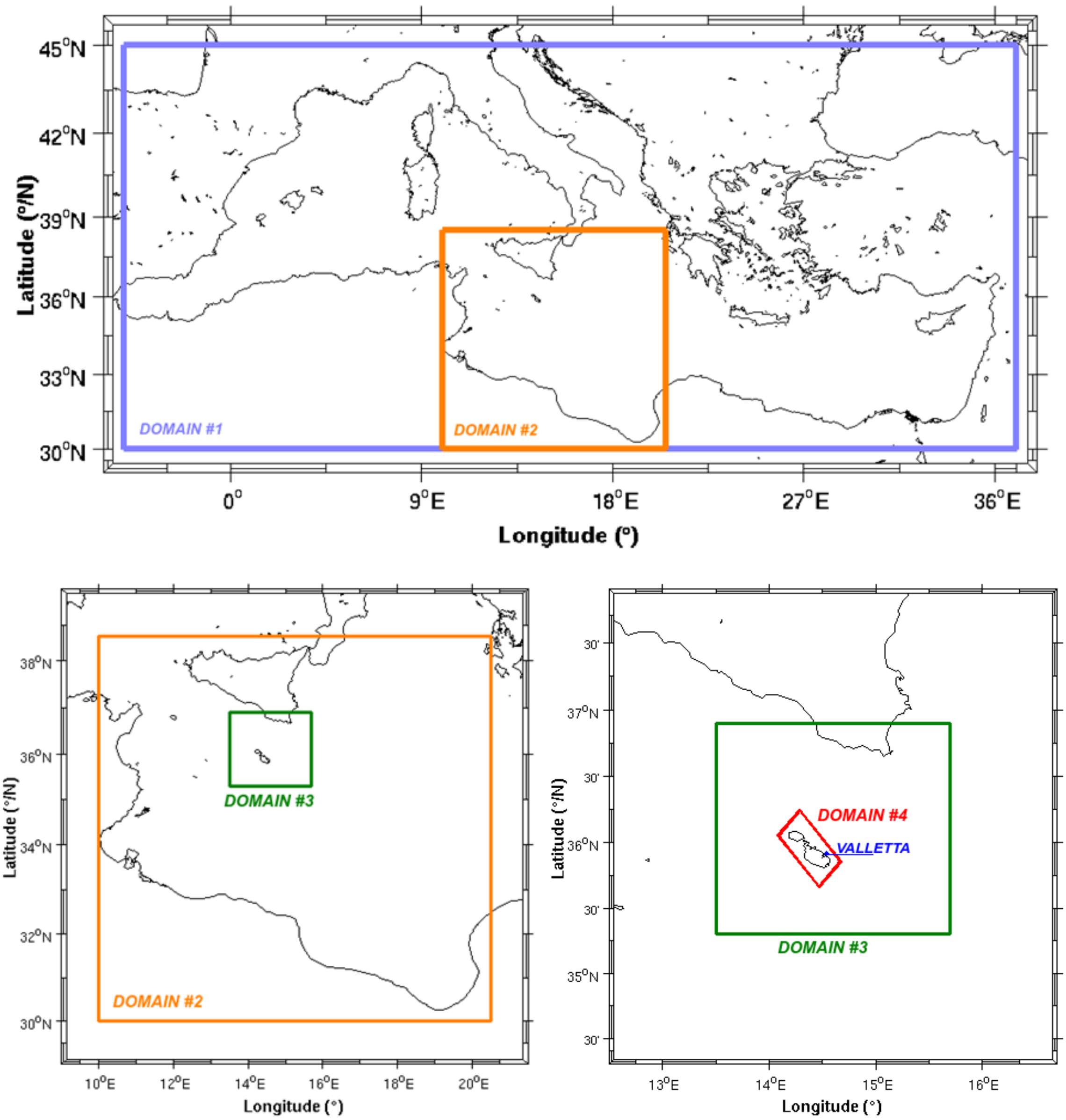

Figure 3. Computational domains for sea state generation

1.1.2. Wind fields

1.1.2.1. Atmospheric model

Wind fields used in this study for wave generation are extracted over the wave generation area (Mediterranean Sea) from the reanalysis of the American atmospheric model CFSR of the NCEP. Wind fields are described by the two following parameters:

- wind velocity W_s (m/s), 10 m above the reference level (mean sea level) and averaged over 10 min;
- wind direction W_{dir} (°N) associated to the mean velocity.

The spatial resolution is 0.3° x 0.3° between 1992 and 2010 and 0.2° x 0.2° between 2011 and 2015. The time step is 1 hour. The accuracy of the data is 0.1 m/s for the velocity and 1° for the direction.

Figure 4 illustrates an example of wind field over the computation Domain #1.

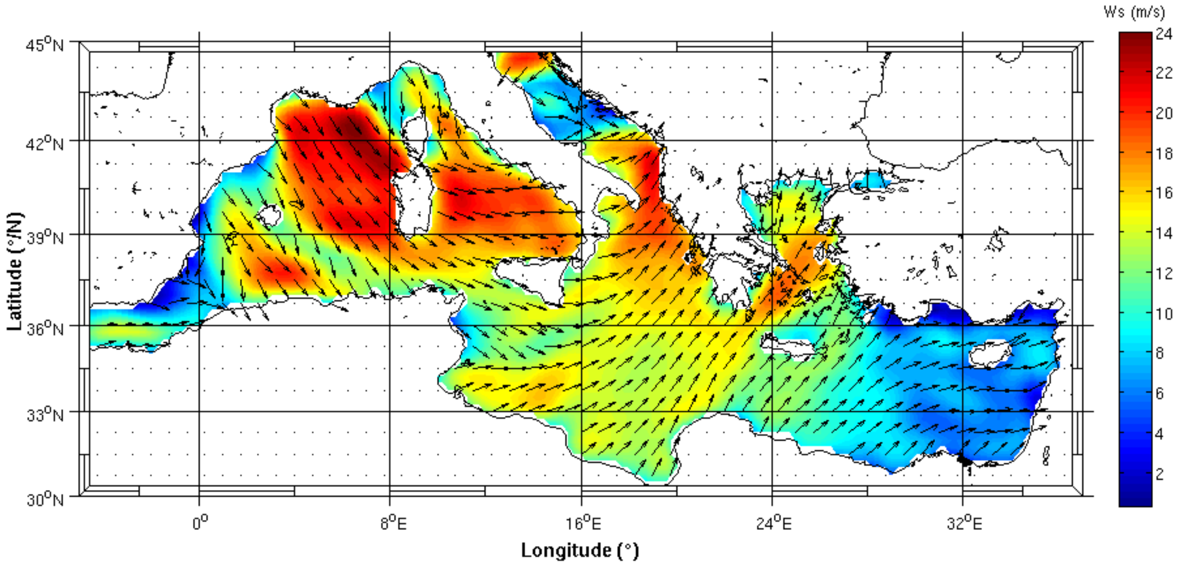

Figure 4. Example of wind field over Domain #1

1.1.2.2. Validation of wind forcing

A. Methodology

Satellite measurements of wind velocity are used for validation of the wind fields over the three first domains set up for the wave generation / propagation model (see Figure 5 below). The fourth domain is too small for performing the calibration / validation by satellite measurements, but benefit from the calibration applied on the larger domains.

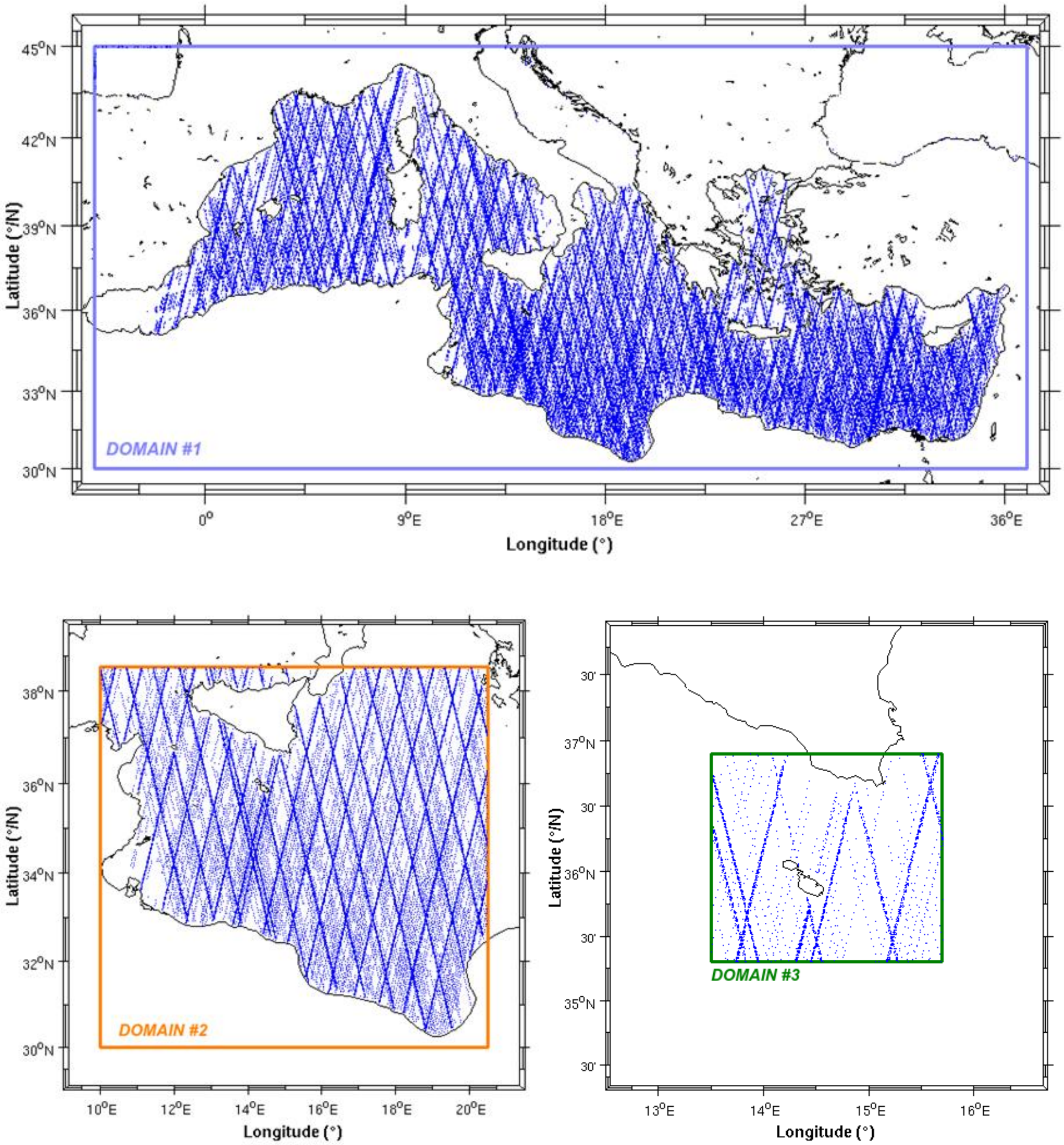

Figure 5. Tracks of altimetric measurements over Domains #1 to #3

Within each computational domain, available satellite data (tracks represented in Figure 5 above) are compared with the associated value from the model wind fields (closest value in space and time). A scatterplot[3] and a quantile-quantile plot[4] are performed in order to visualize the difference

[3] A scatter plot displays values for two variables for a set of data, as a collection of points, each of which corresponding to a given time and having the value of one variable determining the position on the horizontal axis and the value of the other variable determining the position on the vertical axis.

[4] A quantile-quantile plot is a probability plot for comparing two probability distributions by plotting their quantiles against each other. First, the set of intervals for the quantiles is chosen (typically 1/100). A point (x, y) on the plot corresponds to one of the quantiles of the second distribution (y-coordinate) plotted against the same quantile of the first distribution (x-coordinate).

between the distributions of measured and modelled wind speeds. If the discrepancy between the two distributions is too important, a calibration coefficient is determined and applied to the model wind field within the domain.

B. Wind field validation – Domain #1

Figure 6 below shows the scatterplot and quantile-quantile plot in Domain #1.

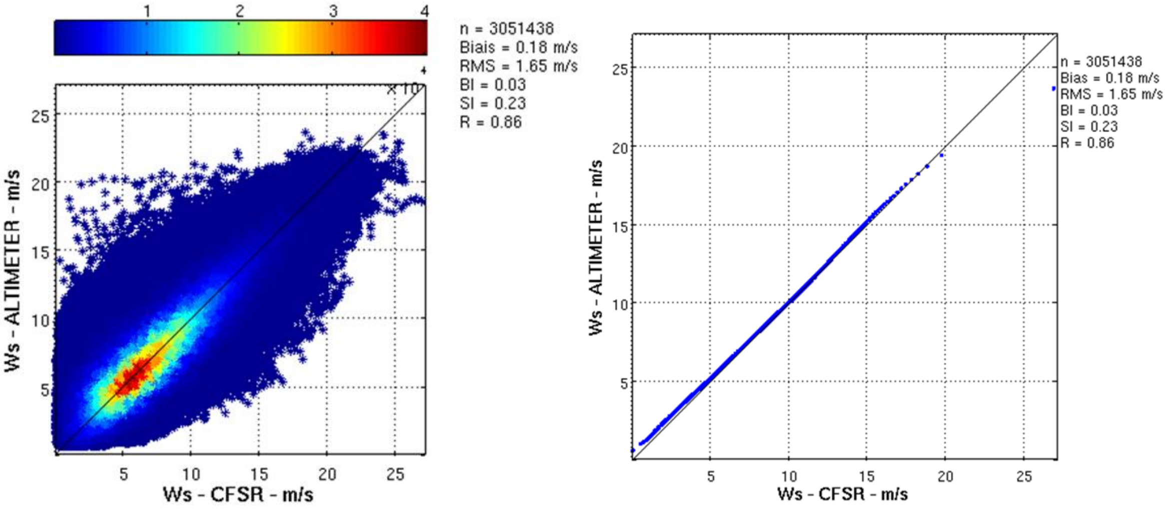

Figure 6. Scatterplot and quantile-quantile plot for wind velocity validation within Domain #1

The plots show very good agreement between the model and the observations up to the 99% percentile: the wind fields are validated in Domain #1.

C. Wind field validation – Domain #2

Figure 7 below shows the scatterplot and quantile-quantile plot in Domain #2.

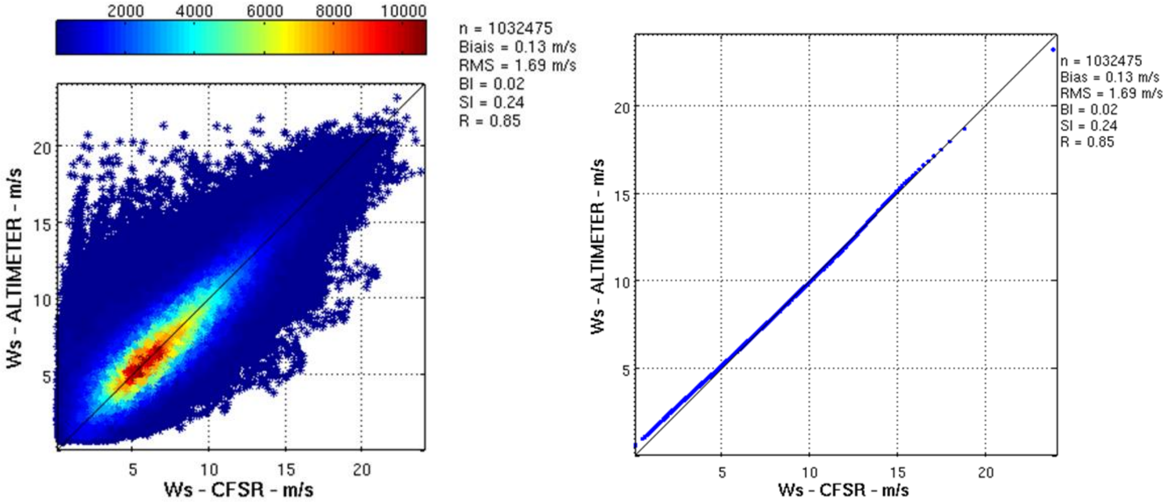

Figure 7. Scatterplot and quantile-quantile plot for wind velocity validation within Domain #2

The plots show very good agreement between the model and the observations over the full range of measurements: the wind fields are validated in Domain #2.

D. Wind field validation – Domains #3 and #4

Figure 8 below shows the scatterplot and quantile-quantile plot in Domain #3.

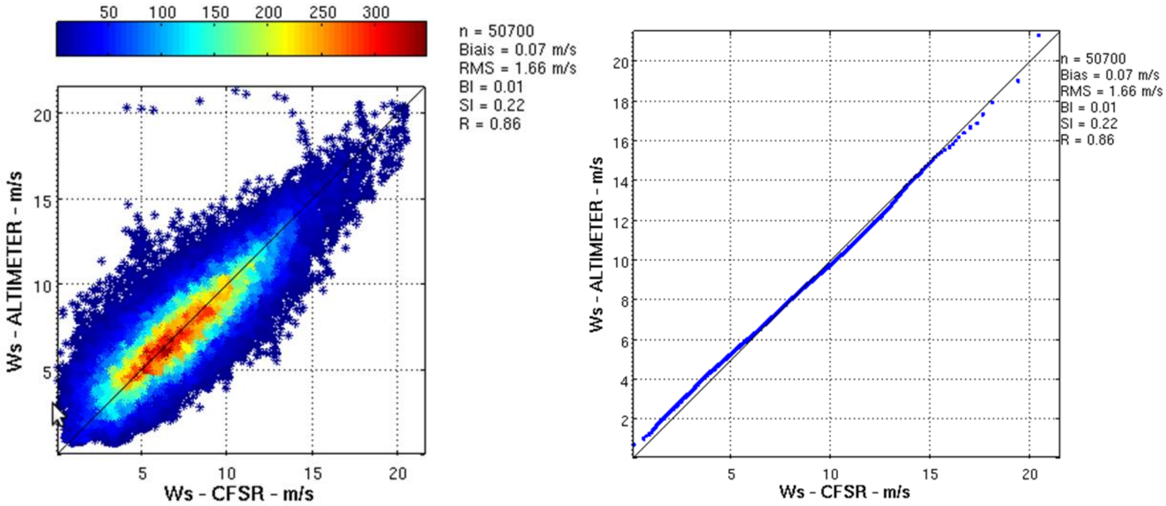

Figure 8. Scatterplot and quantile-quantile plot for wind velocity validation within Domain #3

The plots show very good agreement between the model and the observations over the full range of measurements: the wind fields are validated in Domain #3, and by extension in Domain #4.

1.1.3. Sea state modelling

1.1.3.1. Modelling software

Sea states were simulated through the use of two wave generation and propagation modelling software:

- **WaveWatch III** v4.18 was used for the first two domains. This state-of-the-art, 3rd-generation code, developed at the NOAA/NCEP, is dedicated to the simulation of offshore wave generation and propagation, accounting for the following phenomena:
  - energy dissipation,
  - wind-wave interactions,
  - wave-wave interactions,
  - bottom-wave interactions,
- **SWAN** (Simulating WAves Nearshore) v40.91 was used for the local domains (Domains #3 and #4). This state-of-the-art, 3rd-generation code, developed at the University of Delft (the Netherlands), is more specifically dedicated to the wave propagation in coastal waters, accounting for the phenomena associated with wave transformation in shallow water:
  - refraction,
  - shoaling,
  - diffraction,
  - reflection,
  - wave breaking.

The different computation grids are fully nested: the wave boundary conditions for Domain 2 (resp. 3, 4) are issued from the output of Domain 1 (resp. 2, 3).

1.1.3.2. Bathymetry

The bathymetry used for Domains #1 and #2 was sourced from the GEBCO[5] global bathymetric database at a base resolution of 1', while the bathymetry used for Domains #3 and #4 was sourced from the SRTM[6] bathymetric database at a base resolution of 15". The bathymetry was subsequently interpolated to the same resolution as was used in the model simulations (see Table 1). The resulting bathymetry is illustrated in Figure 9 below.

[5] GEneral Bathymetric Chart of the Oceans - http://www.gebco.net/

[6] Shuttle Radar Topography Mission - http://www2.jpl.nasa.gov/srtm/

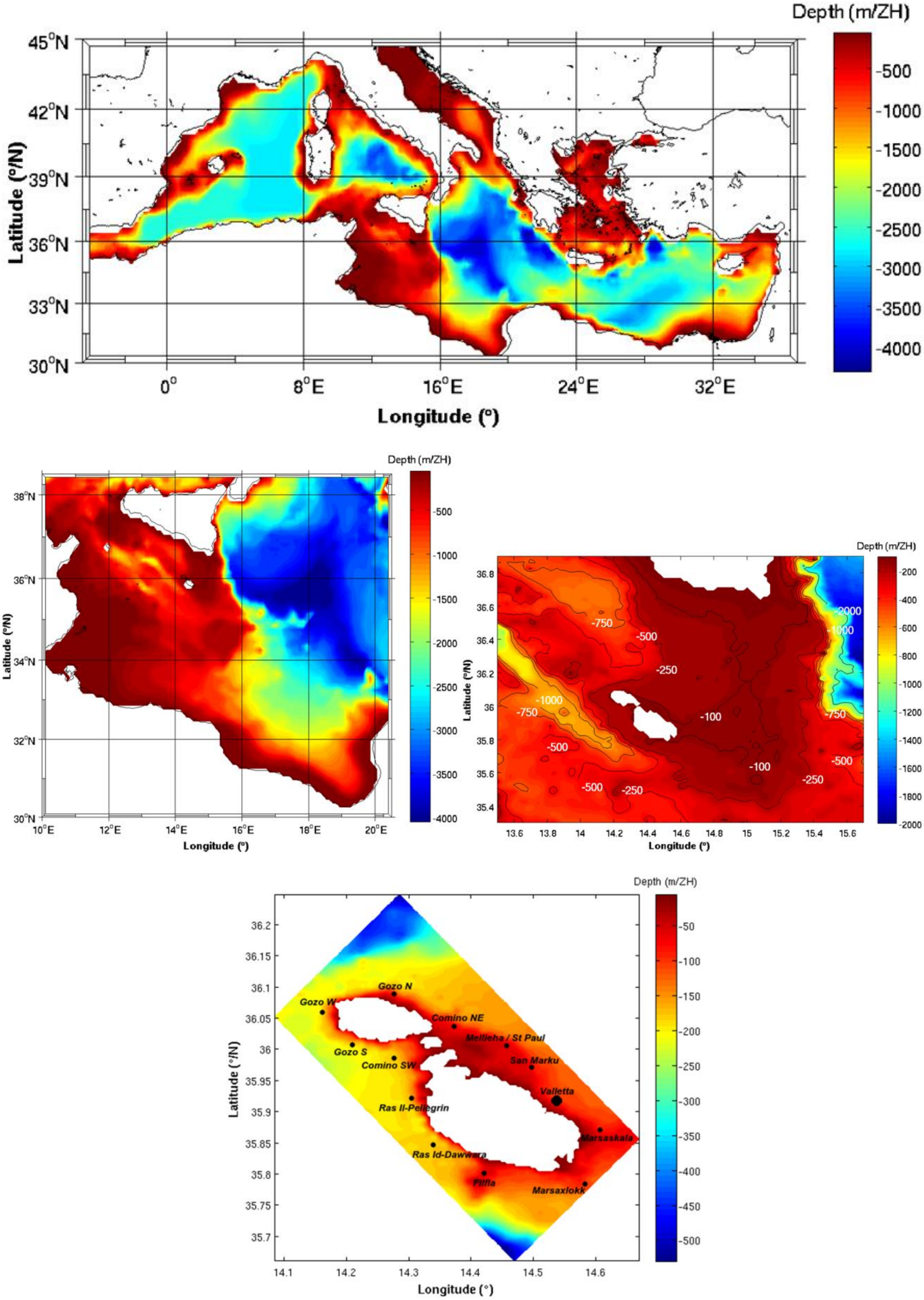

***Figure 9.* Bathymetry of the four computational domains**

The version of WaveWatch III (4.18) used in this study is also capable of integrating obstruction data to improve the simulation results of wave propagation around islands and other land forms that are smaller than the spatial resolution of the model and are thus not considered as land. A percentage value is given to each grid point for both zonal and meridian propagation which determines roughly how much of each component passes through the given grid point.

1.1.3.3. Model parameterization

The configuration of the four models is detailed in Table 1 below.

Table 1 – Set-up and parameterization of the wave models

		Domain 1	Domain 2	Domain 3	Domain 4
Modelling software		WaveWatch III v 4.18		SWAN v 40.91	
Computation grids					
Projection		WGS84 DMS			
North limit		45°N	38°30'N	36°54'N	36°14'56"N
South limit		30°N	30°00'N	35°18'N	35°39'36"N
West limit		5°W	10°00'E	13°30'E	14°05'06"E
East limit		37°E	20°30'E	15°42'E	14°40'12"E
Spatial resolution		1° x 1°	0.25° x 0.25°	0.1° x 0.1°	0.02° x 0.02°
Parameterization					
Directional bin		10°			
Frequency	**Number**	32			
	Range (Hz)	0.0373 – 0.7159			
Breaking	**Formula**	Battjes et Janssen (1978)			
	Parameters	$\alpha = 1, \gamma = 1.26$		$\alpha = 1, \gamma = 0.73$	
Bottom friction		SHOWEX		Madsen et al. (1984)	
Input and forcing					
Modelling period		01/01/1992 – 31/12/2015 (24 years)			
Bathymetry		GEBCO 1'		SRTM 15"	
Sea level		Constant Mean Sea Level (0 m MSL = 0.7 m CD)			
Wind	**Source**	CFSR			
	Resolution	1992-2010: 0.3° x 0.3° 2011-2015: 0.2° x 0.2°			
	Time step	1 h			
Waves: boundary conditions	**Source**	-	Domain 1	Domain 2	Domain 3
	Resolution	-	1°	0.25°	0.1°
	Time step	-	1 h	1 h	1 h

1.1.3.4. Validation of sea states

A. Methodology

Satellite measurements of significant wave height are used for validation of the sea states.

Around the boundaries of the nested domains 2 and 3, available satellite data (see Figure 5) are compared with the associated co-located value from the model (closest value in space and time). A scatterplot and a quantile-quantile plot are performed in order to visualize the difference between the distributions of measured and modelled H_{m0}. If the discrepancy between the two distributions is too important, a linear calibration coefficient is determined and applied to sea state spectra energies entering the nested domain.

Domain 4 is too small for performing the calibration / validation by satellite measurements, but benefits from the calibration applied on the larger domains.

B. Sea-state validation – Boundary conditions for Domain #2

Figure 10 below shows the scatterplot and quantile-quantile plot along the boundaries of Domain #2. Three zones have been defined for the validation:

- Zone 1: sea states coming from NW, generated in the Occidental Mediterranean Sea;
- Zone 2: sea states coming from the NNE, generated in the Ionian Sea;
- Zone 3: sea states coming from the E, generated in the western part of the Oriental Mediterranean Sea.

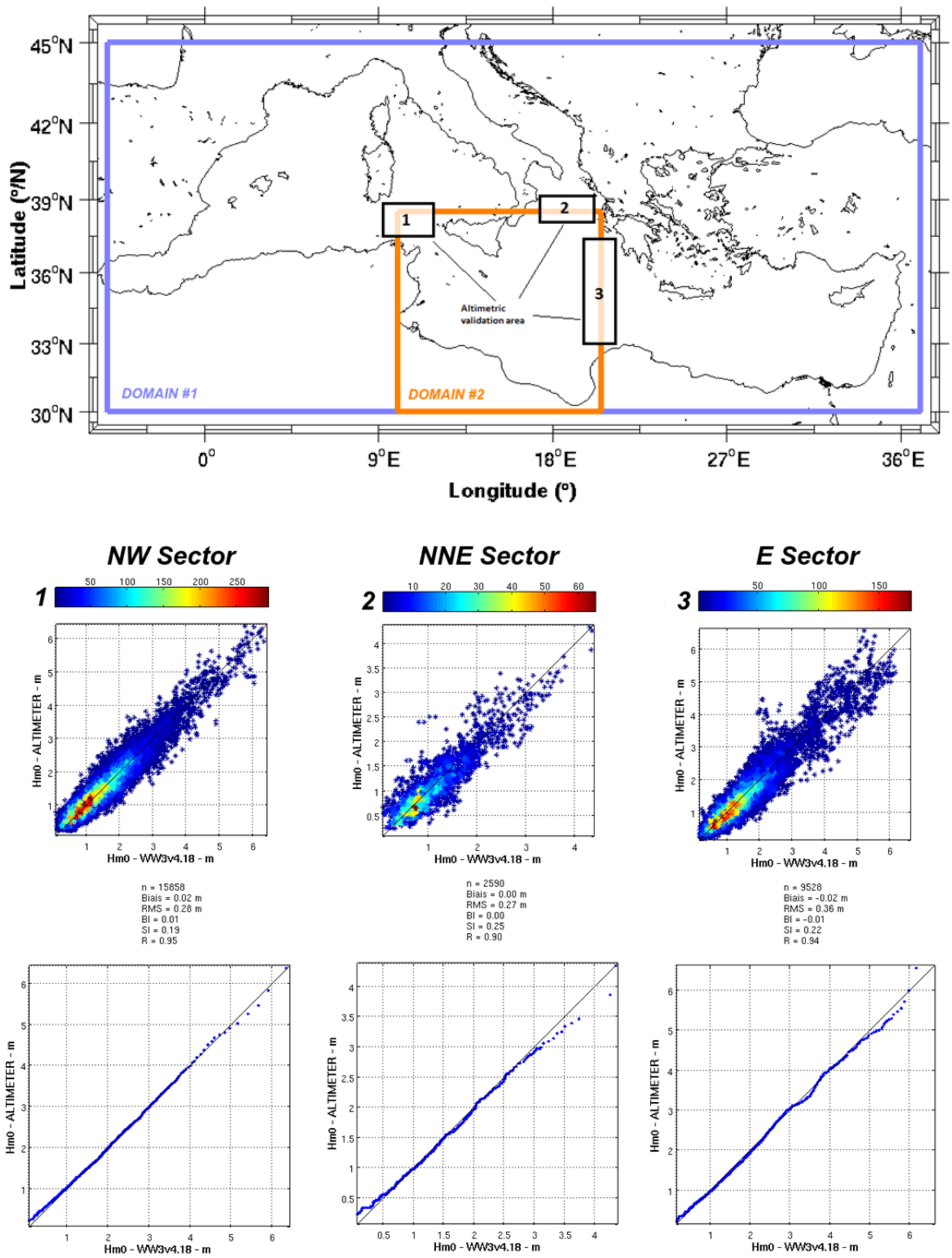

Figure 10. Scatterplot and quantile-quantile plot for sea state validation at the boundaries of Domain #2

The plots show good agreement between the model and the observations, in particular for the prevailing NW sector: the sea states generated in Domain #1 are validated along the boundaries of Domain #2.

C. Sea-state validation – Boundary conditions for Domain #3

Figure 11 below shows the scatterplot and quantile-quantile plot along the boundaries of Domain #3. Three zones have been defined for the validation:

- Zone 1: sea states coming from W, generated in the Occidental Mediterranean Sea;
- Zone 2: sea states coming from the S, generated in the central part of the Mediterranean Sea;
- Zone 3: sea states coming from the E, generated in the western part of the Oriental Mediterranean Sea and the Ionian Sea.

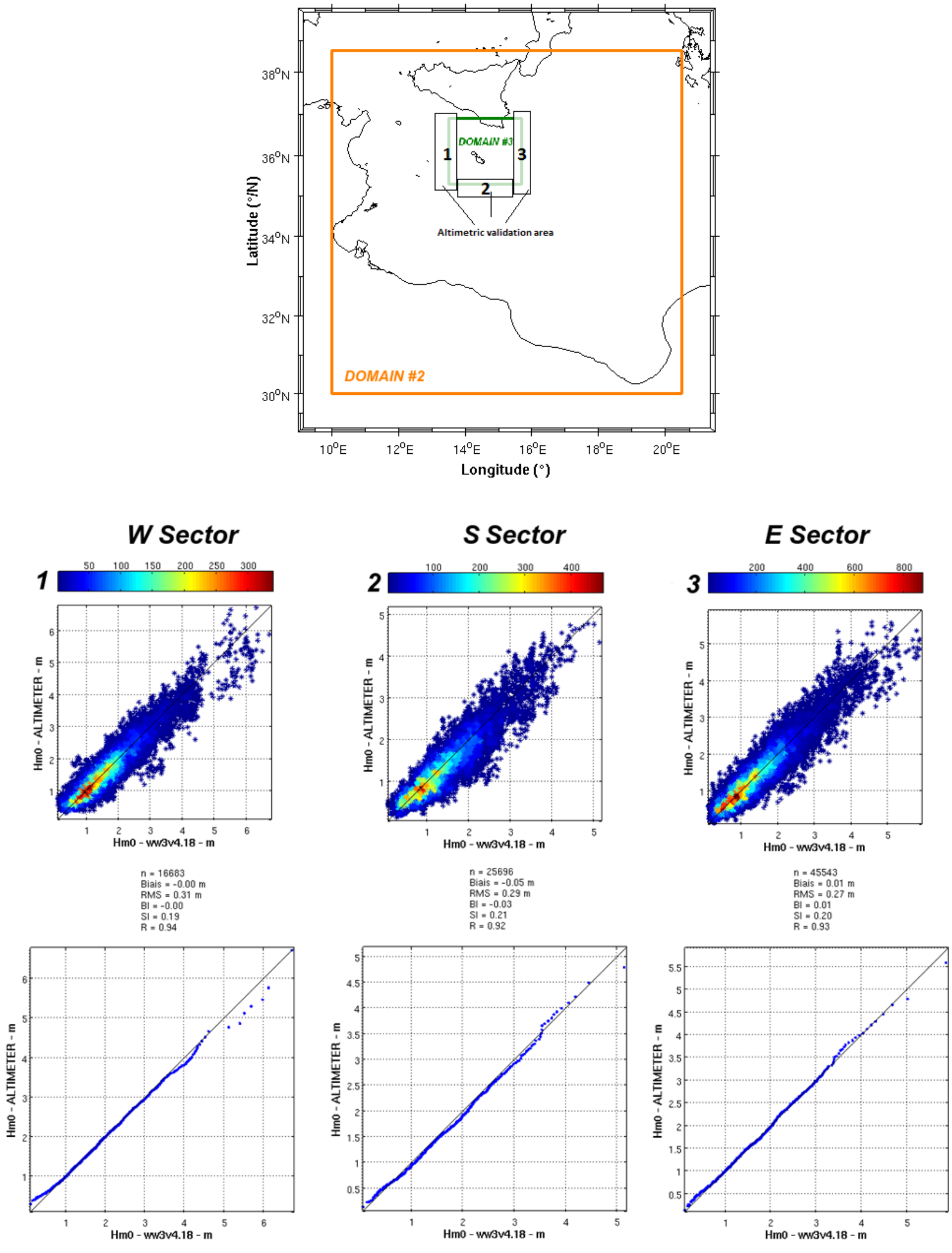

Figure 11. Scatterplot and quantile-quantile plot for sea state validation at the boundaries of Domain #3

The plots show very good agreement between the model and the observations for all sectors: the sea states generated in Domain #2 are validated along the boundaries of Domain #3.

1.1.3.5. Model output

The output of the models consists of the hourly time series of sea state spectra (spectral density as a function of the direction and frequency) computed at each point of the grids and saved at the grid boundaries. In addition, the sea state spectra are archived at 13 output points illustrated in Figure 9 above and summed up in Table 2 below.

Table 2 – Location of output points

Name	Longitude (°E)	Latitude (°N)	Depth (m CD)
Gozo W	14.161	36.059	193
Gozo N	14.277	36.089	93
Comino NE	14.373	36.036	70
Mellieha / St Paul	14.457	36.007	56
San Marku	14.498	35.971	75
Valletta	14.538	35.917	90
Marsaskala	14.607	35.871	84
Marsaxlokk	14.583	35.784	98
Filfla	14.421	35.802	60
Ras Id-Dawwara	14.339	35.847	176
Ras Il-Pellegrin	14.305	35.922	158
Comino SW	14.277	35.987	177
Gozo S	14.210	36.008	181

In the frame of this study, only the "Mellieha / St Paul" output point is processed. It is located nearly 6 km north-north-west of St Paul's Islands (Figure 12), in water depths of approximately 56 m. Its location is chosen so as to be free of nearshore effects and relevant for being used for studies in the vicinity of Mellieha Bay and St Paul's Bay.

In particular, this point is considered fully representative of the wind and wave conditions at the fish farm.

At this point, the wind speed and direction are interpolated from the CFSR field and the sea state spectra are processed to get the hourly time series from January 1992 to December 2015 (24 years) of the wind and spectral wave parameters:

- wind:
  - wind velocity at 10 m, averaged over 10 min W_s (m/s),
  - wind direction W_{dir} (°N),
- sea states:
  - spectral significant wave height H_{m0} (m) ;
  - peak period T_p (s) ;
  - peak direction θ_p (°N) ;
  - directional spreading σ (°) or equivalently the spreading parameter (exponent of the cosine function) s (-) ;
  - peak enhancement factor γ (-) based on the assumption of a JONSWAP-type spectrum.

In addition, a spectral partitioning of sea states is carried out in order to separate the different wave systems (wind waves, swell) and the associated spectral parameters are provided for each wave system.

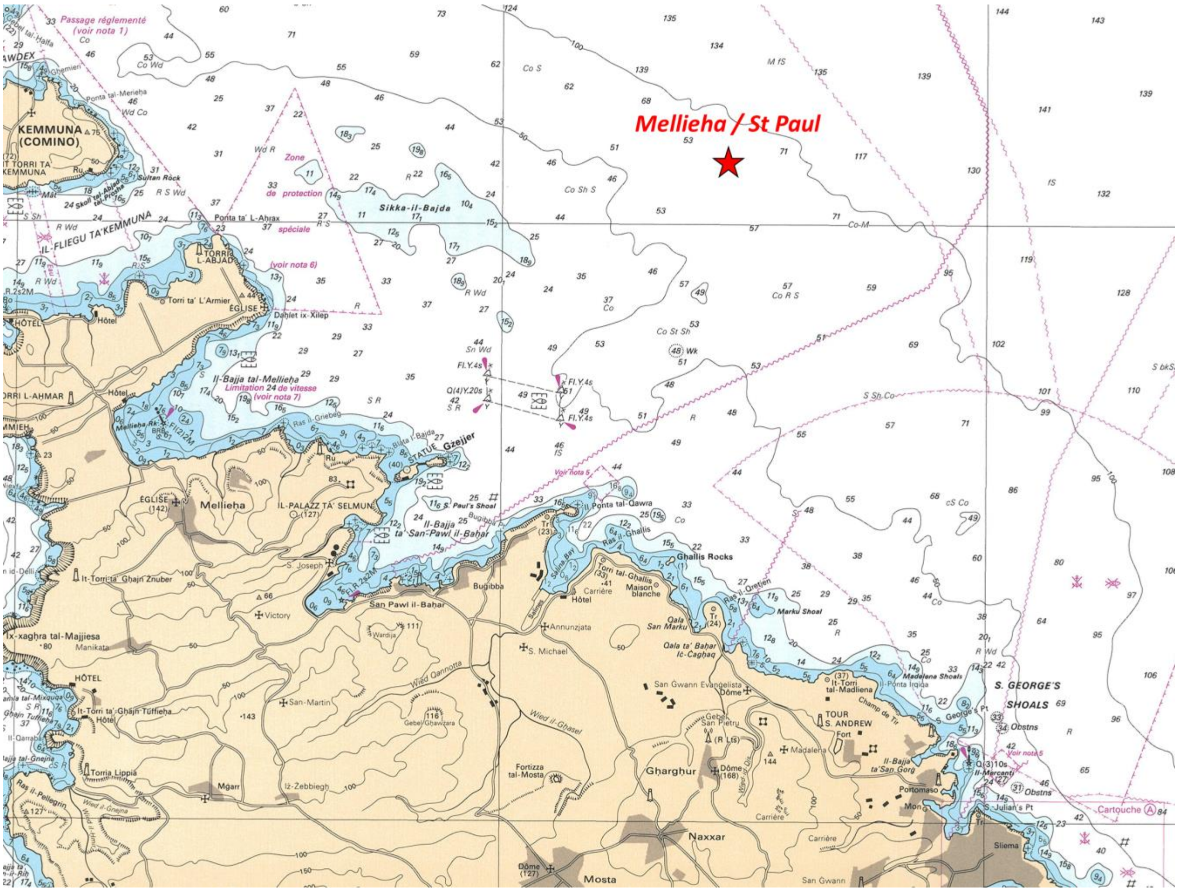

Figure 12. Location of the "Mellieha / St Paul" output point

1.2. ANALYSIS OF WINDS AND WAVES

1.2.1. Methodology for extremes

Extreme wind speeds and wave heights are estimated for the different directional sectors (wind and wave populations) identified through the assessment of the wind and wave climates.

This estimation is performed through a statistical extrapolation. Its methodology is as follows:

- determination of homogeneous (identically distributed) wind or wave populations, based on directional criteria or others (e.g. wave steepness);
- declustering of the time series (over a K-year duration) using the Peaks-Over-Threshold (POT) approach:
- identification and extraction from the time series of storm events exceeding a "physical threshold" u_p set so as to get $\lambda_p = 5$-10 storm events per year in average,
- Selection of the wind speed / wave height peaks of the storm events for setting up a sample of N_p independent and identically distributed (i.i.d.) data ($\lambda_p = N_p/K$),
- statistical extreme value analysis applied to the i.i.d. sample:

- determination of a "statistical threshold" u_s: the N peaks exceeding this threshold are considered as extreme values ($\lambda = N/K$ peaks per year in average),
- fitting of statistical distributions (GPD, Weibull, Gamma, Exponential) to these extreme peaks,
- determination of the best-fitting distribution using a statistical test (such as χ^2 or Kolmogorov-Smirnov),
- computation of quantiles (return values) for a set of return periods (e.g. 1, 5, 10, 50, 100 years),
- computation of 90% confidence intervals using the parametric bootstrap method.

ARTELIA presented this state-of-the-art methodology in several presentations in international congresses (both coastal engineering- and statistics-oriented) and in several papers published in international peer-reviewed journals[7,8,9,10].

1.2.2. Wind

1.2.2.1. Wind climate

The local wind climate is established in order to identify the different wind populations. The following plots are provided in the ***Appendix A***:

- directional wind roses;
- scatter diagrams speed / direction;
- exceedance frequency curve for wind speed.

The wind rose, in Beaufort scale, is provided in Figure 13 below.

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[7] Hamm, L.; Mazas, F.; Garcia, N. & Bailly, B., 2010. Réconcilier théorie et pratique dans la détermination des houles extrêmes. *European Journal of Environmental and Civil Engineering*, **14**(2), 127-148.

[8] Mazas, F., Hamm, L., 2011. A multi-distribution approach to POT methods for determining extreme wave heights. *Coastal Engineering*, **58**, 385-394.

[9] Bernardara, P., Mazas, F., Kergadallan, X., Hamm, L., 2014. A two-step framework for over-threshold modelling of environmental extremes. *Nat Hazards Earth Syst Sci* **14**, 635–647.

[10] Mazas, F., Garat, P., Hamm, L., 2014. Questioning MLE for the estimation of environmental extreme distributions. *Ocean Engineering* **92**, 44–54.

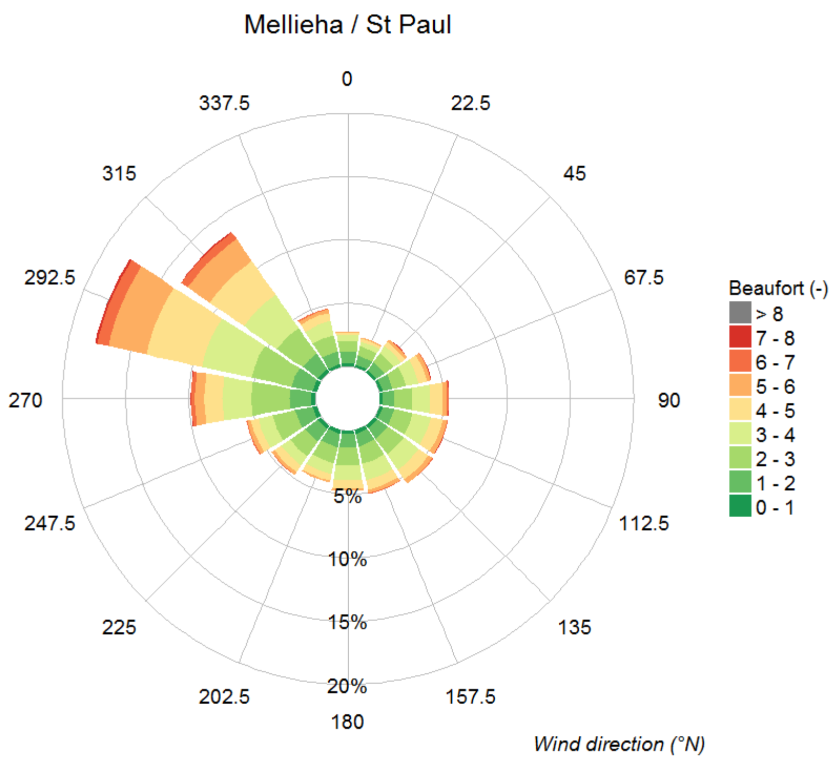


Figure 13. Wind rose off Valletta

Table 3 provides the description of the Beaufort scale.

Table 3 – Beaufort scale in m/s, km/h and knots

Beaufort scale	Description	Wind speed range		
		m/s	km/h	knots
0	Calm	< 0.3	< 1	< 1
1	Light air	0.3 – 1.5	1 – 5	1 – 3
2	Light breeze	1.6 – 3.3	6 – 11	4 – 6
3	Gentle breeze	3.4 – 5.4	12 – 19	7 – 10
4	Moderate breeze	5.5 – 7.9	20 – 28	11 – 16
5	Fresh breeze	8 – 10.7	29 – 38	17 – 21
6	Strong breeze	10.8 – 13.8	39 – 49	22 – 27
7	High wind, near gale	13.9 – 17.1	50 – 61	28 – 33
8	Gale, fresh gale	17.2 – 20.7	62 – 74	34 – 40
9	Strong / severe gale	20.8 – 24.4	75 – 88	41 – 47
10	Storm, whole gale	24.5 – 28.4	89 – 102	48 – 55
11	Violent storm	28.5 – 32.6	103 – 117	56 – 63
12	Hurricane force	≥ 32.7	≥ 118	≥ 64

However the largest wind speeds (more than 20 m/s) may occur not only from this sector but also from a wide NE (*gregale*) to SE (sirocco or *xlokk*) sector. Two directional sectors may then be defined:

- **ESE sector [0°N, 202.5°N[**: 39.8% of occurrences (the wind rose and the wind velocity / direction scatterplot do not allow to distinguish the NE and SE winds);
- **NW sector [202.5°N, 360°N[**: 60.2% of occurrences.

1.2.2.2. Extreme winds

The extreme wind speeds are extrapolated following the methodology presented in section 1.2.1 for the two directional sectors identified above. The extrapolation plots are presented in ***Figures A-4*** and ***A-5*** and the results summed up in Table 4 below.

Table 4 – Results of the statistical extrapolation of extreme wind speeds

Sector	Return period (year)	Wind speed (m/s)	
		Best estimation	90% confidence interval
ESE [0°N, 202.5°N[	1	17.4	*17.1 - 17.8*
	5	19.4	*18.7 - 20.0*
	10	20.1	*19.3 - 20.9*
	50	21.6	*20.5 - 23.0*
	100	22.3	*20.9 - 23.8*
NW [202.5°N, 360°N[	1	19.4	*19.1 - 19.8*
	5	21.5	*20.8 - 22.2*
	10	22.3	*21.5 - 23.2*
	50	24.2	*22.9 - 25.6*
	100	24.9	*23.5 - 26.6*

1.2.3. Waves

1.2.3.1. Wave climate

The local wave climate is detailed in the ***Appendix A*** with the following plots:

- directional wave roses in H_{m0} and T_p;
- scatter diagrams H_{m0}/θ_p, H_{m0}/T_p and T_p/θ_p;
- exceedance frequency curves for H_{m0} and T_p;
- histogram of the frequency of occurrence of H_{m0} and T_p;
- correlograms H_{m0}/θ_p, H_{m0}/T_p and T_p/θ_p.

Figure 14 below illustrates the wave rose in significant wave height H_{m0}.

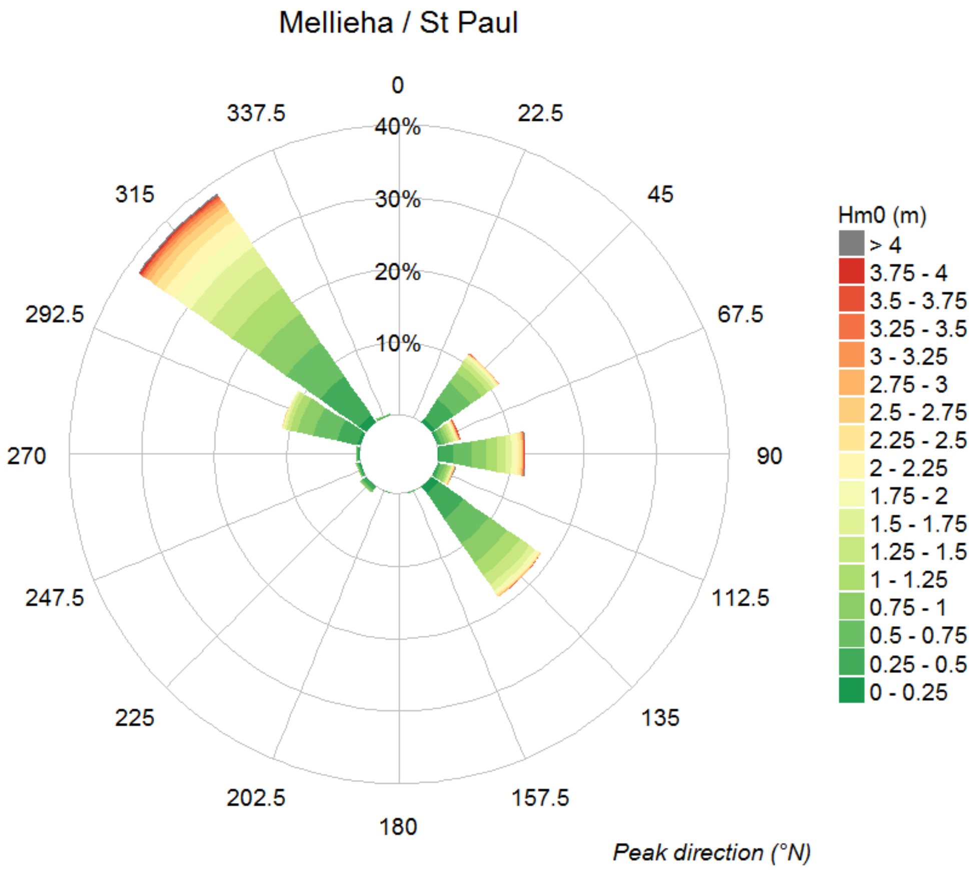


Figure 14. Wave rose off Valletta

The NW sector (*majjistral*) is still predominant (around 45% of sea states). However, it is seen that a significant part of the sea states come from NE, E and SE directions. Figure 15 splits the omnidirectional H_{m0} exceedance frequency curve (in black) into curves for each directional sector that may be distinguished:

- NE sector [0°N, 67.5°N[: 14.0% of sea states;
- E sector [67.5°N, 112.5°N[: 13.9% of sea states;
- SE sector [112.5°N, 157.5°N[: 19.9% of sea states;
- SW sector [180°N, 275°N[: 2.4% of sea states;
- NW sector [275°N, 360°N[: 49.7% of sea states.

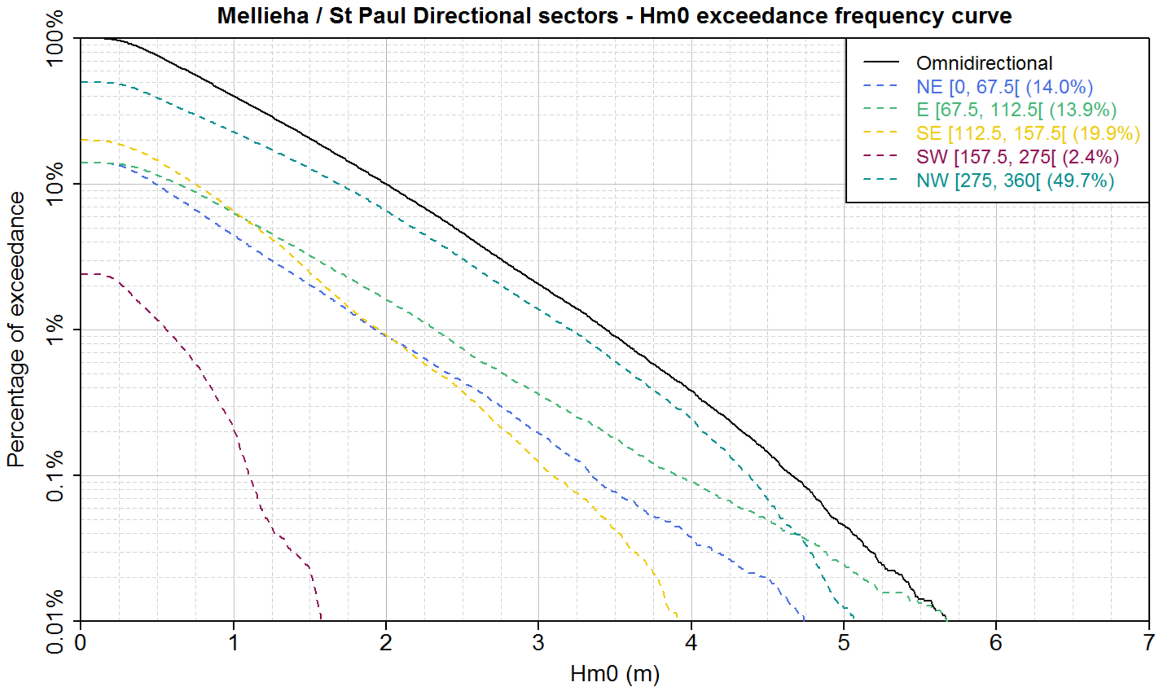


Figure 15. Exceedance frequency curves off Valletta: omnidirectional and per directional sector

1.2.3.2. Extreme waves

The extreme wave heights are extrapolated following the methodology presented in section 1.2.1 for the main directional sectors E, NE and NW as identified above. The extrapolation plots are presented in ***Figures A-14*** to ***A-19*** and the results summed up in Table 5 below. In addition, the ranges of peak periods T_p associated to the extreme wave heights are estimated by interpolating power laws that keep the wave steepness constant (see ***Figure A-15*** for an illustration).

Table 5 – Results of the statistical extrapolation of extreme wave heights

Sector	Return period (year)	H_{m0} (m)		T_p (s)
		Best estimation	90% confidence interval	
NE [0°N, 67.5°N[	1	3.41	*3.24 - 3.59*	*7.0 - 10.0*
	5	4.54	*4.16 - 4.95*	*8.0 - 11.5*
	10	5.01	*4.51 - 5.55*	*8.5 - 12.0*
	50	6.07	*5.27 - 6.98*	*9.5 - 13.0*
	100	6.51	*5.57 - 7.61*	*9.5 - 13.0*
E [67.5°N, 112.5°N[	1	3.66	*3.45 - 3.90*	*7.5 - 11.5*
	5	5.16	*4.70 - 5.67*	*9.0 - 13.0*
	10	5.75	*5.11 - 6.45*	*9.5 - 14.0*
	50	6.99	*5.70 - 8.50*	*10.5 - 15.0*
	100	7.47	*5.82 - 9.53*	*10.5 - 15.5*
NW [275°N, 360°N[	1	4.47	*4.36 - 4.58*	*8.5 - 11.5*
	5	5.12	*4.91 - 5.33*	*9.0 - 12.5*
	10	5.35	*5.09 - 5.63*	*9.5 - 12.5*
	50	5.85	*5.45 - 6.30*	*9.5 - 13.0*
	100	6.05	*5.59 - 6.57*	*10.0 - 13.5*

Although the NW sector is the predominant sector in terms of size, the largest wave heights come from the E sector. However, the large width of the confidence interval associated to the extrapolation of this sector shows a large uncertainty for the highest return periods.

oOo

2. TASK B: HYDRODYNAMIC STUDY

2.1. DESCRIPTION OF THE FISH FARM

2.1.1. Fish farm location and structure

The proposed extended fish farm is located approximately 4.5 km offshore and will be composed of 24 cages, which includes the 12 existing cages and the projected additional 12 cages (the northeastern row). Each cage is circular with a diameter of 50 m. The distance between the sides of the nets from the cages is 30 m. The mesh size of the net is 70 x 70 mm and the twine diameter is 5 mm.

2.1.2. Local bathymetric survey

Two bathymetric surveys have been carried out in 2016 and 2018 for the area of the farms and the area further offshore. The resulting bathymetry is illustrated in Figure 16 below (the location of the fish farm is illustrated in green).

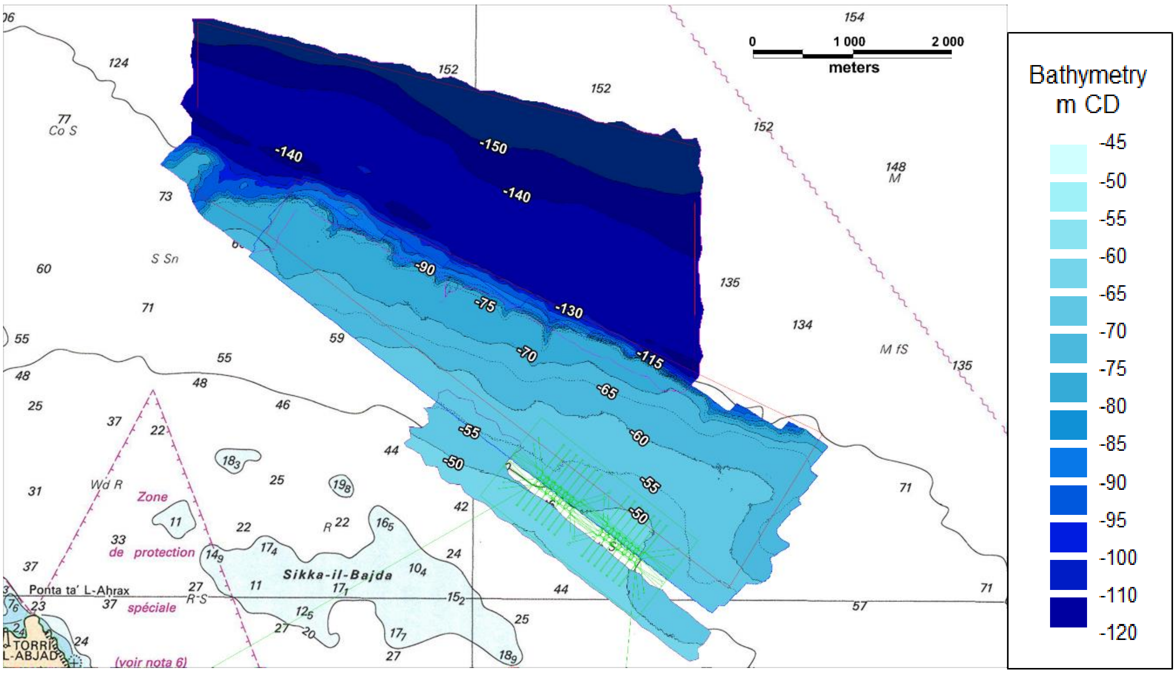


Figure 16. Bathymetric survey (2016-2018)

2.1.3. Fish farm characteristics and waste products

The tunas will be distributed in 24 cages. Each cage will contain approximately 1,200 fishes with an average mass of 115 kg, which means each cage contains around 137.5 tons of fish. This stocking density in the cage corresponds to the maximum capacity of the farm, as defined by the ICCAT quota of AJD Tuna Ltd and MML together. The farmed tuna are fed defrosted baitfish once a day, which are distributed until satiation of the tuna. The baitfish is composed of whole sardine, mackerel and herring. Approximately 5,500 kg of baitfish per day is provided to each cage to feed the farmed tuna.

The waste product from tuna fattening includes fish oil released from baitfish feed, uneaten baitfish, and solid and dissolved waste excreted by the tuna (Figure 17). Uneaten baitfish, solid and liquid wastes are a source of nitrogen and phosphorus to the marine environment. The uneaten baitfish and the tuna faeces are subject to degradation in the water column and therefore release nutrients in dissolved form in the marine environment.

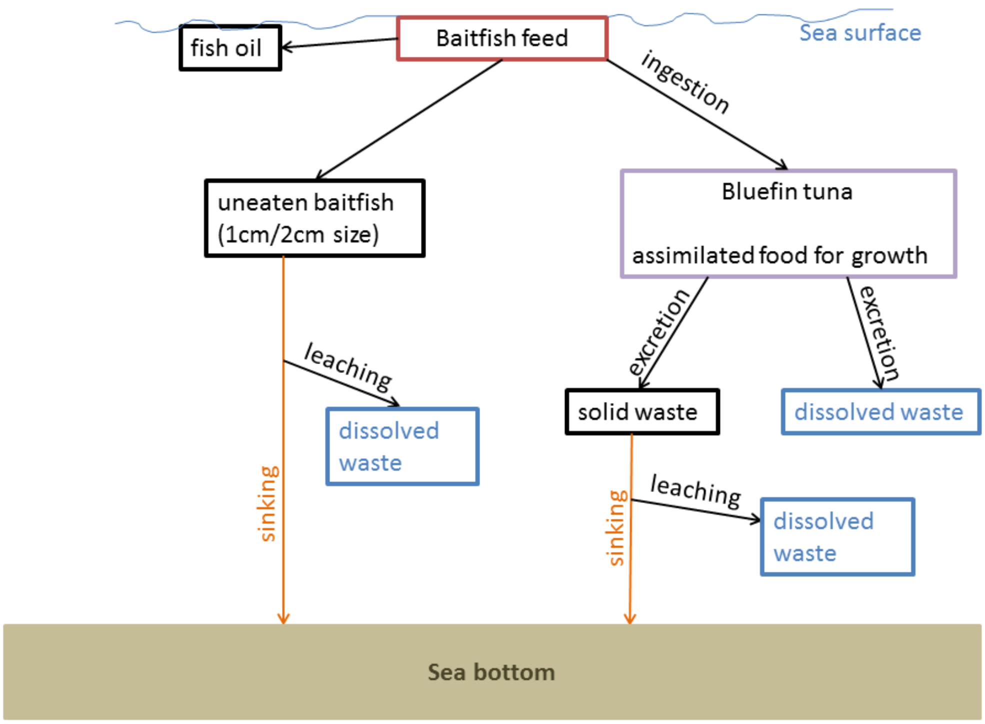


Figure 17. Schematic of the food chain and the by-products of the fish rearing

The following assumptions are made for the daily baitfish feed (source: AJD Tuna Ltd):

- 0.5% passes through the net uneaten;
- 5% is lost as fish oil per day;
- 94.5% is ingested by tuna.

Therefore, the amount of uneaten baitfish represents 27.5 kg/day/cage, the mass of fish oil released is 275 kg/day/cage, and the food intake by tuna is 5,197.5 kg/day/cage.

2.2. HYDRODYNAMIC MODEL

2.2.1. Presentation of the modelling software

The study is based on the set up of a 3D numerical model using the **TELEMAC-3D** modelling software. TELEMAC-3D is part of the TELEMAC-MASCARET system (www.opentelemac.org) and is designed to study environmental processes in free surface transient flows. TELEMAC-3D solves three-dimensional hydraulic equations and transport-diffusion equations for intrinsic values such as temperature, salinity and other tracer concentrations (with possible settling velocity). TELEMAC-3D makes use of the flexibility of unstructured grids, which allows increasing the number of computational grid points near areas of interest or of complex features (irregular coastline and bathymetry, harbour for example).

The main results obtained at each point of the computational grid are the water level, the velocity in the three directions and the concentration of tracers like salinity, temperature, pollutants, etc. The main applications of TELEMAC-3D are in free-surface maritime or estuarine hydraulics. The model can consider the following phenomena:

- influence of temperature and/or salinity on density;
- bottom friction;
- influence of the Coriolis force;
- influence of meteorological conditions (wind, pressure);
- heat exchanges with the atmosphere;
- fluid and momentum sources and sinks within the domain;
- simple or complex turbulence models including effects of Archimedes' forces (buoyancy);
- wetting and drying of coastal areas (tidal flats);
- tracer transport and diffusion by the current, with source and sink terms.

TELEMAC-MASCARET system was developed by the National Hydraulics and Environment Laboratory, a department of Electricité de France's Research and Development Division. TELEMAC-MASCARET is managed by a consortium of organisations, among which ARTELIA. The system is constantly updated by the members of the core group to improve its performances and its capabilities to treat complex engineering situations.

The model takes into account all the different requirements applicable to the present study, such as the detailed characteristics of the topography near the coasts and the required hydro-meteorological forcing.

TELEMAC presents the advantage to use an unstructured mesh as it is based on a finite element technique, which allows the size of the triangular mesh to be adjusted to represent in detail any important bathymetry, or shoreline features such as channels, tidal flats, dredged area, as well as structures like harbours or dikes.

2.2.2. Model mesh and bathymetry

The 3D model used for this study represents the Mediterranean Sea between Sicily and the Tunisian and Libyan coasts. Its characteristic dimensions are 460 km in the West-East direction and 500 km in the North-South direction (Figure 18).

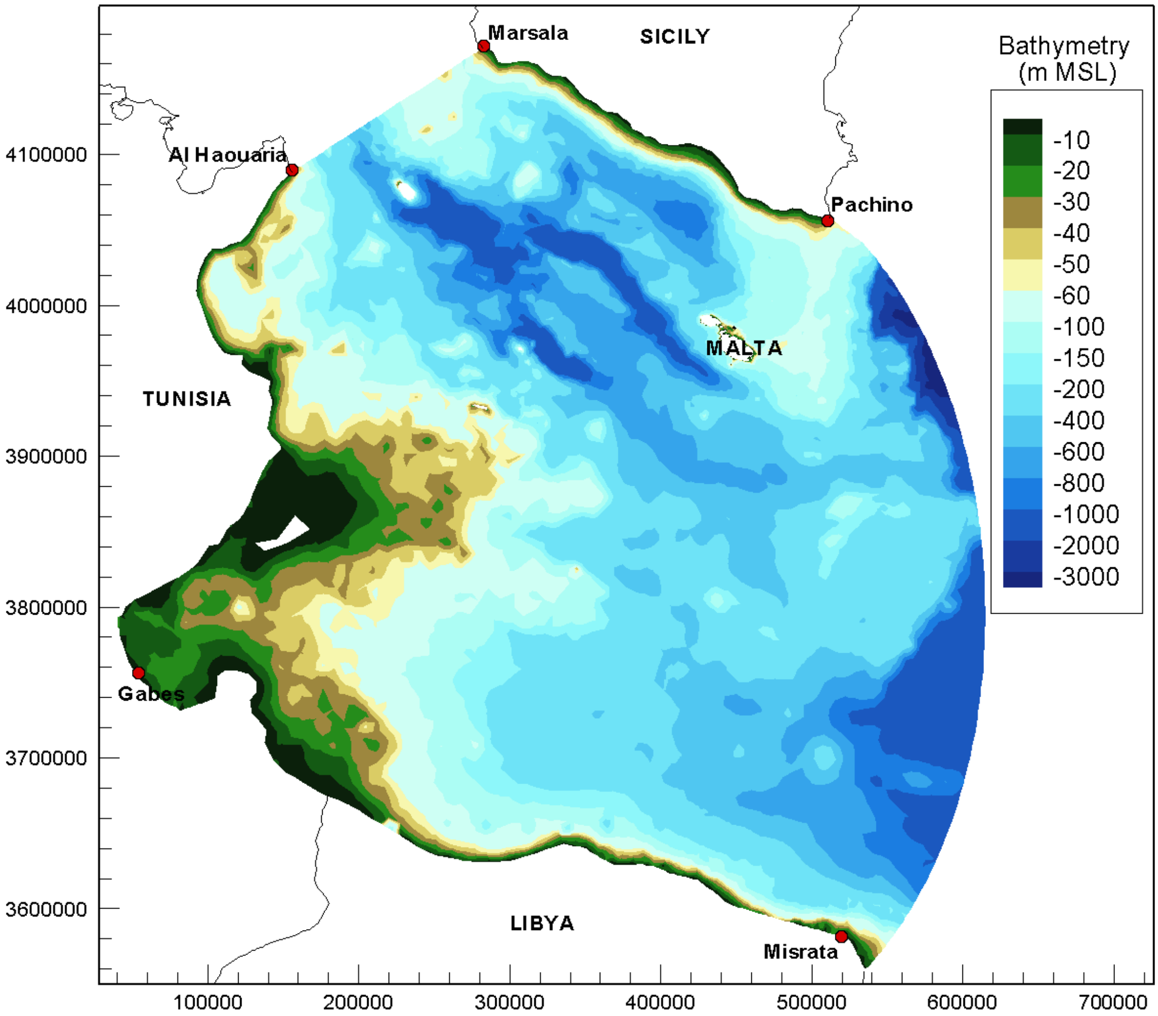


Figure 18. Model extent and bathymetry

The Digital Elevation Model (grid of bathymetric and topographic values constructed using raw data) is based on:

- GEBCO database (General Bathymetric Chart of the Oceans);
- digitized Shom (French Naval Hydrographic and Oceanographic Service) Charts n° 6606 (*Canal de Sicile*) and n° 7339 (*Malta et Ghawdex*);
- results of bathymetric surveys carried out on the project area in 2016 and 2018 (Figure 16).

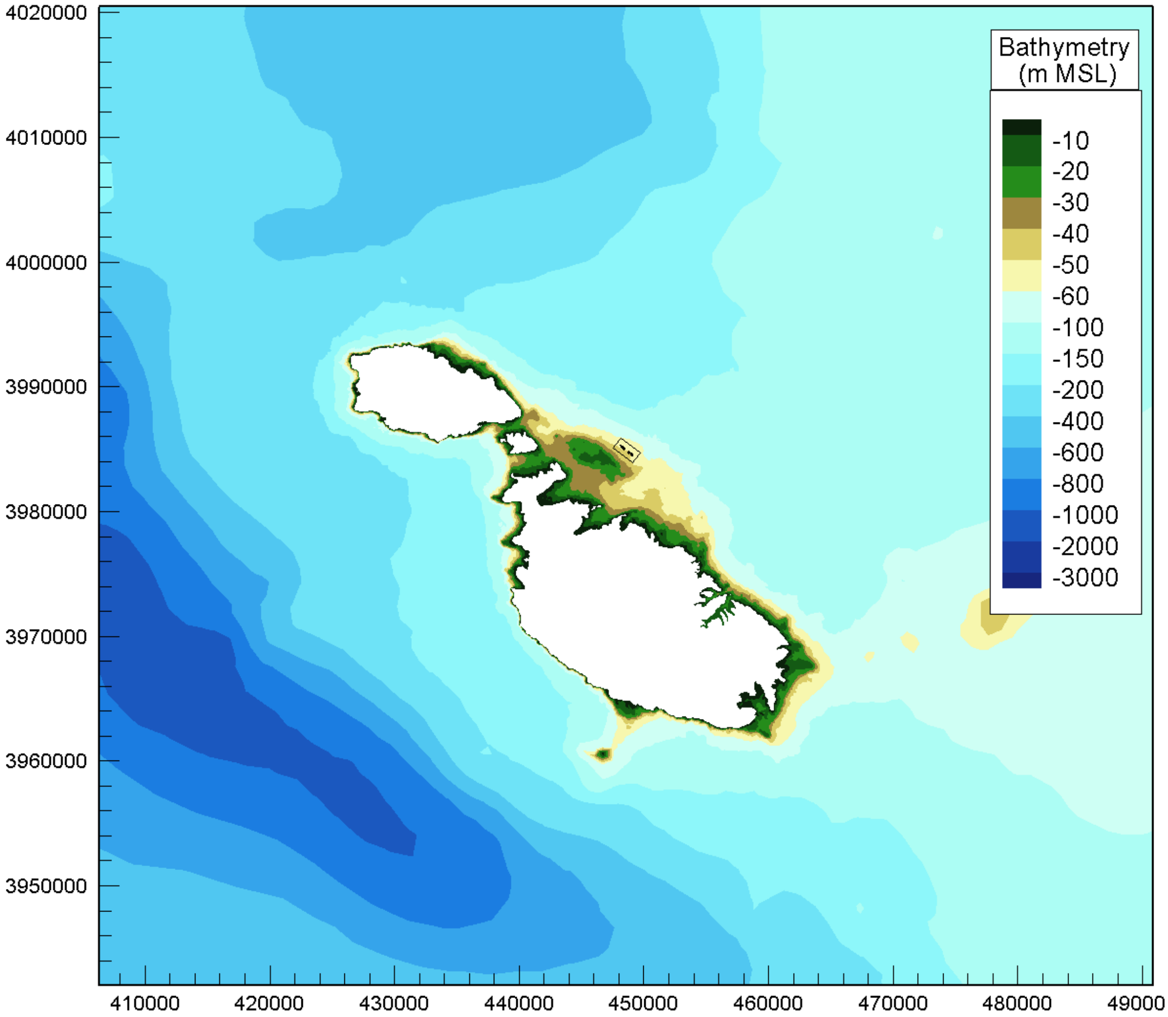
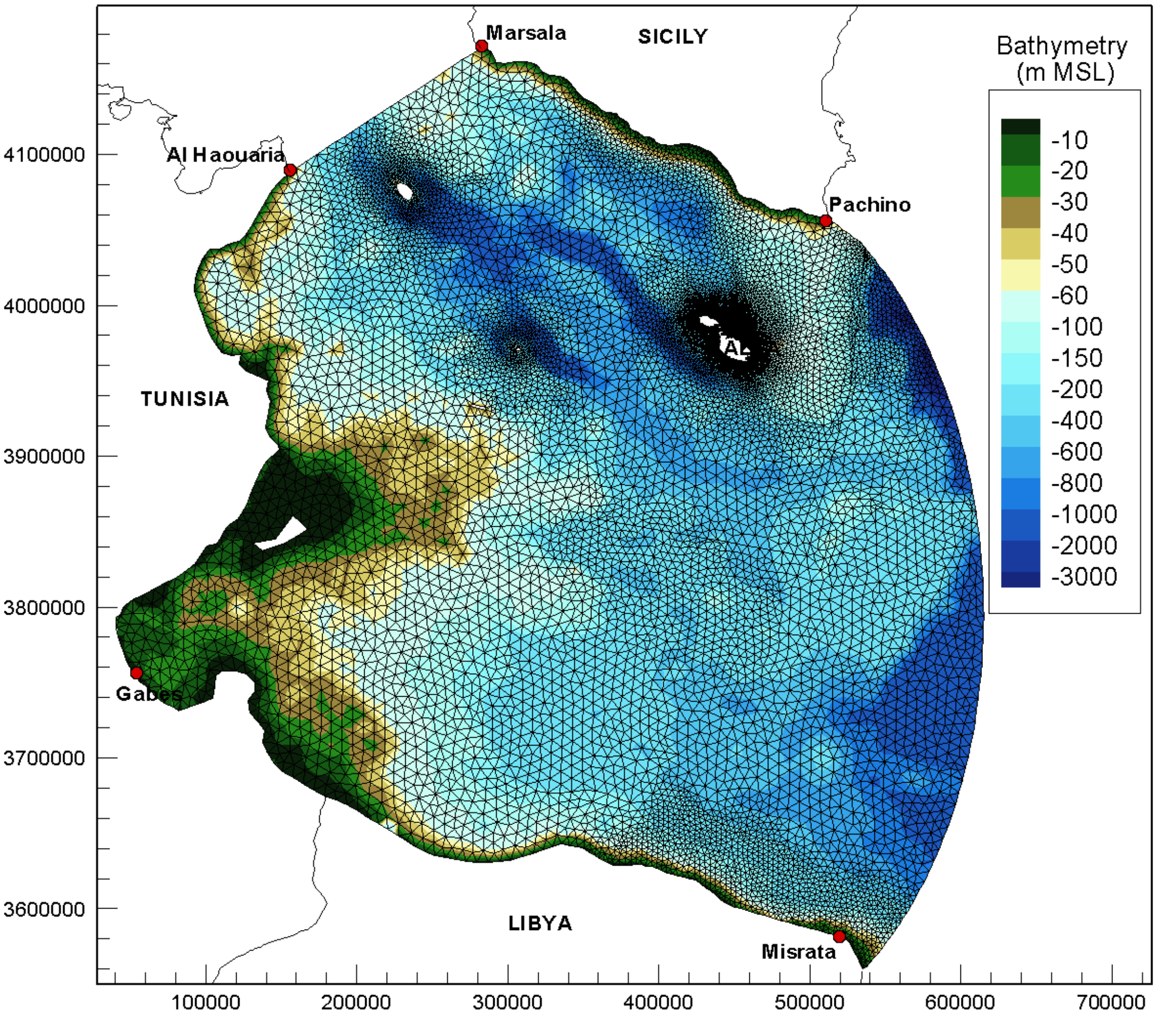


Figure 19. Model bathymetry around Malta

The altimetric references of all these data have been standardised at the Mean Sea Level (MSL).

The unstructured computation grid, called mesh, is composed of triangles of different sizes according to interest zones. In the present study, the size of the mesh is greater than 8 km offshore and is reduced to less than 5 m around the fish pens. The horizontal grid is composed of approximately 36 000 nodes and 70 000 elements (Figure 20).

The horizontal mesh is then reproduced on the vertical to create the three-dimensional mesh consisting of triangular-based prismatic elements. The lower plane follows the bathymetry while the upper plane follows the evolution of the free surface over time. The three-dimensional mesh is composed of 13 horizontal planes.


Marsala
SICILY
Al Haouaria
Pachino
TUNISIA
Gabes
LIBYA
Misrata
Bathymetry (m MSL)
-10
-20
-30
-40
-50
-60
-100
-150
-200
-400
-600
-800
-1000
-2000
-3000
4100000
4000000
3900000
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3600000
100000
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300000
400000
500000
600000
700000

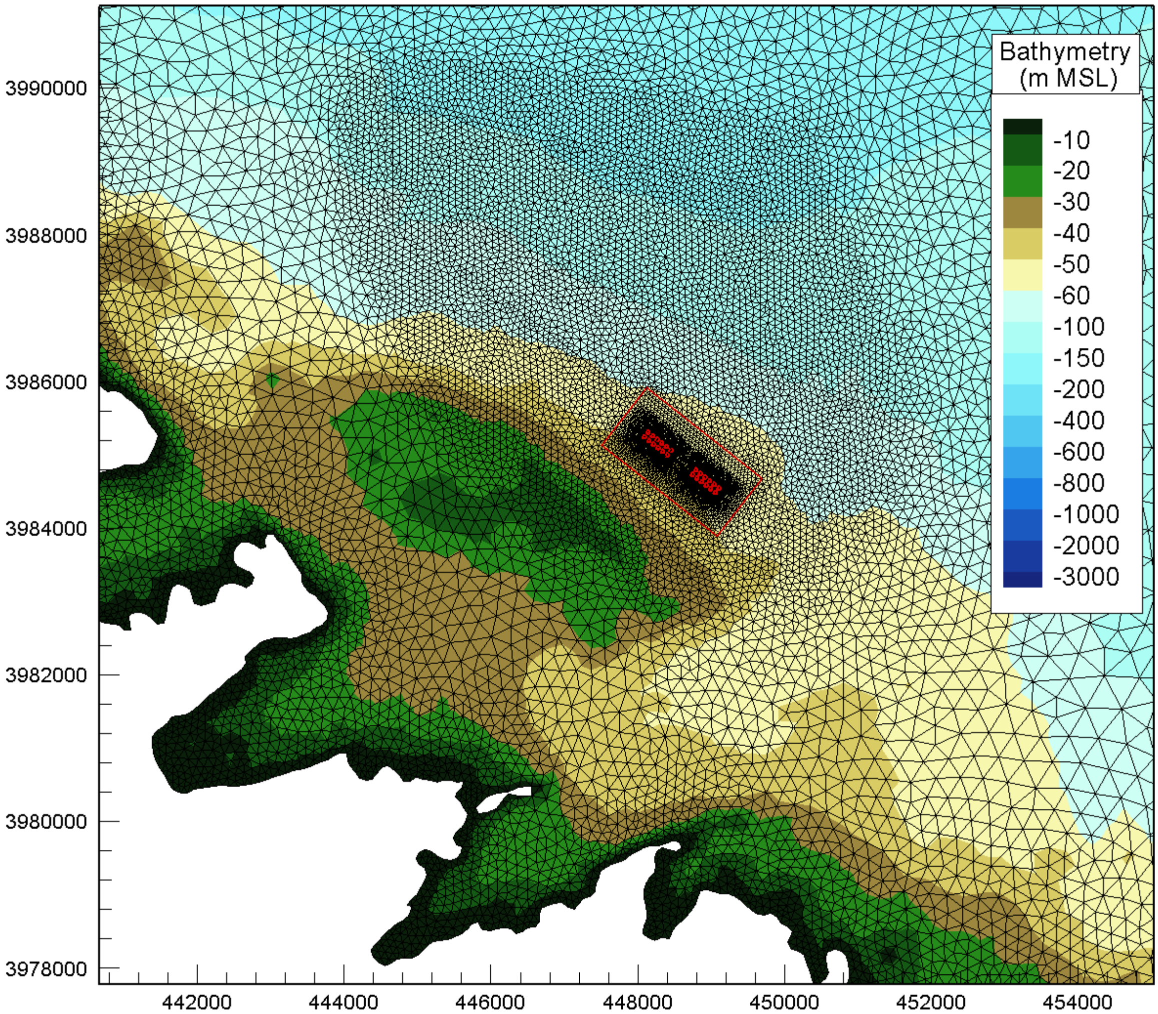


Figure 20. **Global model mesh and zoom on the project area**

2.2.3. Drag force

The flow around the fish pen is reduced by the cage net. This influence is represented by a drag force applied locally on the fish pen. The drag force takes the form of the Morrison equation:

$$Fx = \frac{1}{2}\, \rho\; Ap\; Cd\; |V|\vec{V} \qquad (1)$$

where:

- ρ water density (kg/m^3);
- C_d drag coefficient;
- V flow velocity (m/s);
- A_p projected area of all threads (m^2).

A_p is calculated using the total area of the outline area of the mesh net A and the solidity ratio S:

$$A_p = S \times A \qquad (2)$$

The solidity ratio depends on the twine diameter d and the mesh size a:

$$S = \frac{2\,a\,d - d^2}{a^2} \tag{3}$$

The drag force is applied from 0 to 35 m depth. The drag coefficient C_d is expressed for a knotted net as a function of the twine diameter d and the mesh size a (***Milne, 1970***):

$$C_d = 1 + 3.77\frac{d}{a} + 9.37\left(\frac{d}{a}\right)^2 \tag{4}$$

In the present case, $d = 5$ mm and $a = 70$ mm. A summary of the parameter value is given in Table 6. Other parameters, which can influence the flow reduction like the degree of fouling and the stocking density are not accounted for in the parameterization.

Table 6 – Drag force parameters

Parameter	Value	Source
a	0.07 m x 0.07 m	AJD Tuna Ltd
d	0.005 m	AJD Tuna Ltd
S	0.138	calculated
C_d	1.32	calculated

A series of tests have been carried out by ***Aarsnes et al (1990)*** for different solidity ratio values to study the velocity distribution within net cage systems. It concluded that the velocity reduction from cage to cage is estimated to be 20% (19.7% solidity), 30% (40.8% solidity) and 58% (58.8% solidity) with an inlet velocity of 1 m/s.

Some tests are also performed in this study to ensure that the numerical model can simulate correctly the flow field around the project. For these simulations, the bathymetry in the AJD & MML fish farms region is defined as constant (-50 m MSL). A constant current is imposed upstream of the farm, with a constant direction along net cages. The flow fields near the cages are investigated with different upstream velocities: 10 cm/s, 50 cm/s and 1 m/s.

Figure 21 presents the calculated flow field on a vertical plane through the first row of six cages with an upstream velocity of 50 cm/s. The flow velocity continuously decreases along the flow direction due to the drag force exerted by the netting. A slight increase of the flow velocity is also observed beneath the first net cages. These observations are consistent with the laboratory experiments.

The attenuation of flow velocity in the wake of the first three cages is given in Table 7, at 10 m below the surface. The simulated velocity reduction is about 15% from one cage to the next cage, which is consistent with the ***Aarsnes et al (1990)*** experiments for the same range of the solidity ratio.

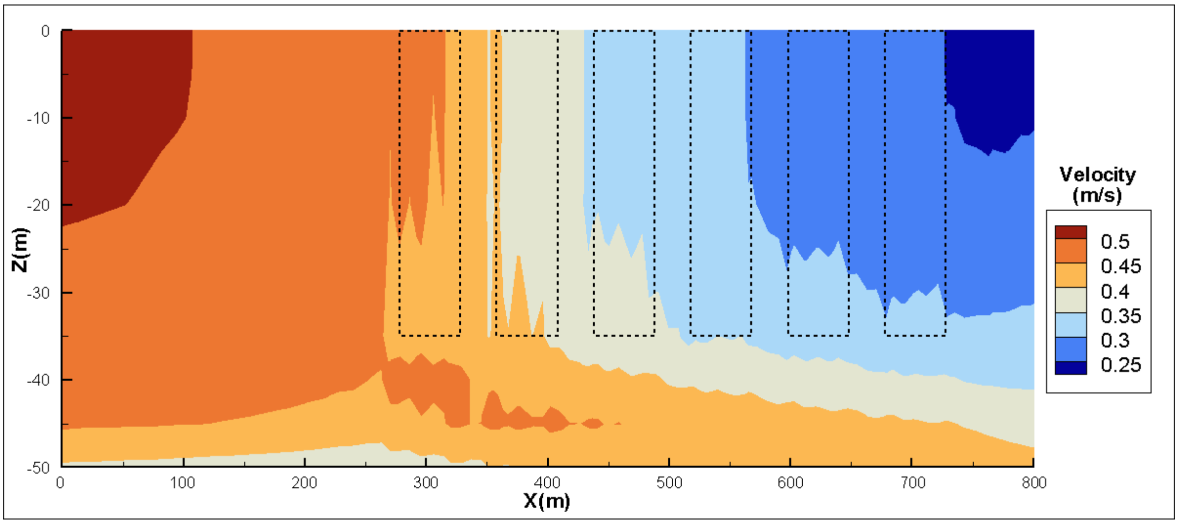


Figure 21. Flow field on a vertical plane along the cages with an upstream velocity of 50 cm/s. Locations of the six cages are indicated by the dotted lines.

Table 7 – Velocity reduction in the wake of cages

Source	Solidity ratio	Upstream velocity	Velocity behind the cage (% of upstream velocity)		
			Wake of 1st cage	Wake of 2nd cage	Wake of 3rd cage
Aarsnes et al, 1990	*0.197*	*1 m/s*	*80%*	*64%*	*51%*
calculated	0.138	1 m/s	85%	72%	64%
calculated	0.138	0.5 m/s	84%	71%	63%
calculated	0.138	0.1 m/s	82%	70%	65%

2.2.4. Forcing data

The regional model above is forced at its boundaries with inputs from the following available datasets:

- Spatial and temporal varying wind datasets from IFREMER CERSAT available from the COPERNICUS marine environment monitoring services. The IFREMER CERSAT Global Blended Mean Wind Fields include wind components (meridional and zonal), wind module, wind stress. They are estimated from scatterometers ASCAT and OSCAT retrievals and from ECMWF operational wind analysis with a horizontal resolution of 0.25 x 0.25 degrees. They are available at synoptic time 00:00; 06:00; 12:00; 18:00 since 1st January 2015.
- Results from a numerical model of the Mediterranean Sea, namely products MEDSEA_REANALYSIS_PHY_006_004 with a resolution of 1/16° degree, from the COPERNICUS marine environment monitoring. The 72-level vertical discretization retained for this system has 1 m resolution at the surface, decreasing to 450 m at the bottom, and 22 levels within the upper 100 m. This product makes use of data assimilation of Sea Surface Temperature, Sea Level and In situ Temperature and Salinity profile. This product includes daily mean files of potential temperature, salinity, currents, sea level, horizontal currents from the top to the bottom over the whole Mediterranean Sea.
- Tidal elevations from the FES 2012 atlas. FES 2012 is based on the resolution of the tidal barotropic equations in a spectral configuration using T-UGO model, developed by LEGOS, NOVELTIS and CLS (company based in Toulouse, France), in collaboration with CNES

(French Spatial agency) in Toulouse, France. The numerical solution is improved by assimilating long-term altimetry data (Topex/ Poseidon, Jason-1, Jason-2, ERS-1, ERS-2 and ENVISAT) through an improved assimilation method. FES 2012 provides 32 tidal constituents distributed on a grid with a resolution of 1/16°.

2.2.5. Period selected for the hydrodynamic simulations

The direction and intensity of the wind from CERSAT on the AJD/MML fish farms from June to September 2015 are plotted in Figure 22 and Figure 23. Winds blowing from the northwest are predominant. In June and September 2015, periods of wind intensity above 10 m/s occurred. A lower dispersion of the pollutants occurs when wind intensity is the lowest, therefore July and August represent the most unfavourable conditions over the whole summer period. The wind field from the 1st to 31st August 2015 is selected for the simulations, as it is characterised by:

- light to moderate wind condition with a wind intensity below 10 m/s;
- varying direction of the wind, and more specifically a period of time with a persistent wind blowing from East to West from 25th to 30th August 2015.

These time series are representative of typical summer wind conditions.

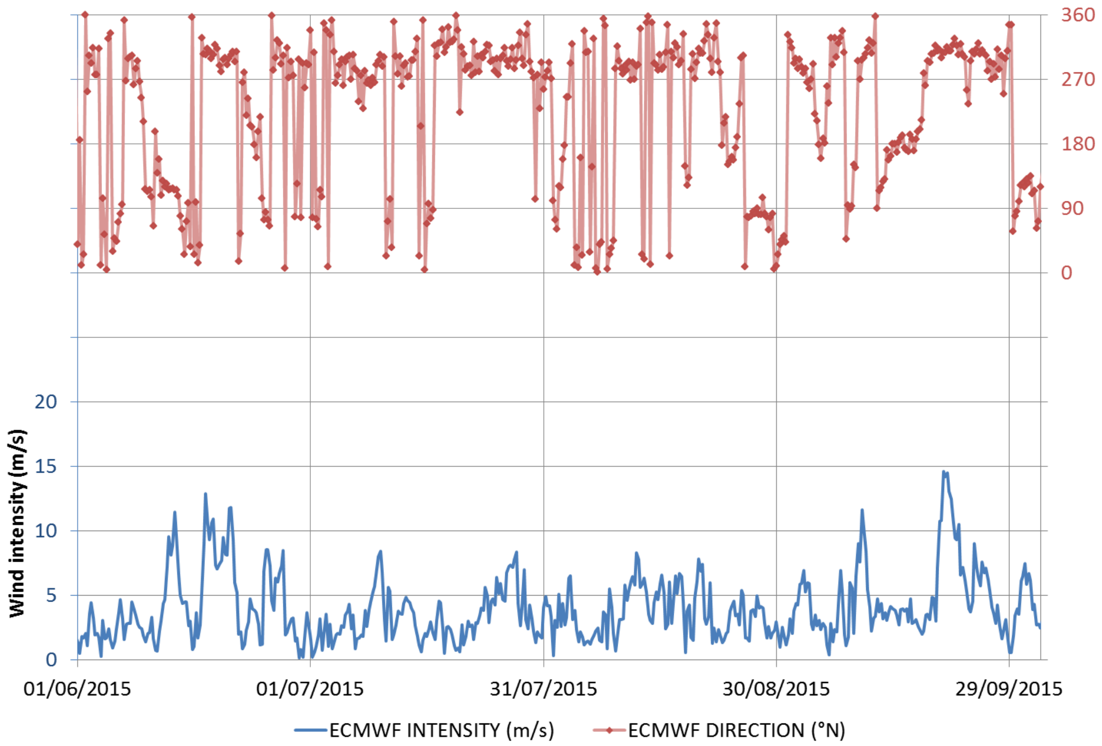


Figure 22. Time-series of the wind intensity and direction (meteorological convention) on the study site

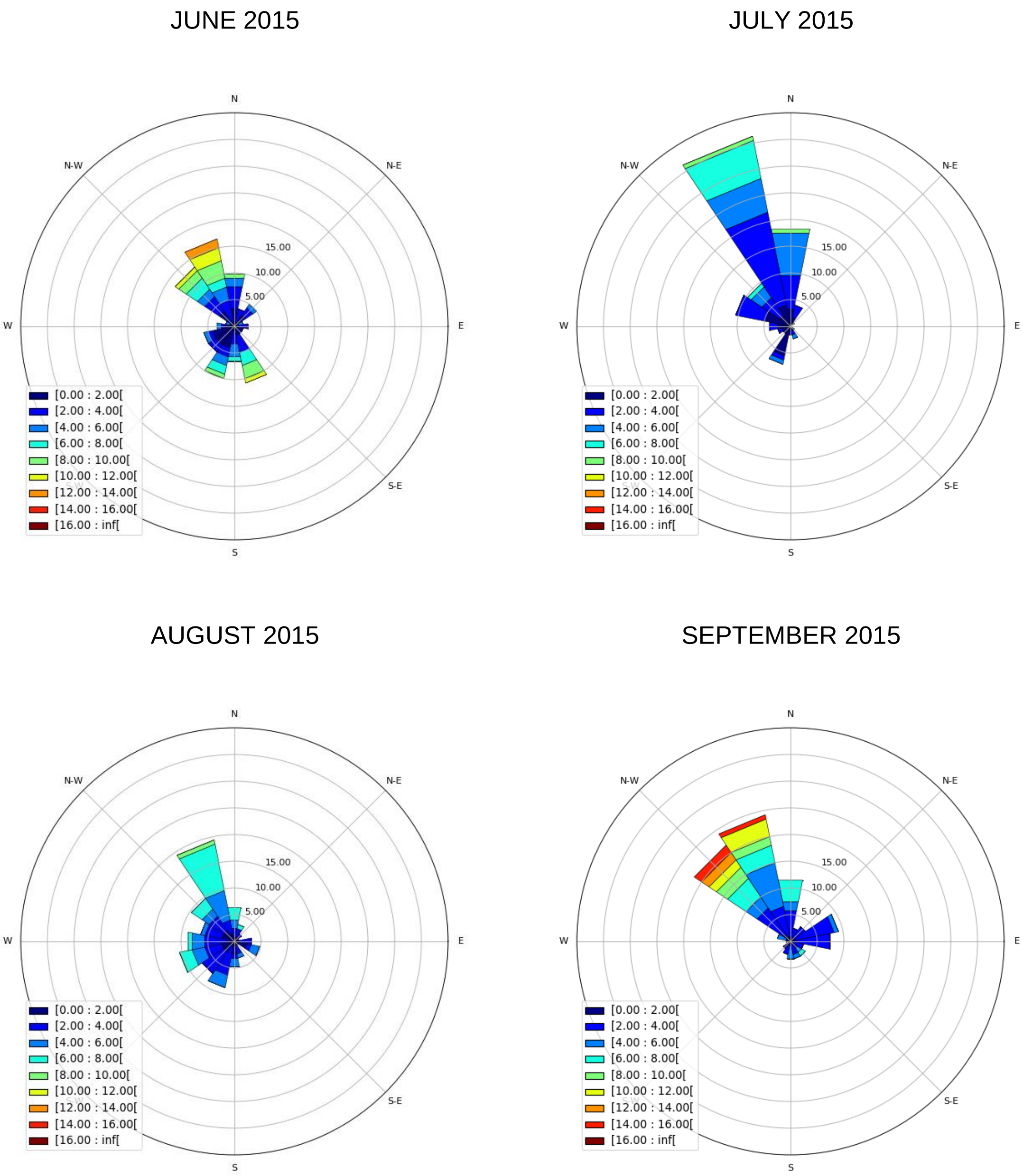


Figure 23. Wind roses on the AJD/MML location (wind direction in meteorological convention)

2.2.6. Baseline situation and model validation

A first simulation was carried out over August 2015, without taking into account the fish pens of the AJD/MML farms. This calculation validates the model and it will serve as a reference state for calculating the hydrodynamic impact of the pens.

Figure 24 shows the comparison of the water levels calculated by the model to the predictions provided by the Shom (French national hydrographic service) at the port of Valletta.

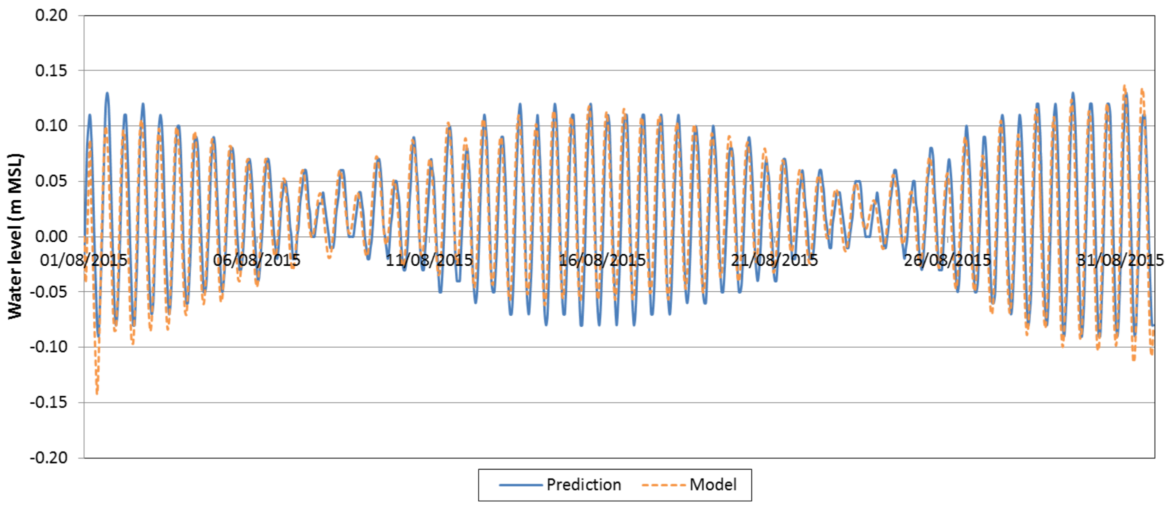


Figure 24. Comparison of water levels

Changes in tidal water levels are very low in Valletta. The maximum tidal range is about 20 cm. The model accurately reproduces the variation in tidal range between neap tide and spring tide.

No current measurement is available in the project area. The following maps (Figure 25) show the current fields from the model (on the right) at different moments of the simulation and at 2 m below the surface, compared to those extracted from the MyOcean model (on the left), which serve as forcing conditions.

Results of the MyOcean model are provided on a 1/16 degree resolution grid (5.63 km x 6.94 km). Due to the coarse model resolution, it does not correctly represent the hydrodynamics close to the coast, and especially in the project area.

The general circulation around the island of Malta is comparable to the global ocean model Myocean. More specifically, the specific features are represented:

- the Atlantic Ionian Stream on the Malta channel flowing from the Northwest to the Southeast direction is represented;
- presence of mesoscale features like eddies and meanders, whose positions vary.

Current intensity are lower in the Telemac model by 5 cm/s compared to the global model on some areas.

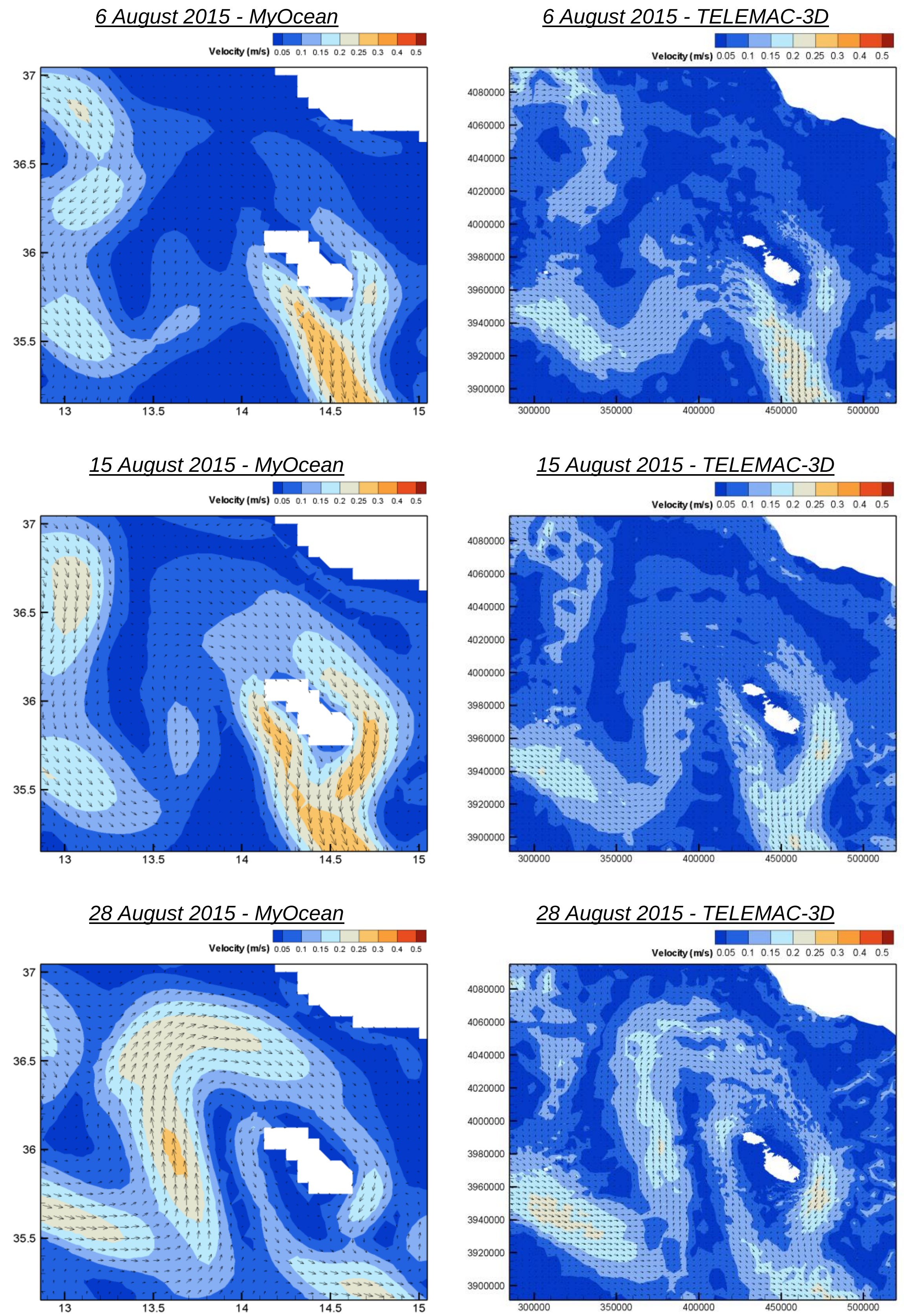


Figure 25. Comparison of the velocity fields at 2 m under the sea surface

2.2.7. Impact of the fish cage on the velocity field

Figure 26 shows the temporal evolution of the current velocity at 2 m below the surface, at a point of the project area (black point on the figure below), for the simulation without the fish pens. This graph shows that the current velocity on site is always below 10 cm/s. Due to the global currents offshore, the main direction of the current in the project area is South-South-East. The influence of the tide on currents (velocity and direction) is low.

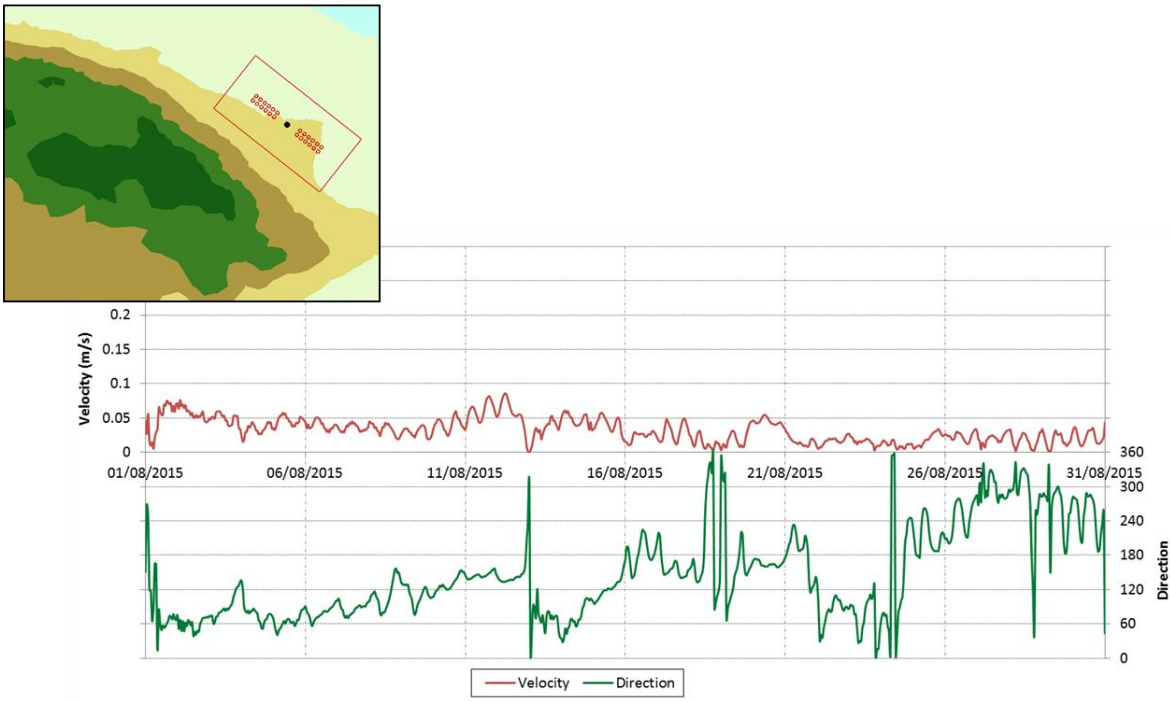


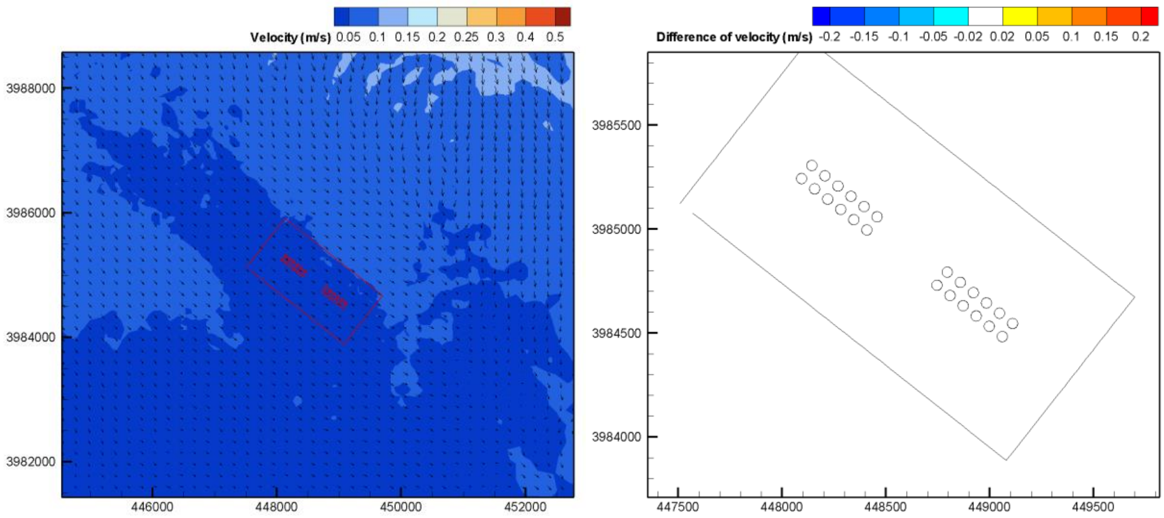
Figure 26. Current velocity at the AJD/MML fish farm (baseline siuation). Location is indicated by the black point on the map

Figure 27 below shows the current field in the project area at different times for the reference state with no cage (left) and the difference of velocity between the cases with and without fish pens (right). Given the low speed of the ambient currents, the impact of the fish pens on the current velocity is less than 5 cm/s (in absolute value) and remains in the immediate vicinity of the cages.

Figure 28 shows the maximum current velocity reached at each computational node during the simulation, at 2 m below the surface. Figure 29 displays the maximum current velocity at 5 m depth. Dashed lines represent the bathymetry isolines. These figures demonstrate that current velocity does not exceed 10 cm/s during the simulation in the reference situation (with no cage) and the future configuration in the project area. The influence of the cages is not visible on the maximum velocity reached during the simulation and it can be deemed negligible.

10 August 2015, 6h

Baseline situation *Evolution of current velocity with the cages*



11 August 2015, 19h

Baseline situation *Evolution of current velocity with the cages*

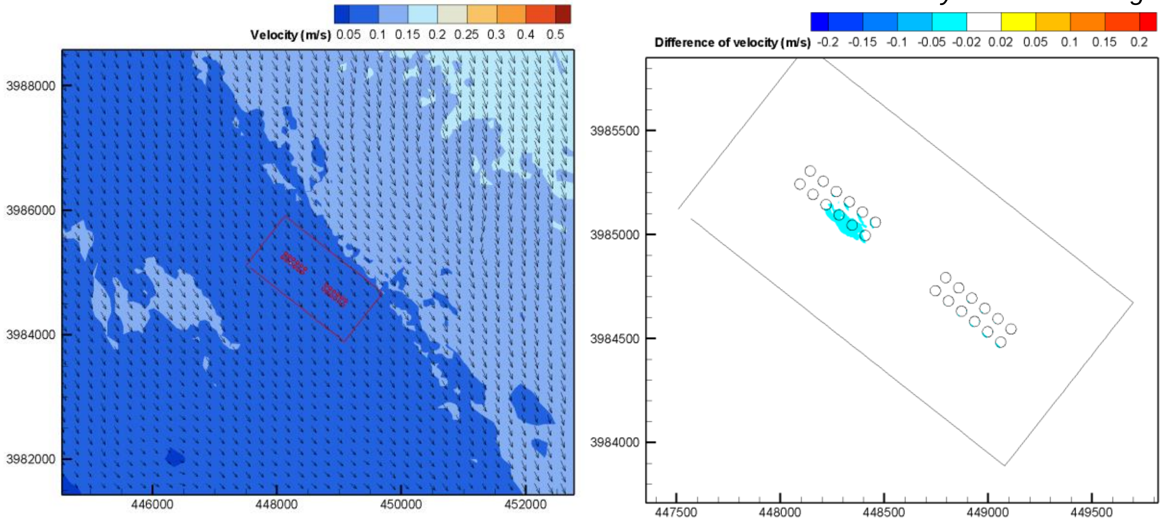
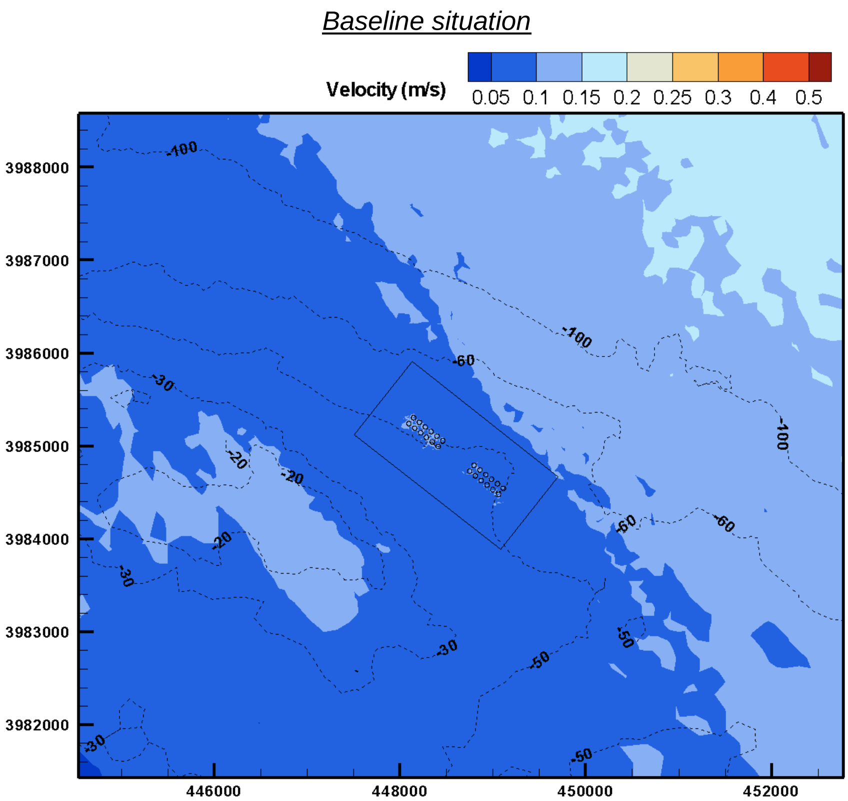


Figure 27. Current field in baseline configuration (left) and impact of the AJD/MML farm on the current velocity (right)



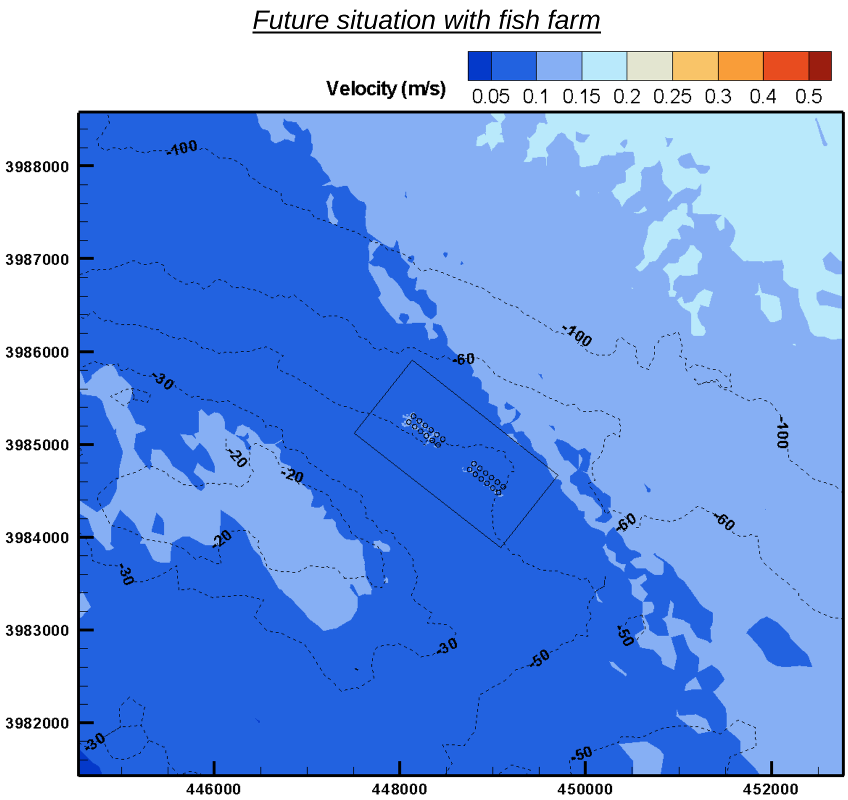
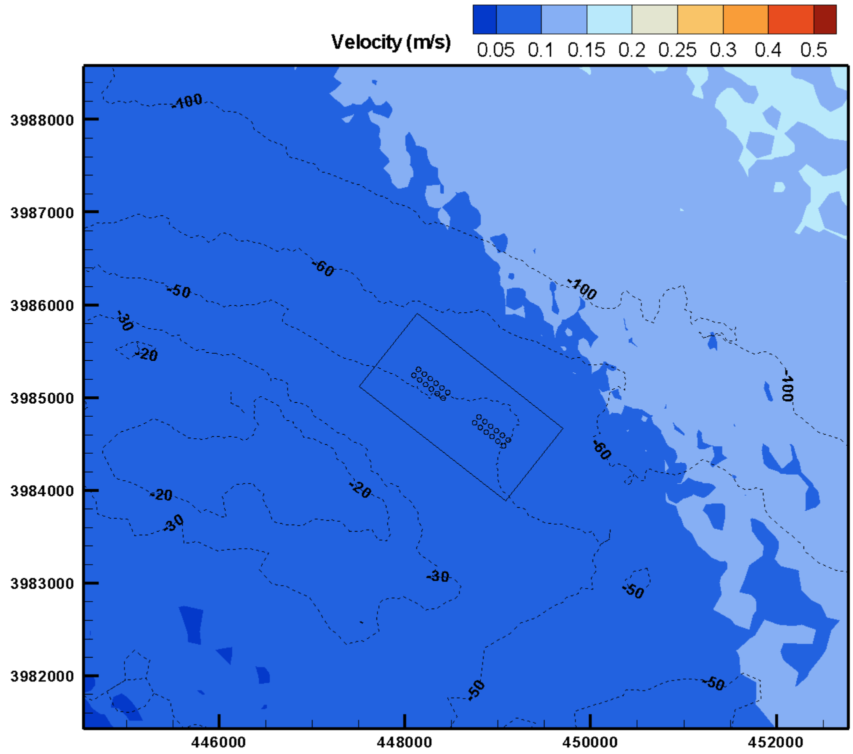


Figure 28. Maximum intensity of the velocity field in the baseline situation with no cage (top) and in the future configuration with 24 cages (bottom) at 2 m depth

Baseline situation



Future situation with fish farm

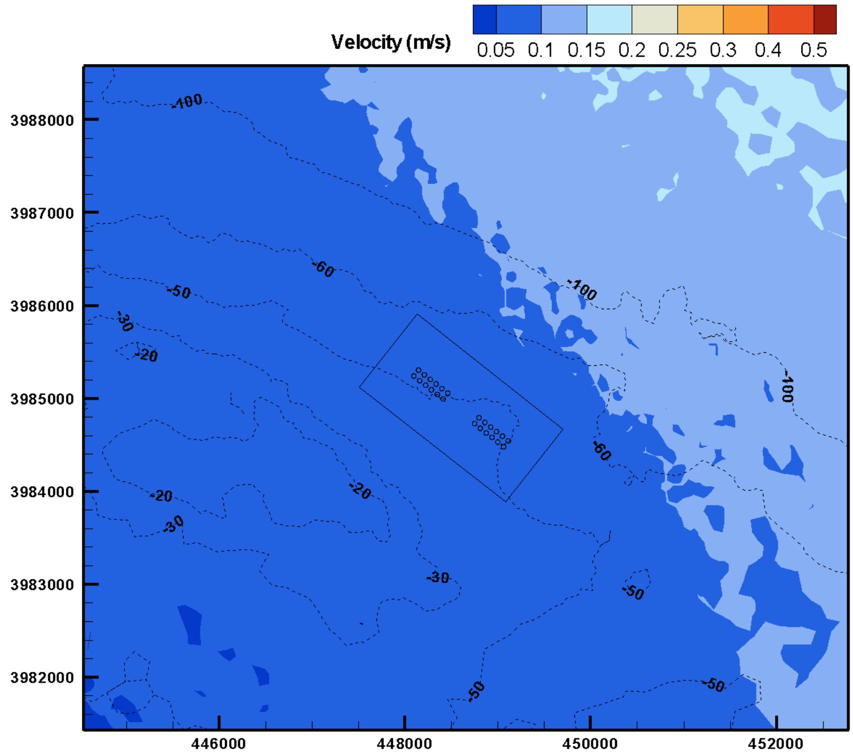


Figure 29. Maximum intensity of the velocity field in the baseline situation with no cage (top) and in the future configuration with 24 cages (bottom) at 5 m depth

2.3. ENVIRONMENTAL MODELLING

2.3.1. Enrichment in dissolved nutrients

2.3.1.1. Input data and hypotheses

The fish farm generates an increase of nutrient loads (Nitrogen N and Phosphorus P) into the water column. Dissolved nutrients originate from three sources (Figure 17):

- liquid wastes excreted directly by the fish metabolism;
- dissolved nutrients leached by tuna solid wastes;
- dissolved nutrients leached by uneaten feed.

For the assimilated food, the following amount of nutrients is estimated to be excreted directly by the Bluefin tuna metabolism as dissolved wastes: 51.69 mg P/kg fish/day and 694.27 mg N/kg fish/day in average (***Aguado-Gimenez et al, 2006***). For a cage of approximately 137.5 tons of fish, the total amount of N and P in dissolved form per day is evaluated as:

- 95.46 kg P/cage/day;
- 7.11 kg N/cage/day.

For the dissolved nutrients originating from the degradation of solid wastes, the estimation of the dissolved nutrients leached is based on the calculation of the total contents in nutrients in the solid wastes per cage (Table 8). The calculation gives the following values:

- 2.38 kg P/cage/day;
- 1.64 kg N/cage/day.

Table 8 –Dissolved nutrient leached from Bluefin tuna faeces

Parameter	Nitrogen	Phosphorus	source
Nutrient contents in faeces per day and per fish	49.45 mg /kg fish/day	70.01 mg/kg fish/day	Aguado-Gimenez et al, 2006
Nutrient contents in faeces per day in a cage	6.80 kg/cage/day	9.63 kg/cage/day	Aguado-Gimenez et al, 2006
Percentage of nutrient contents available for leaching in faeces	35%	17%	Fernandez et al, 2007
nutrient contents from faeces available for leaching	2.38 kg/cage/day	1.64 kg/cage/day	calculated

A total of 27.5 kg of baitfish remains uneaten per day in a cage, as mentioned in section 2.1.3. As the water content of baitfish is 71% (***Fernandez et al, 2007***), the dry mass of uneaten baitfish is therefore 8 kg. The amount of nitrogen and phosphorus released by uneaten baitfish is then calculated from the nitrogen content available for leaching in the remaining baitfish (Table 9). Therefore, the final amount of nitrogen and phosphorus contents leached by uneaten feed is the following:

- 0.36 kg N/cage/day;
- 0.04 kg P/cage/day.
-

Table 9 – Soluble fraction of nitrogen and phosphorus in uneaten baitfish

Parameter	Nitrogen	Phosphorus	source
Total nutrient contents in baitfish	111 mg N /g DW[11]	21 mg P /g DW	Fernandez et al, 2007
Total nutrient contents in baitfish per cage	885.23 g N /cage/day	167.48 g P /cage/day	calculated
Percentage of nutrient contents available for leaching	41%	21%	Fernandez et al, 2007
nutrient contents available for leaching	0.36 kg N/cage/day	0.04 kg P/cage/day	calculated

Therefore, the final release of nutrient contents in dissolved form in each cage of the tuna farm is the sum of all sources of nutrients (degradation of uneaten baitfish, solid wastes and liquid wastes). The final estimation of the dissolved nitrogen and phosphorus loads is:

- 98.20 kg N/cage/day;
- 8.78 kg P/cage/day.

2.3.1.2. Methodology

Each nutrient category (Nitrogen and Phosphorus) is represented in the model by a passive tracer (a tracer with no impact on hydrodynamics).

The tracer injection is done at one point in the centre of each fish pen, at -5 m MSL, with a constant flow of $5.97.10^{-5}$ m^3/s. The concentrations rejected are:

- Nitrogen: 19.04 kg/m^3;
- Phosphorus: 1.70 kg/m^3.

2.3.1.3. Results

Figure 30 shows the plume of maximum nutrient concentration reached at each point during the simulation. In the project area, currents come mainly from North-West, so the nutrient plume is orientated towards the Southeast. The maximum concentration is located at the centre of the pens, where the tracer is injected. The threshold of 0.1mg/L of total nitrogen is obtained about 1.5 km southeast of the last cages. The threshold of 0.02 mg/L of phosphorus is obtained less than 1 km southeast of the last cages.

[11] DW: dry weight

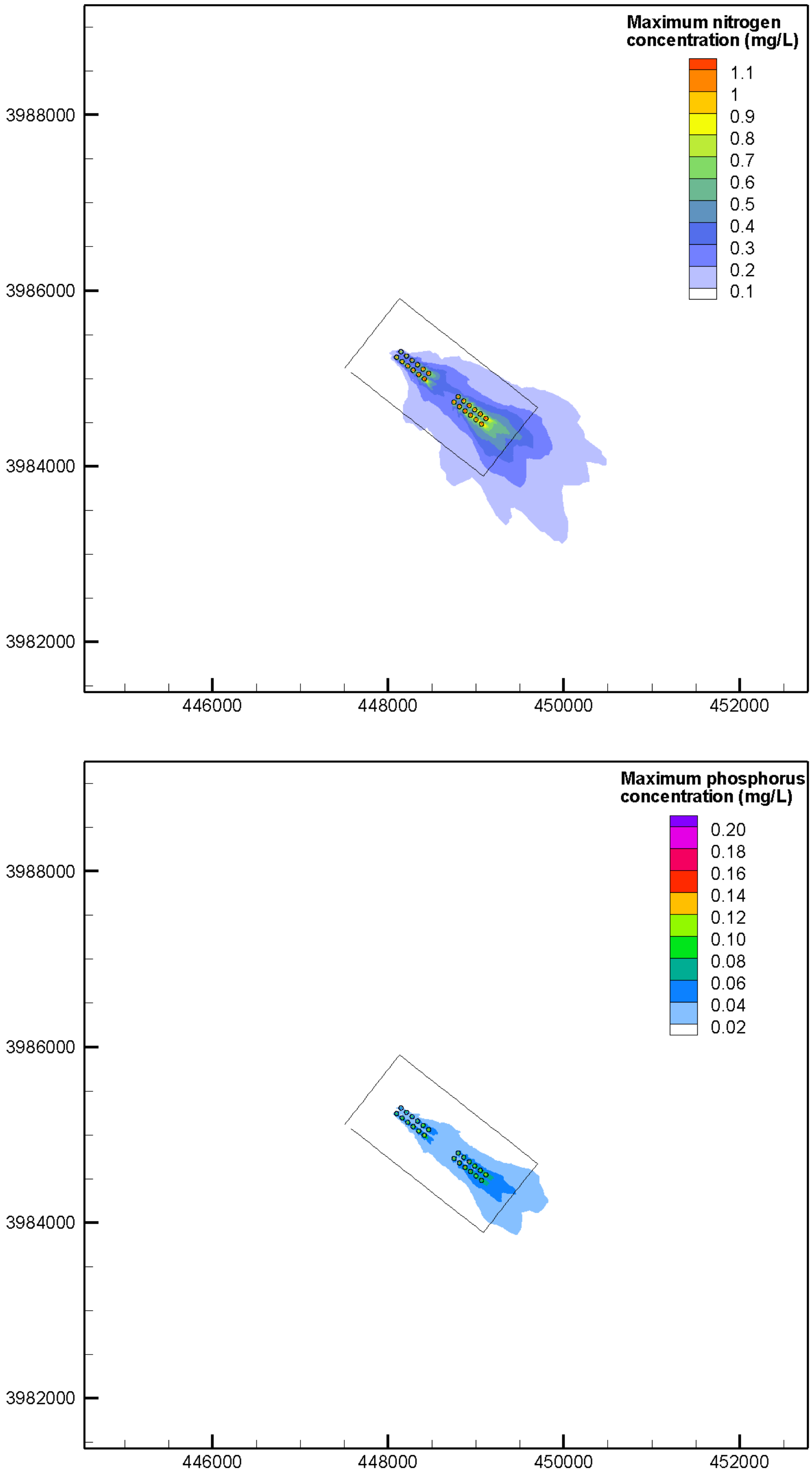


Figure 30. Maps of maximum nitrogen (top) and phosphorus (bottom) concentration

The graph in Figure 31 shows the evolution of the concentration of dissolved nutrients during the simulation, at 200 m behind the cages and at -5 m MSL. At 200 m from the cages, the maximum nitrogen concentration reached is 0.5 mg/L but the threshold of 0.1 mg/L is only exceeded by 10% over the total simulation time. The maximum concentration of phosphorus is 0.044 mg/L.

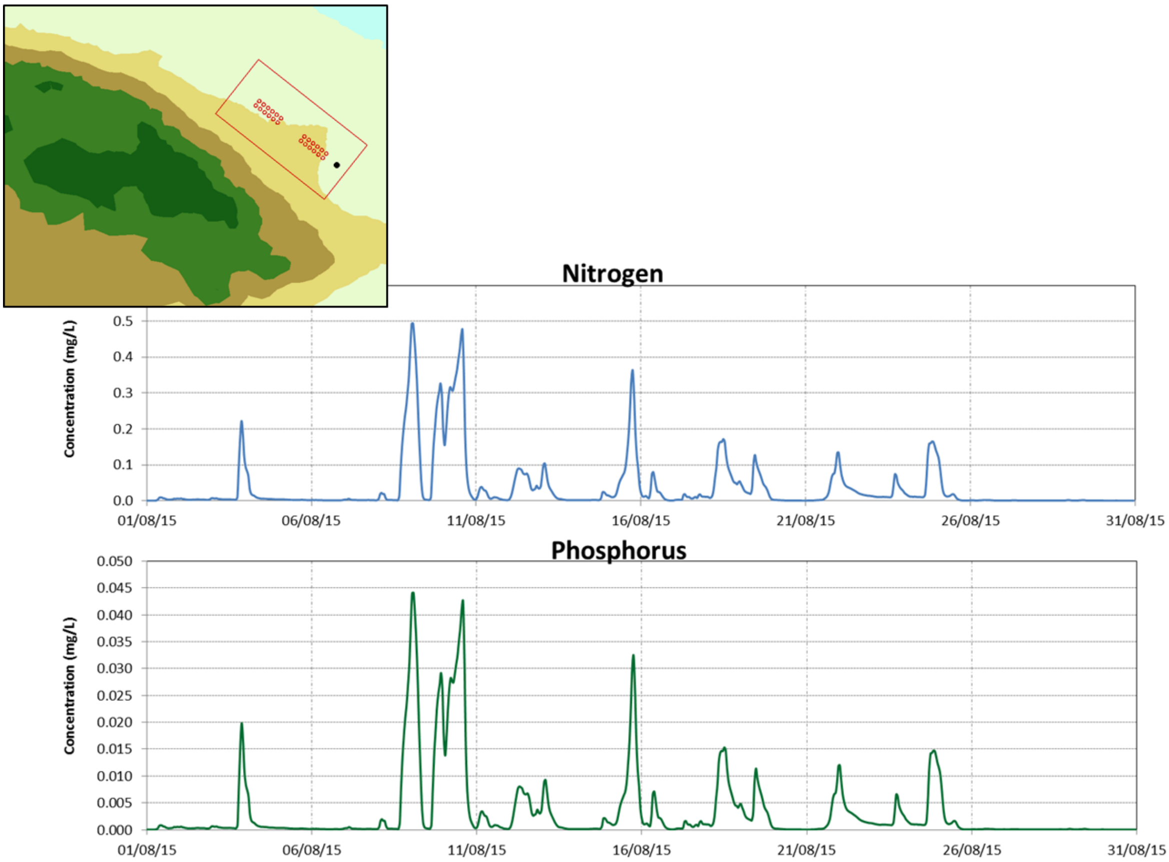


Figure 31. Time-series of the nutrient concentrations. Location of the point is indicated by a black dot on the map

2.3.2. Settlement of uneaten feed

2.3.2.1. Input data and hypotheses

Pieces from uneaten baitfish feed remaining in the water are approximately 1 cm to 2 cm big. The settling rate of these baitfish pieces is 7.2 cm/s as measured by experiments in water columns (***Fernandes et al, 2007***). 0.5% of the daily feed passes through the net uneaten (source: AJD Tuna Ltd). Therefore, it is assumed that 27.5 kg of baitfish reaches the sea bottom per day. It is assumed that the density of uneaten feed is close to neutral, just above the specific density of seawater as it is the case for small alive pelagic fish. Therefore, its value is the density of fresh fish muscle (***Waterman, 1971***). The final uneaten feed characteristics are given in Table 10.

Table 10 – Uneaten feed particle characteristics

Parameter	Value	source
Density of uneaten feed	1,054 kg/m^3	Waterman, 1971
Uneaten feed per day	27.5 kg	AJD Tuna Ltd
Typical uneaten baitfish size	1 cm – 2 cm	AJD Tuna Ltd
Settling rate	7.2 cm/s	Fernandes et al, 2007

2.3.2.2. Methodology

The uneaten baitfish passing through the net is considered as a cohesive sediment with the characteristics described in Table 10. The calculation parameters have been adjusted so that once deposited, the particles are not subject to resuspension by the ambient currents, as uneaten baitfish undergo a fast biodegradation on the bottom. Biodegradation is not taken into account.

2.3.2.3. Results

Figure 32 shows the thickness of uneaten feed deposited at the bottom at the end of the simulation. After 30 days of simulation, the uneaten feed deposit remains located under the fish pens and its thickness is less than 0.5 cm. This result is explained by the settling rate. For a water depth of 50 m, the time necessary for a particle to reach the bottom is 12 minutes. These results do not take into account the natural degradation of the feed.

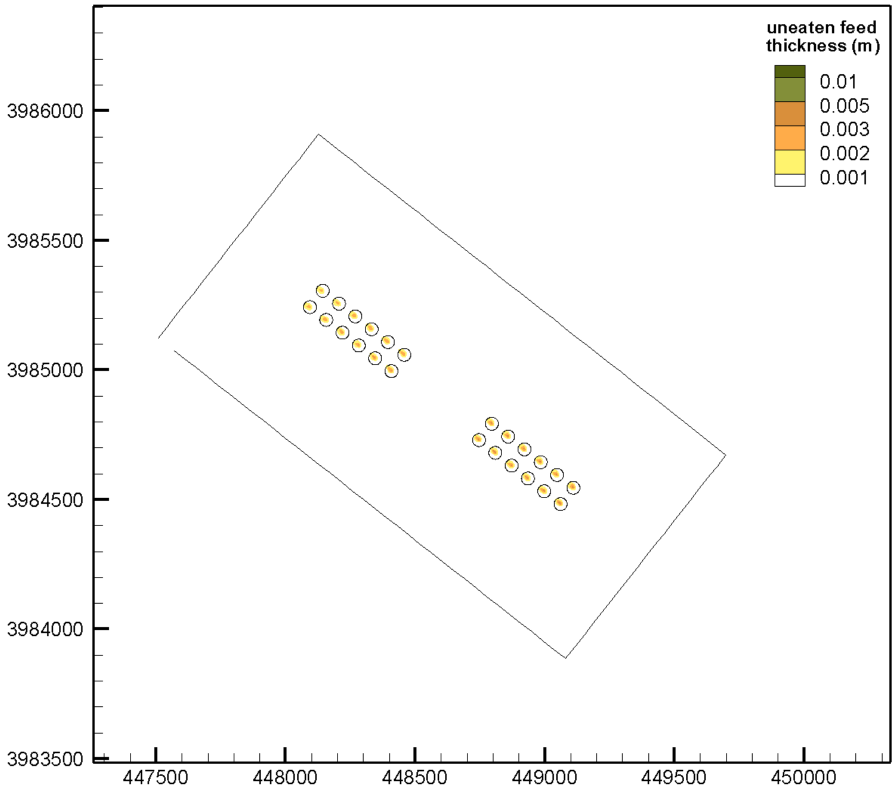


Figure 32. Thickness of uneaten feed after 30 days

2.3.3. Dispersion of fish oil

2.3.3.1. Input data and hypotheses

It is estimated that 5% of the gross weight of the feed is lost as fish oil, which represents 275 kg of fish oil released per cage every day. Contrary to petroleum hydrocarbon, little is known about the fate of non-petroleum hydrocarbon in the marine environment. The fish oil is subject to drifting, spreading, and advection. The biodegradation and evaporation is not taken into account, as too many uncertainties exist on this process in the marine environment and no laboratory data are available to parameterise these processes. The parameter values are described in Table 11.

Table 11 – Oil physical parameters

Parameter	Value	Source
Kinematic Viscosity (20°C)	65.2 mm^2/s	Young, 1986
Density (25°C)	920.0 kg/m^3	Young, 1986

The volume of fish oil released for the whole farm is 7.17 m^3 per day.

2.3.3.2. Methodology

The oil slick is represented as a set of particles. Each particle is subject to drifting, spreading, and advection, while biodegradation and evaporation are not taken into account. 900 particles are released for each scenario; the whole set of particles represents 7.17 m^3 of fish oil.

Two scenarios are simulated, corresponding to various wind conditions:

- Scenario 1: starting on 2 August 2015 (wind initially from the South and then predominantly from the North-West);
- Scenario 2: starting on 27 August 2015 (wind predominantly from the East).

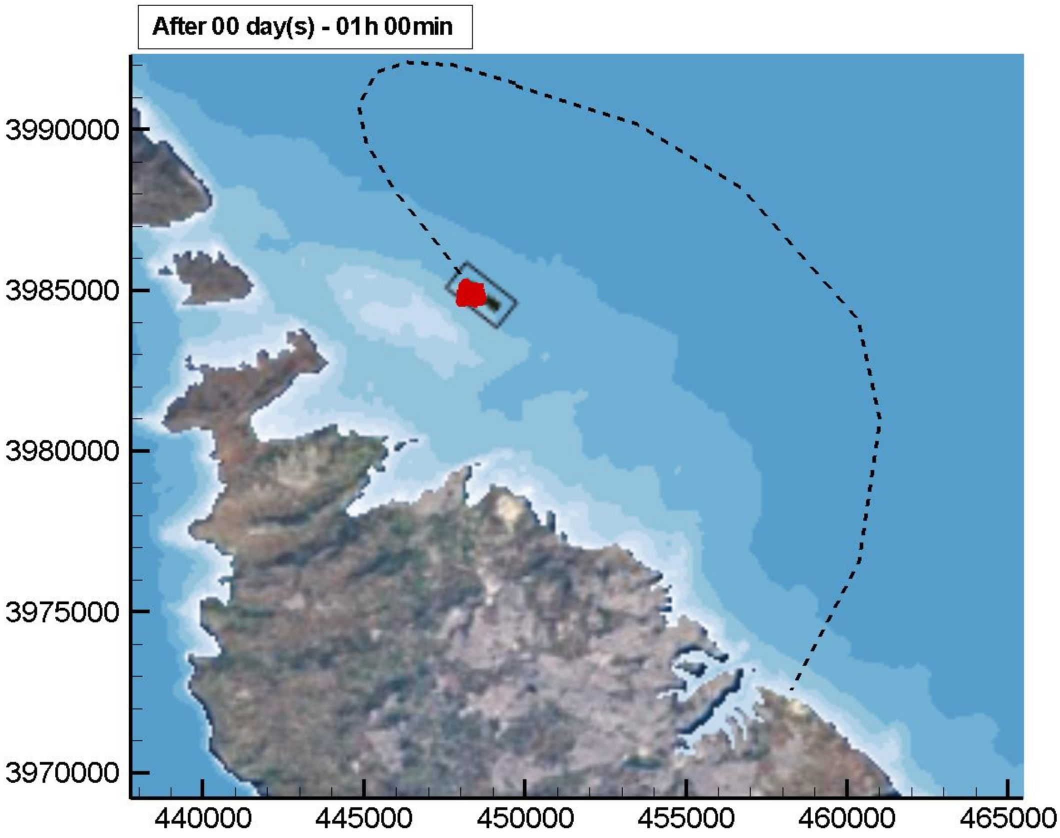
2.3.3.3. Results

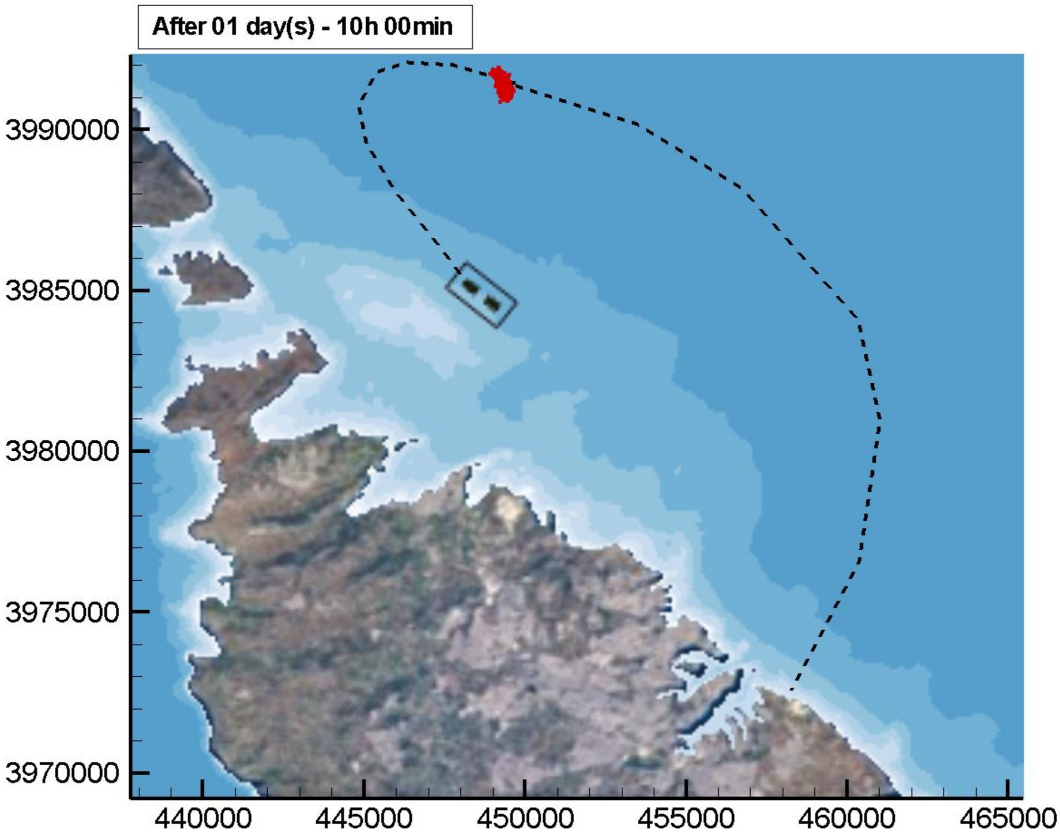
Snapshots of the particle position at various times are shown in Figure 33 for scenario 1 and in Figure 34 for scenario 2. A dashed line delineates the trajectory of the fish oil slick.

Both the velocity field and the wind field influence the slick trajectory. Near the fish farm, the velocity field has an intensity in the range of 5 cm/s to 10 cm/s. The wind drift component of the slick velocity is 3.6% of the wind, which means around 0.15 cm/s for a wind intensity of 5 m/s. In this area, wind intensity is the major contributor of the slick trajectory. The slick drift is in the range of 5 cm/s to 15 cm/s in the scenarios simulated.

In scenario 1, the oil slick moves first towards the North. Then it is transported by the Atlantic Ionian Stream offshore and moves southward. After two days, the slick changes its direction towards the Maltese coast. It is deposited after 1 days and 10 hours on the beach.

In scenario 2, the oil slick flows westward, along the southern coast of Comino. Then it joins the southeastward offshore currents located on the western side of the Maltese islands.


After 00 day(s) - 01h 00min
3990000
3985000
3980000
3975000
3970000
440000
445000
450000
455000
460000
465000


After 01 day(s) - 10h 00min
3990000
3985000
3980000
3975000
3970000
440000
445000
450000
455000
460000
465000

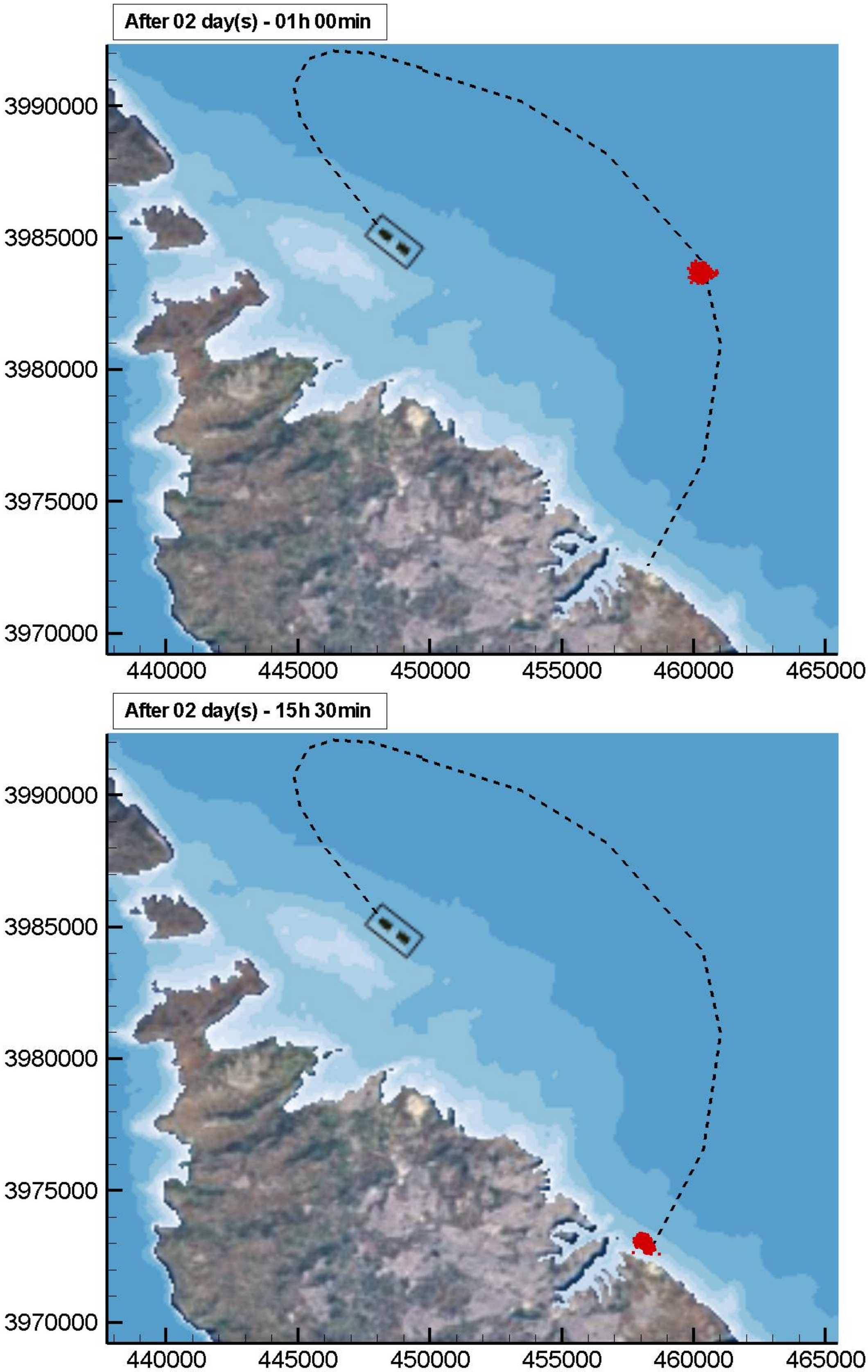
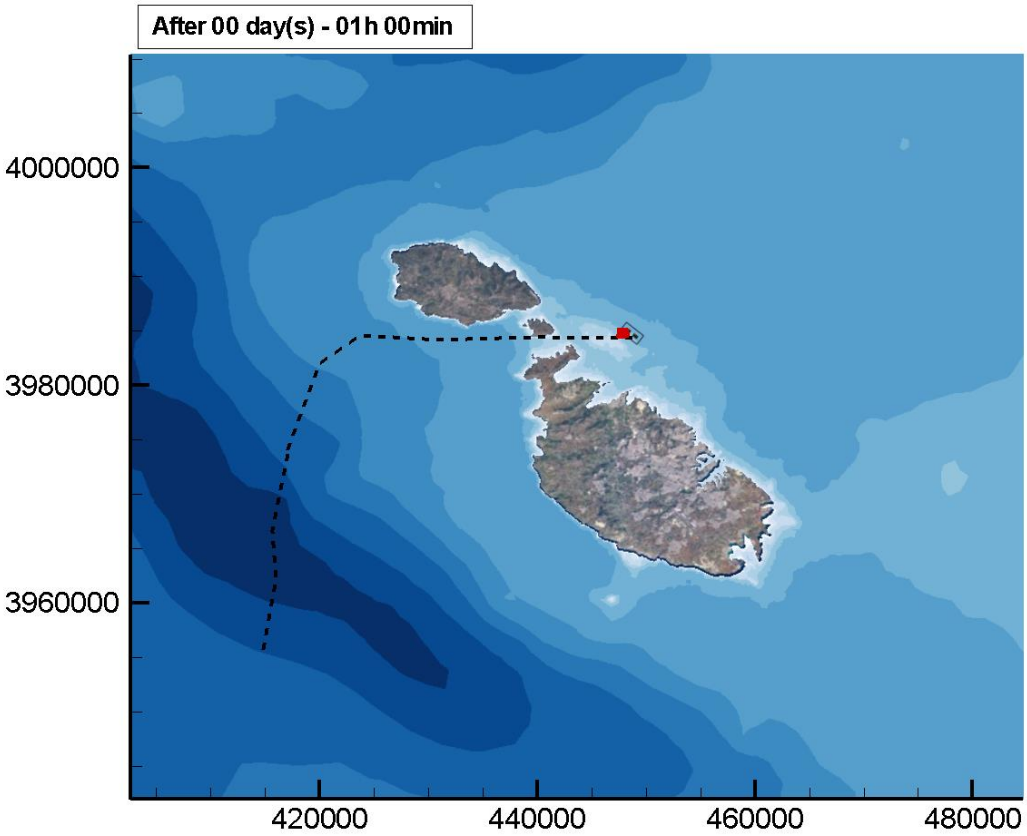
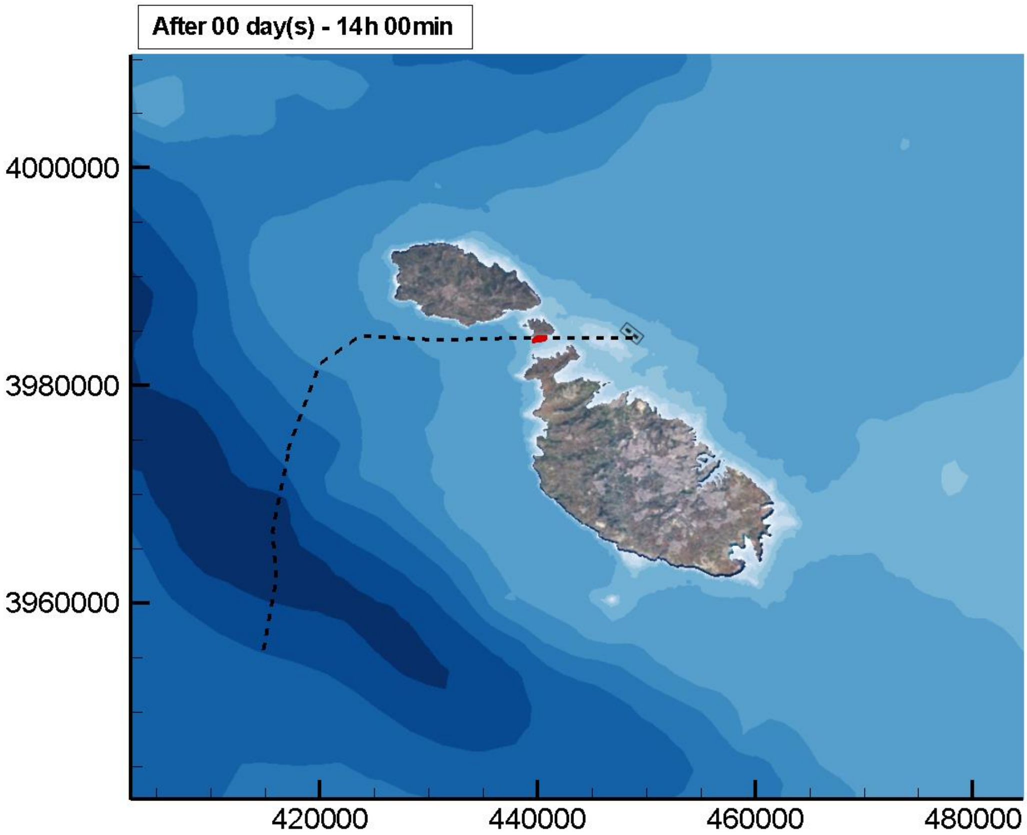


Figure 33. Location of the particles depending on time elapsed in scenario 1. Initial time is 2/08/2015


After 00 day(s) - 01h 00min
4000000
3980000
3960000
420000
440000
460000
480000


After 00 day(s) - 14h 00min
4000000
3980000
3960000
420000
440000
460000
480000

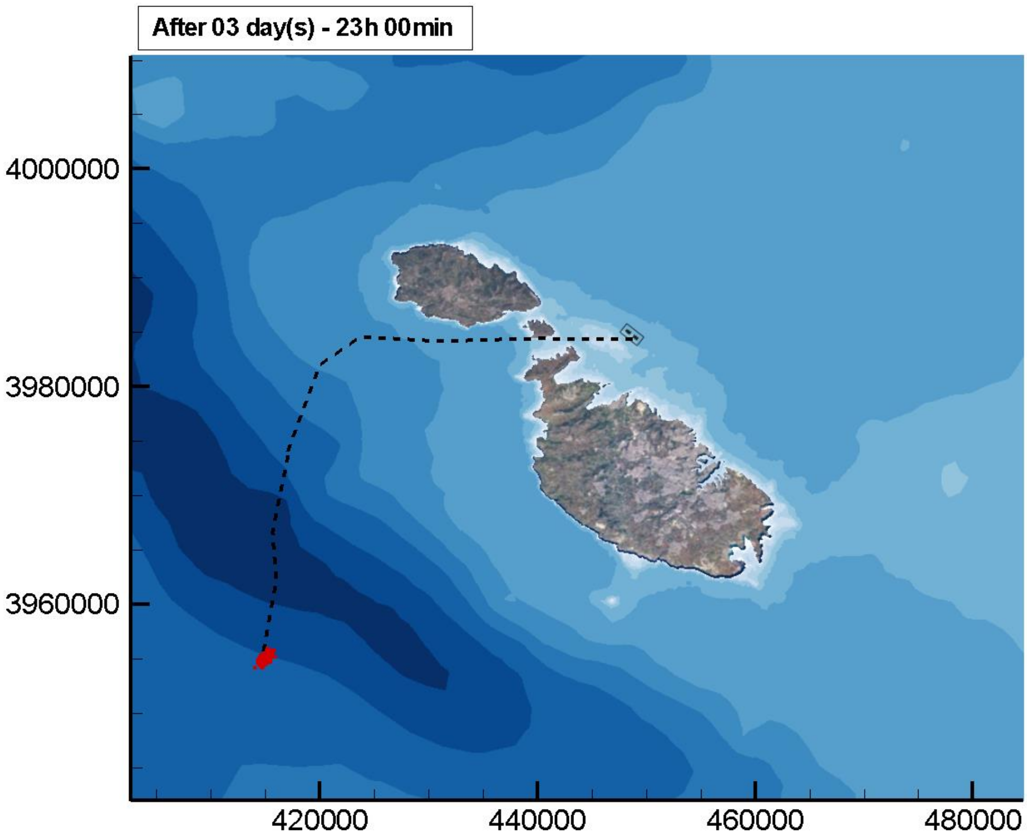


Figure 34. Location of the particles depending on time elapsed in scenario 2. Initial time is 27/08/2015

oOo

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Fernandes M., Angove M., Sedawie T. Cheshire, 2007. Dissolved nutrient release from solid wastes of southern Bluefin tuna (Thunnus Maccoyii, Castelnau) aquaculture. *Aquaculture Research* **38** pp 388-397.

Milne, P. H., 1970.Fish farming: a guide to the design and construction of net enclosures. 31 p. *Marine research*.

Waterman J., J. 1979. Measures, stowage rates and yields in fishery products. Department of Scientific and industrial research. Torry research station, advisory notes n°17. FAO publications.

Young, 1986. The chemical and physical properties of crude fish oils for refiners and hydrogenators. *Fish Oil Bulletin* n°18. 18 p.

APPENDIX A

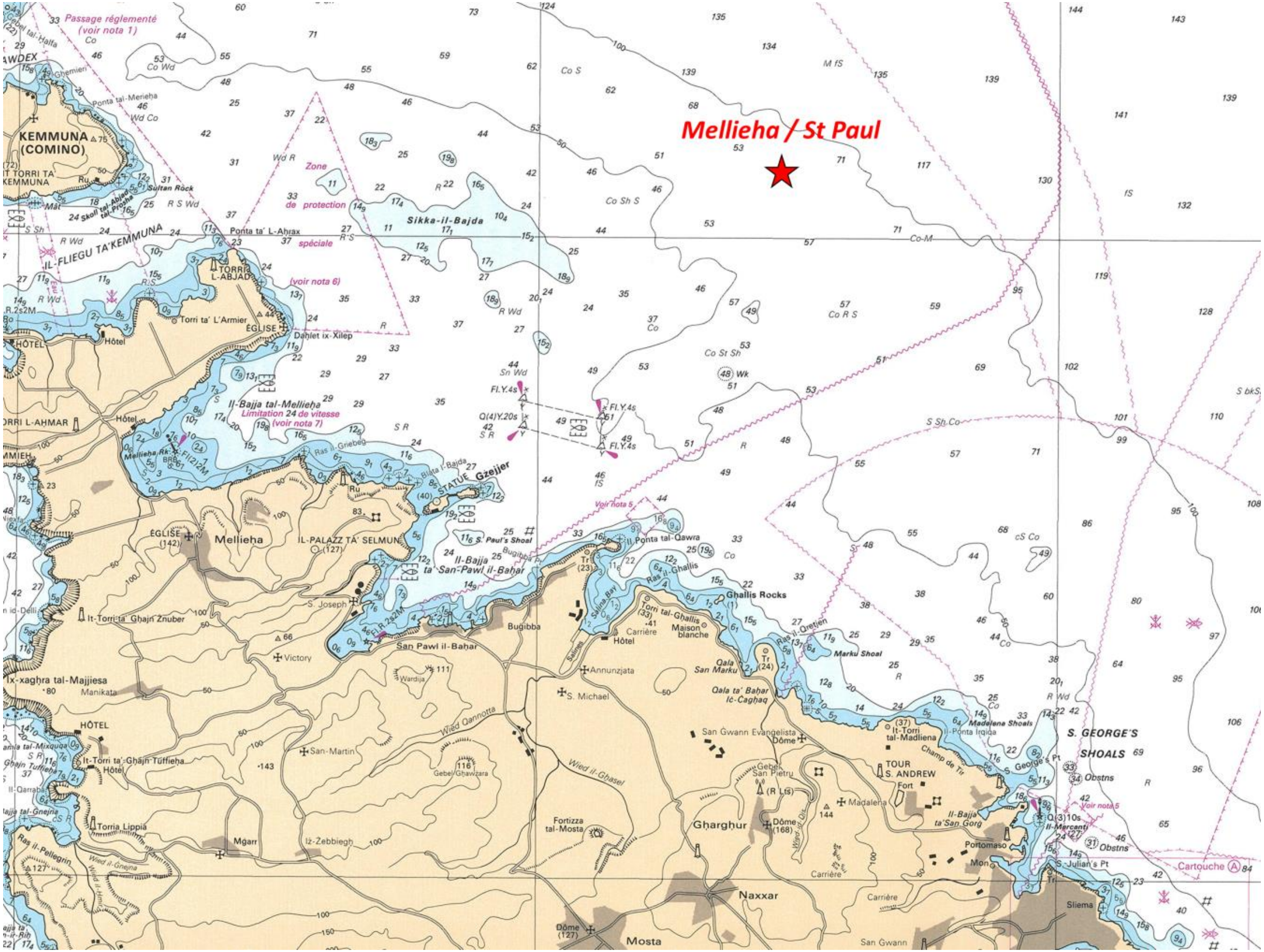
OFFSHORE WINDS AND WAVES

Relocation of the AJD Tuna Farm

Wave and hydrodynamic modelling for the EIA

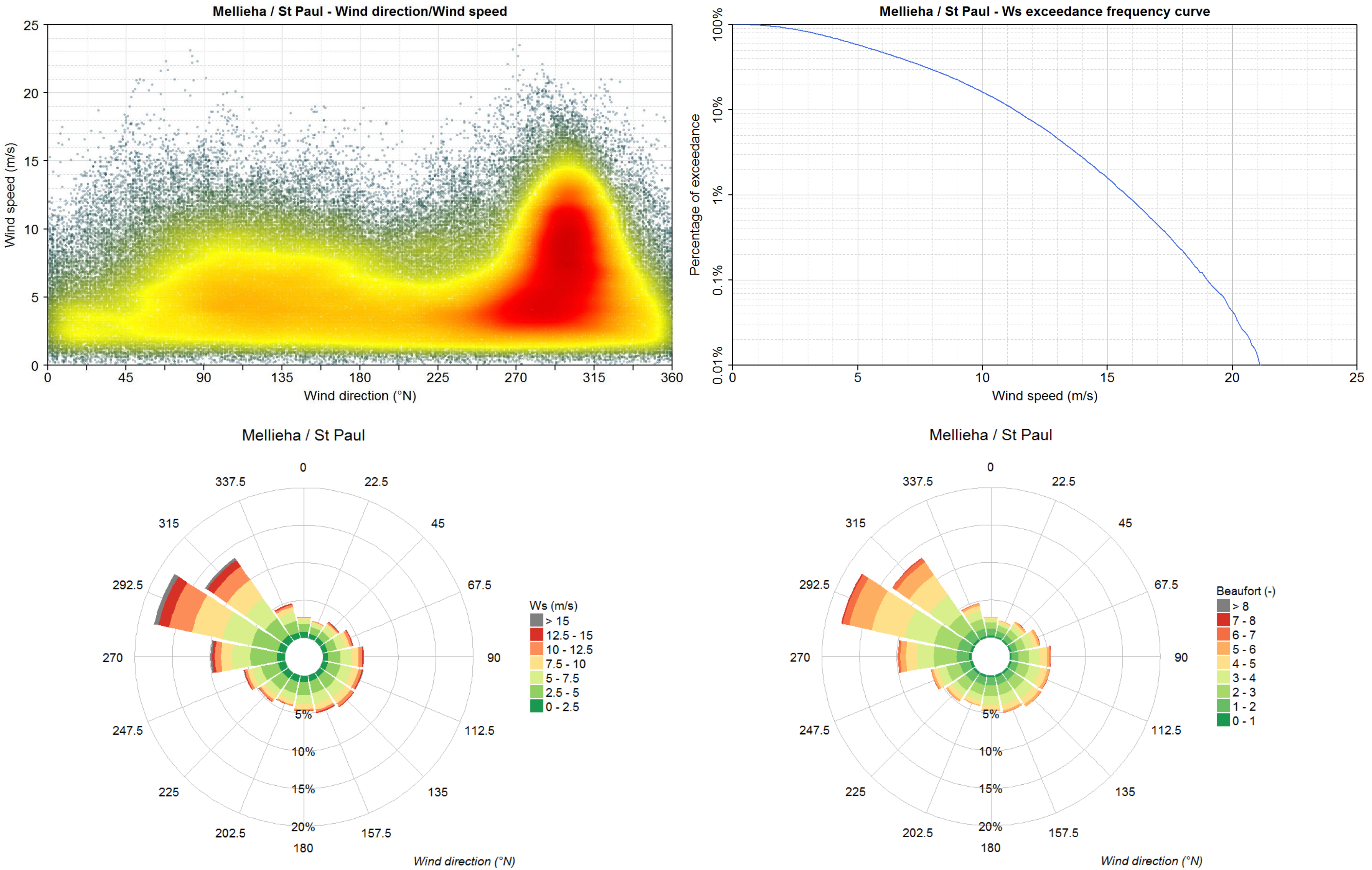
Figures A
Offshore winds and waves

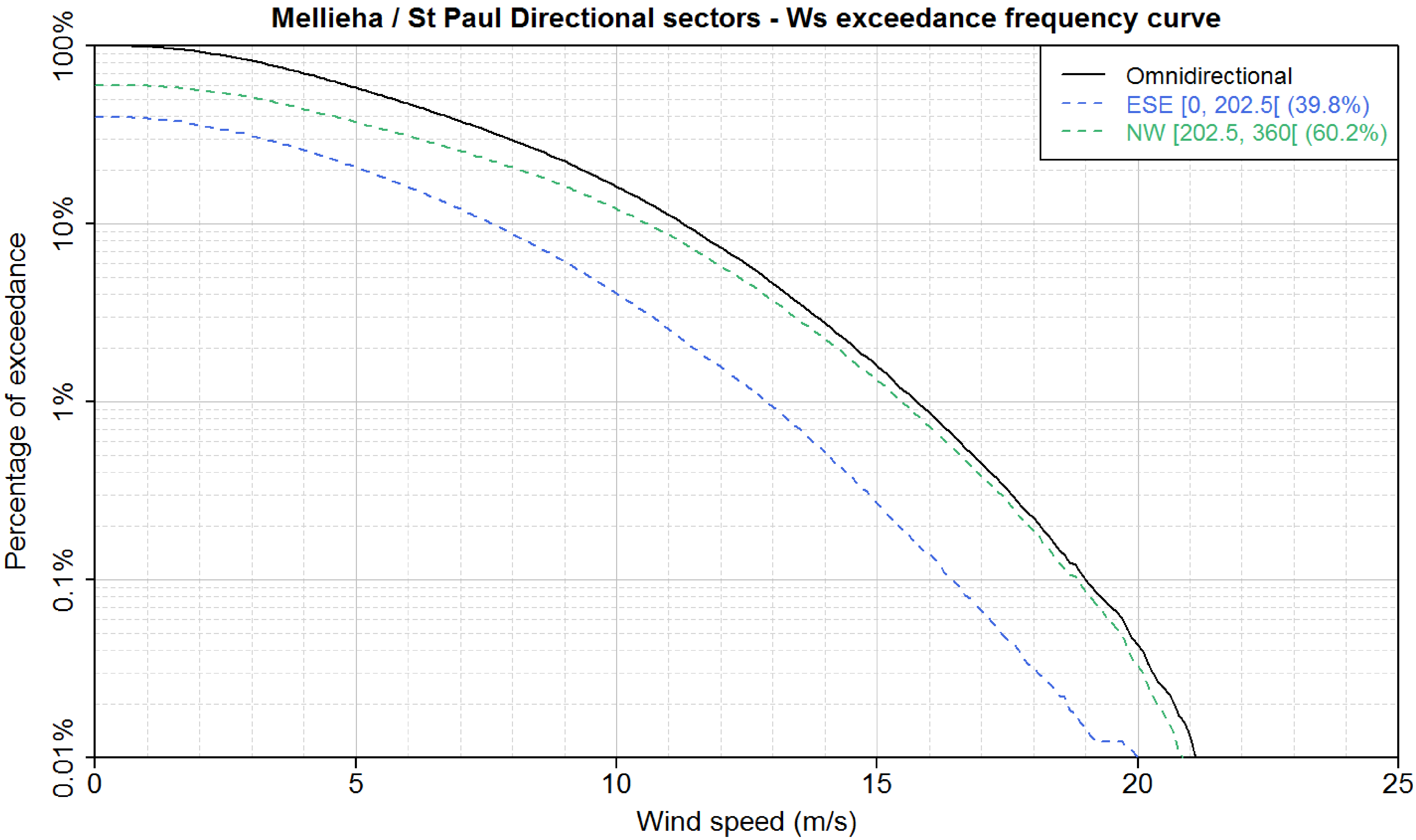
ARTELIA


Mellieha / St Paul
Passage réglementé (voir nota 1)
KEMMUNA (COMINO)
IT TORRI TA' KEMMUNA
IL-FLIEGU TA' KEMMUNA
Zone de protection spéciale
(voir nota 6)
Sikka-il-Bajda
Il-Bajja tal-Mellieħa
Limitation 24 de vitesse (voir nota 7)
Mellieħa
IL-PALAZZ TA' SELMUN
Gżejjer
STATUE
S. Paul's Shoal
Il-Bajja ta' San Pawl il-Baħar
San Pawl il-Baħar
Buġibba
Voir nota 5
Il-Ponta tal-Qawra
Għallis Rocks
Marku Shoal
S. GEORGE'S SHOALS
Torri L-Aħmar
Torri ta' L'Armier
Dahlet ix-Xilep
Ponta ta' L-Aħrax
It-Torri ta' Għajn Żnuber
Victory
Manikata
HÔTEL
It-Torri ta' Għajn Tuffieħa
Torria Lippija
Mġarr
Iż-Żebbiegħ
San-Martin
Wardija
Annunzjata
S. Michael
Wied il-Għasel
Fortizza tal-Mosta
Mosta
Naxxar
Għargħur
San Ġwann Evangelista
Qala ta' Baħar Iċ-Cagħaq
TOUR S. ANDREW Fort
Madalena
It-Torri tal-Madliena
Madliena Shoals
Il-Bajja ta'San Ġorġ
Portomaso
Sliema
San Ġwann
S. Julian's Pt
Cartouche A
Obstns

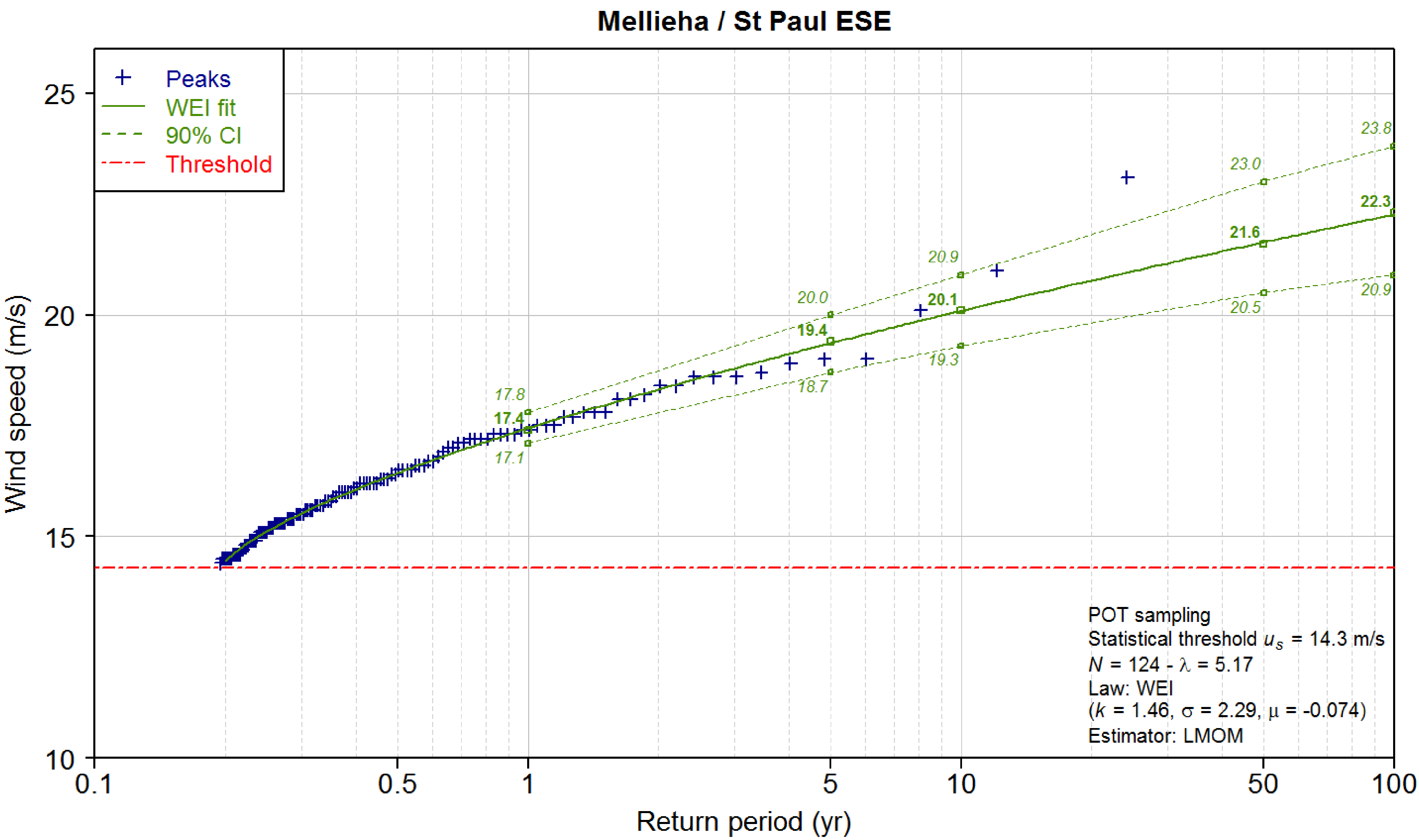
ARTELIA

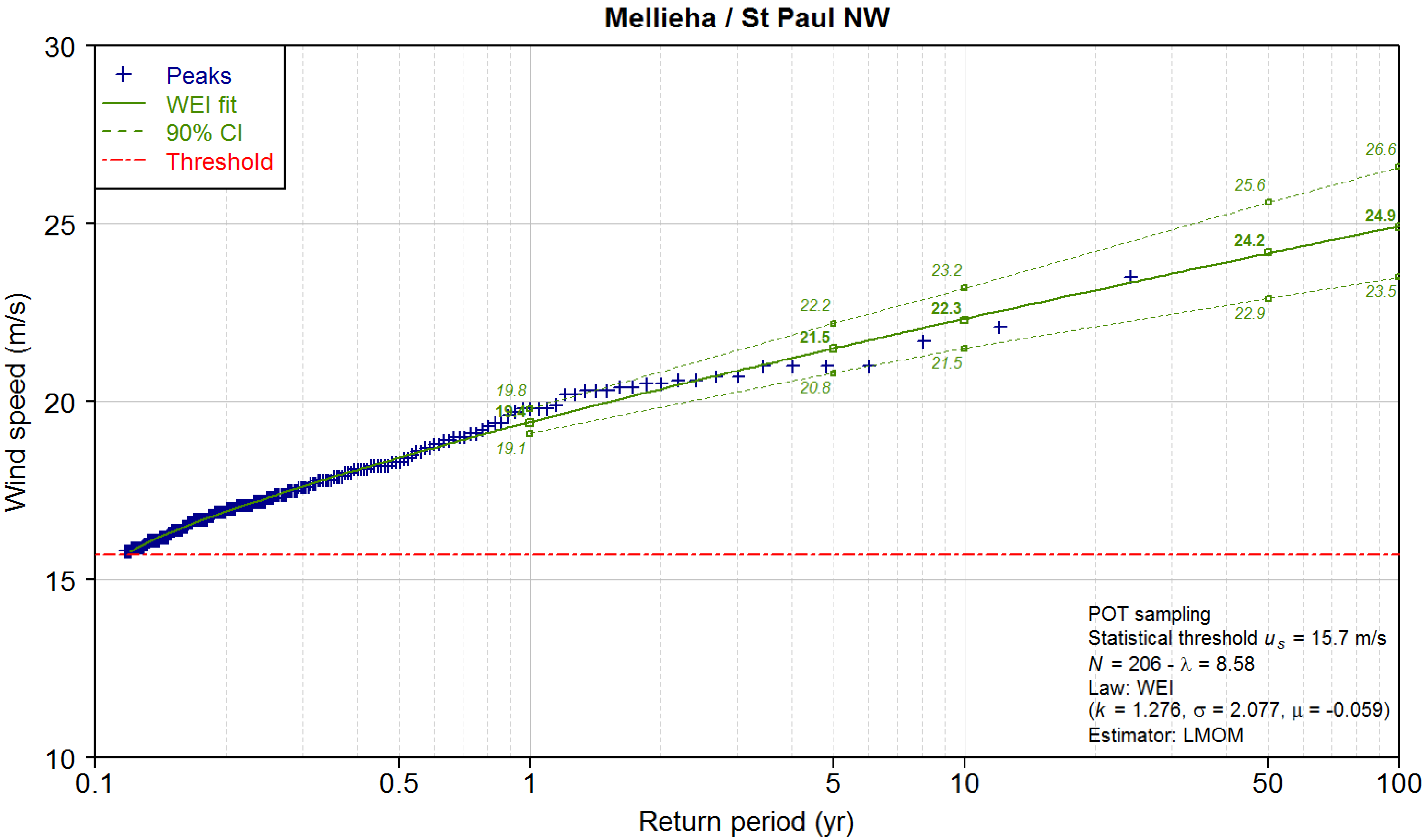
WIND


Mellieha / St Paul - Wind direction/Wind speed
Wind speed (m/s)
Wind direction (°N)
Mellieha / St Paul - Ws exceedance frequency curve
Percentage of exceedance
Wind speed (m/s)
Mellieha / St Paul
Ws (m/s)
> 15
12.5 - 15
10 - 12.5
7.5 - 10
5 - 7.5
2.5 - 5
0 - 2.5
Wind direction (°N)
Mellieha / St Paul
Beaufort (-)
> 8
7 - 8
6 - 7
5 - 6
4 - 5
3 - 4
2 - 3
1 - 2
0 - 1
Wind direction (°N)

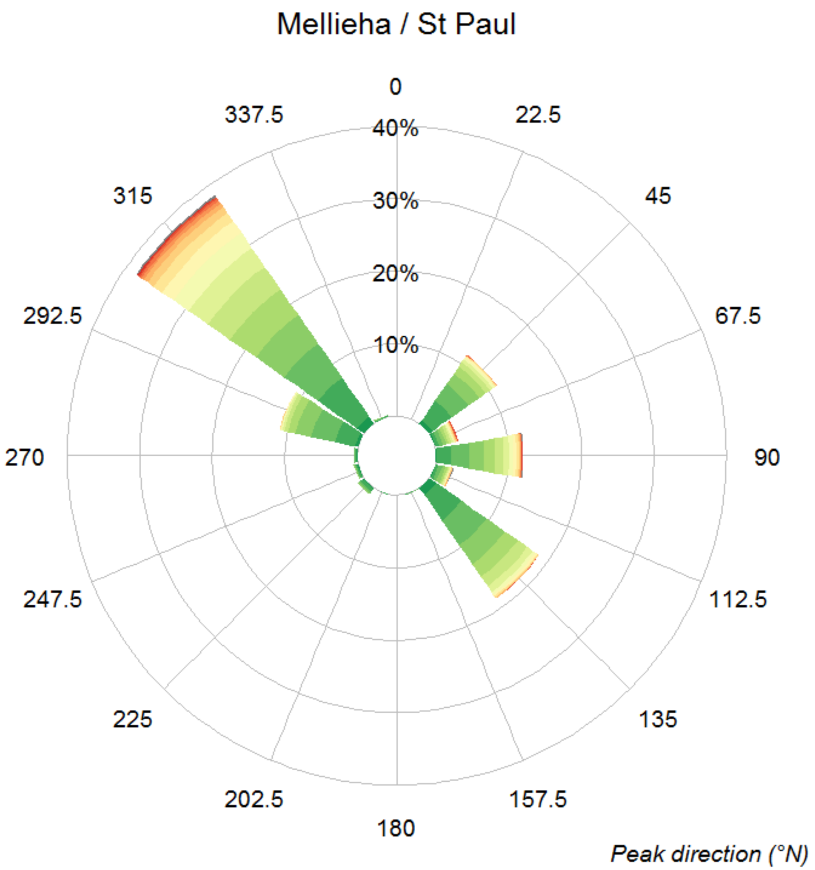

Mellieha / St Paul Directional sectors - Ws exceedance frequency curve
Percentage of exceedance
100%
10%
1%
0.1%
0.01%
0
5
10
15
20
25
Wind speed (m/s)
Omnidirectional
ESE [0, 202.5[(39.8%)
NW [202.5, 360[(60.2%)

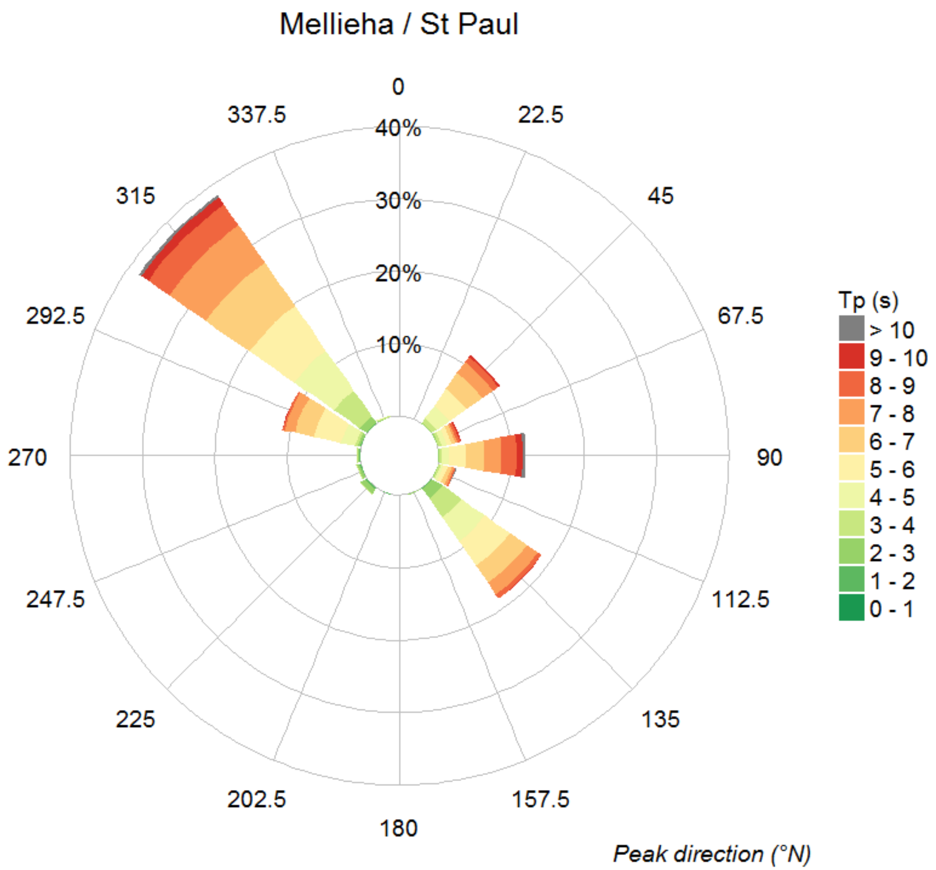
ARTELIA

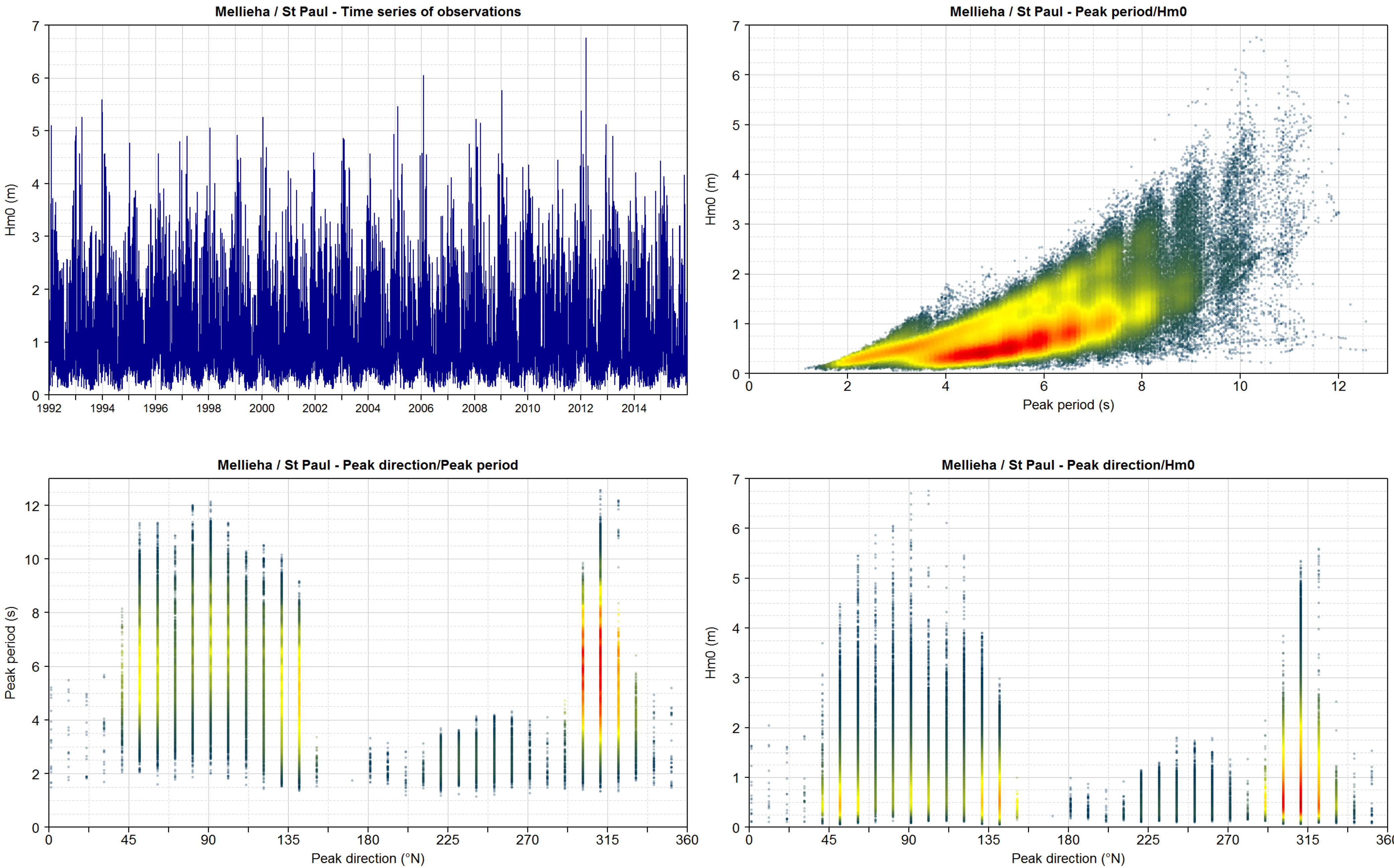

Mellieha / St Paul ESE
Peaks
WEI fit
90% CI
Threshold
Wind speed (m/s)
Return period (yr)
25
20
15
10
0.1
0.5
1
5
10
50
100
17.8
17.4
17.1
20.0
19.4
18.7
20.9
20.1
19.3
23.0
21.6
20.5
23.8
22.3
20.9
POT sampling
Statistical threshold u_s = 14.3 m/s
N = 124 - λ = 5.17
Law: WEI
(k = 1.46, σ = 2.29, μ = -0.074)
Estimator: LMOM


Mellieha / St Paul NW
Peaks
WEI fit
90% CI
Threshold
Wind speed (m/s)
Return period (yr)
30
25
20
15
10
0.1
0.5
1
5
10
50
100
19.8
19.4
19.1
22.2
21.5
20.8
23.2
22.3
21.5
25.6
24.2
22.9
26.6
24.9
23.5
POT sampling
Statistical threshold u_s = 15.7 m/s
N = 206 - λ = 8.58
Law: WEI
(k = 1.276, σ = 2.077, μ = -0.059)
Estimator: LMOM

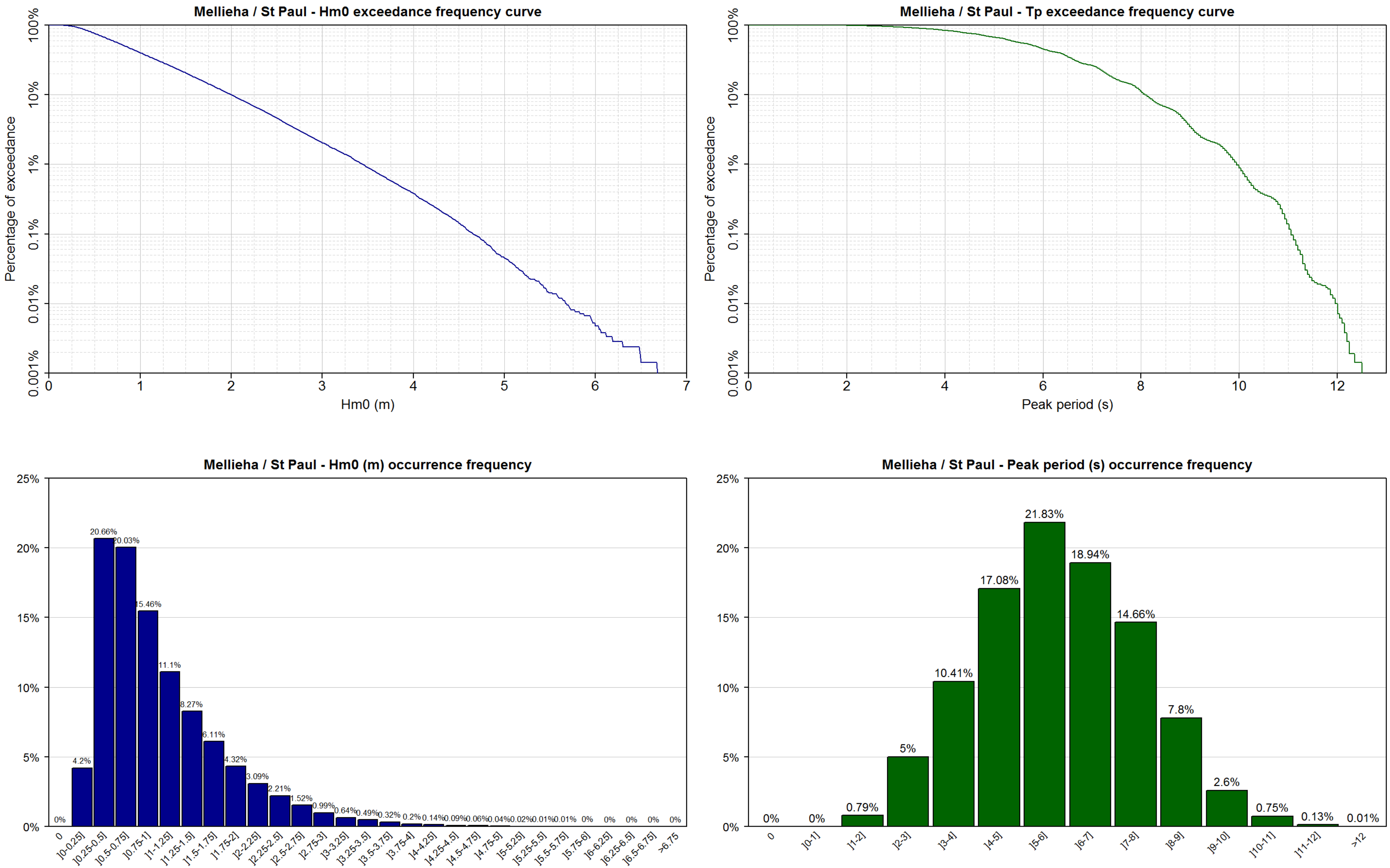
SEA STATES


Mellieha / St Paul
0
22.5
45
67.5
90
112.5
135
157.5
180
202.5
225
247.5
270
292.5
315
337.5
10%
20%
30%
40%
Hm0 (m)
> 4
3.75 - 4
3.5 - 3.75
3.25 - 3.5
3 - 3.25
2.75 - 3
2.5 - 2.75
2.25 - 2.5
2 - 2.25
1.75 - 2
1.5 - 1.75
1.25 - 1.5
1 - 1.25
0.75 - 1
0.5 - 0.75
0.25 - 0.5
0 - 0.25
Peak direction (°N)


Mellieha / St Paul
0
22.5
45
67.5
90
112.5
135
157.5
180
202.5
225
247.5
270
292.5
315
337.5
10%
20%
30%
40%
Tp (s)
> 10
9 - 10
8 - 9
7 - 8
6 - 7
5 - 6
4 - 5
3 - 4
2 - 3
1 - 2
0 - 1
Peak direction (°N)



Mellieha / St Paul - Time series of observations
Hm0 (m)
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Mellieha / St Paul - Peak period/Hm0
Hm0 (m)
Peak period (s)
Mellieha / St Paul - Peak direction/Peak period
Peak period (s)
Peak direction (°N)
Mellieha / St Paul - Peak direction/Hm0
Hm0 (m)
Peak direction (°N)


Mellieha / St Paul - Hm0 exceedance frequency curve
Percentage of exceedance
Hm0 (m)
Mellieha / St Paul - Tp exceedance frequency curve
Percentage of exceedance
Peak period (s)
Mellieha / St Paul - Hm0 (m) occurrence frequency
Mellieha / St Paul - Peak period (s) occurrence frequency
21.83%
18.94%
17.08%
14.66%
10.41%
7.8%
5%
2.6%
0.79%
0.75%
0.13%
0.01%
20.66%
20.03%
15.46%
11.1%
8.27%
6.11%
4.32%
4.2%
3.09%
2.21%
1.52%
0.99%
0.64%
0.49%
0.32%
0.2%
0.14%
0.09%
0.06%
0.04%
0.02%
0.01%

Mellieha / St Paul - Hm0 / Dirp correlogram

Hm0 (m) / Peak direction (°N)

Hm0 (m)	0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total %
]0,0.25]	0.01	0.00	0.61	0.08	0.23	0.08	1.26	0.01	0.01	0.02	0.14	0.1	0.08	0.41	1.13	0.04	4.2
]0.25,0.5]	0.01	0.00	3.2	0.51	1.97	0.39	4.11	0.02	0.04	0.02	0.43	0.24	0.19	2.84	6.57	0.12	20.66
]0.5,0.75]	0.00	0.01	2.72	0.55	2.32	0.53	4.22	0.01	0.01	0.00	0.3	0.17	0.09	3.34	5.67	0.08	20.03
]0.75,1]	0.00	0.00	1.81	0.47	2.1	0.46	3.16	0.00	0.00	0.00	0.16	0.13	0.07	2.21	4.84	0.04	15.46
]1,1.25]	0.00		1.17	0.37	1.52	0.28	2.13				0.06	0.06	0.04	1.13	4.33	0.01	11.1
]1.25,1.5]		0.00	0.72	0.29	1.15	0.19	1.59				0.00	0.01	0.01	0.55	3.76	0.00	8.27
]1.5,1.75]	0.00	0.00	0.48	0.26	0.82	0.13	0.93					0.02	0.00	0.29	3.18		6.11
]1.75,2]		0.00	0.28	0.18	0.57	0.11	0.46					0.00	0.00	0.15	2.57	0.00	4.32
]2,2.25]	0.00		0.16	0.13	0.42	0.08	0.28							0.09	1.92		3.09
]2.25,2.5]			0.12	0.1	0.33	0.06	0.17							0.03	1.4		2.21
]2.5,2.75]			0.07	0.08	0.18	0.07	0.11							0.01	0.99	0.00	1.52
]2.75,3]			0.04	0.08	0.12	0.05	0.06							0.00	0.64		0.99
]3,3.25]			0.02	0.05	0.08	0.04	0.02							0.00	0.43		0.64
]3.25,3.5]			0.02	0.04	0.06	0.03	0.01							0.00	0.33		0.49
]3.5,3.75]			0.01	0.02	0.04	0.02	0.01							0.00	0.22		0.32
]3.75,4]			0.01	0.01	0.02	0.01	0.01							0.00	0.14		0.2
]4,4.25]			0.00	0.01	0.02	0.00									0.11		0.14
]4.25,4.5]			0.00	0.01	0.01	0.00									0.07		0.09
]4.5,4.75]				0.01	0.01	0.00									0.03		0.06
]4.75,5]				0.01	0.01	0.00									0.02		0.04
]5,5.25]				0.00	0.01	0.00									0.01		0.02
]5.25,5.5]				0.00	0.00	0.00									0.00		0.01
]5.5,5.75]				0.00	0.00										0.00		0.01
]5.75,6]				0.00	0.00												0.00
]6,6.25]					0.00	0.00											0.00
]6.25,6.5]					0.00												0.00
]6.5,6.75]					0.00												0.00
]6.75,7]					0.00												0.00
>=7																	
Total %	0.03	0.02	11.45	3.28	12	2.53	18.53	0.03	0.07	0.04	1.09	0.73	0.49	11.05	38.35	0.29	100%

Dirp: 22.5 =]11.25,33.75]

Mellieha / St Paul - Hm0 / Tp correlogram

Hm0 (m)

	]0,1]	]1,2]	]2,3]	]3,4]	]4,5]	]5,6]	]6,7]	]7,8]	]8,9]	]9,10]	]10,11]	]11,12]	]12,13]	Total %
]0,0.25]		0.65	0.68	1.48	1.09	0.22	0.07	0.01	0.01	0.00	0.00			4.2
]0.25,0.5]		0.14	3.41	3.98	7.34	4.44	0.97	0.27	0.09	0.02	0.00	0.00	0.00	20.66
]0.5,0.75]			0.86	3.57	3.8	6.92	3.59	1.02	0.2	0.04	0.02	0.01	0.00	20.03
]0.75,1]			0.06	1.15	2.85	3.99	4.63	2.28	0.39	0.08	0.01	0.01		15.46
]1,1.25]				0.21	1.61	2.45	3.01	2.84	0.85	0.1	0.02	0.00	0.00	11.1
]1.25,1.5]				0.02	0.34	2.19	2.1	2.2	1.24	0.16	0.02	0.00	0.00	8.27
]1.5,1.75]				0.01	0.04	1.25	1.76	1.56	1.22	0.25	0.02	0.00		6.11
]1.75,2]					0.01	0.33	1.53	1.14	0.95	0.33	0.04	0.00		4.32
]2,2.25]					0.00	0.03	0.89	1.16	0.65	0.29	0.07	0.00		3.09
]2.25,2.5]						0.00	0.29	1	0.52	0.29	0.11	0.01		2.21
]2.5,2.75]						0.00	0.08	0.7	0.45	0.23	0.07	0.01		1.52
]2.75,3]							0.01	0.32	0.43	0.16	0.05	0.01		0.99
]3,3.25]							0.00	0.12	0.33	0.14	0.04	0.02		0.64
]3.25,3.5]							0.00	0.04	0.27	0.13	0.04	0.01		0.49
]3.5,3.75]								0.01	0.14	0.12	0.04	0.00		0.32
]3.75,4]								0.00	0.05	0.1	0.04	0.01		0.2
]4,4.25]								0.00	0.01	0.08	0.05	0.00		0.14
]4.25,4.5]									0.01	0.04	0.04	0.00		0.09
]4.5,4.75]									0.00	0.01	0.04	0.01		0.06
]4.75,5]										0.01	0.02	0.01	0.00	0.04
]5,5.25]									0.00	0.00	0.01	0.01	0.00	0.02
]5.25,5.5]									0.00	0.00	0.00	0.00	0.00	0.01
]5.5,5.75]										0.00	0.00	0.00	0.00	0.01
]5.75,6]										0.00	0.00			0.00
]6,6.25]										0.00	0.00			0.00
]6.25,6.5]											0.00			0.00
]6.5,6.75]											0.00			0.00
]6.75,7]											0.00			0.00
>=7														
Total %		0.79	5	10.41	17.08	21.83	18.94	14.66	7.8	2.6	0.75	0.13	0.01	100%

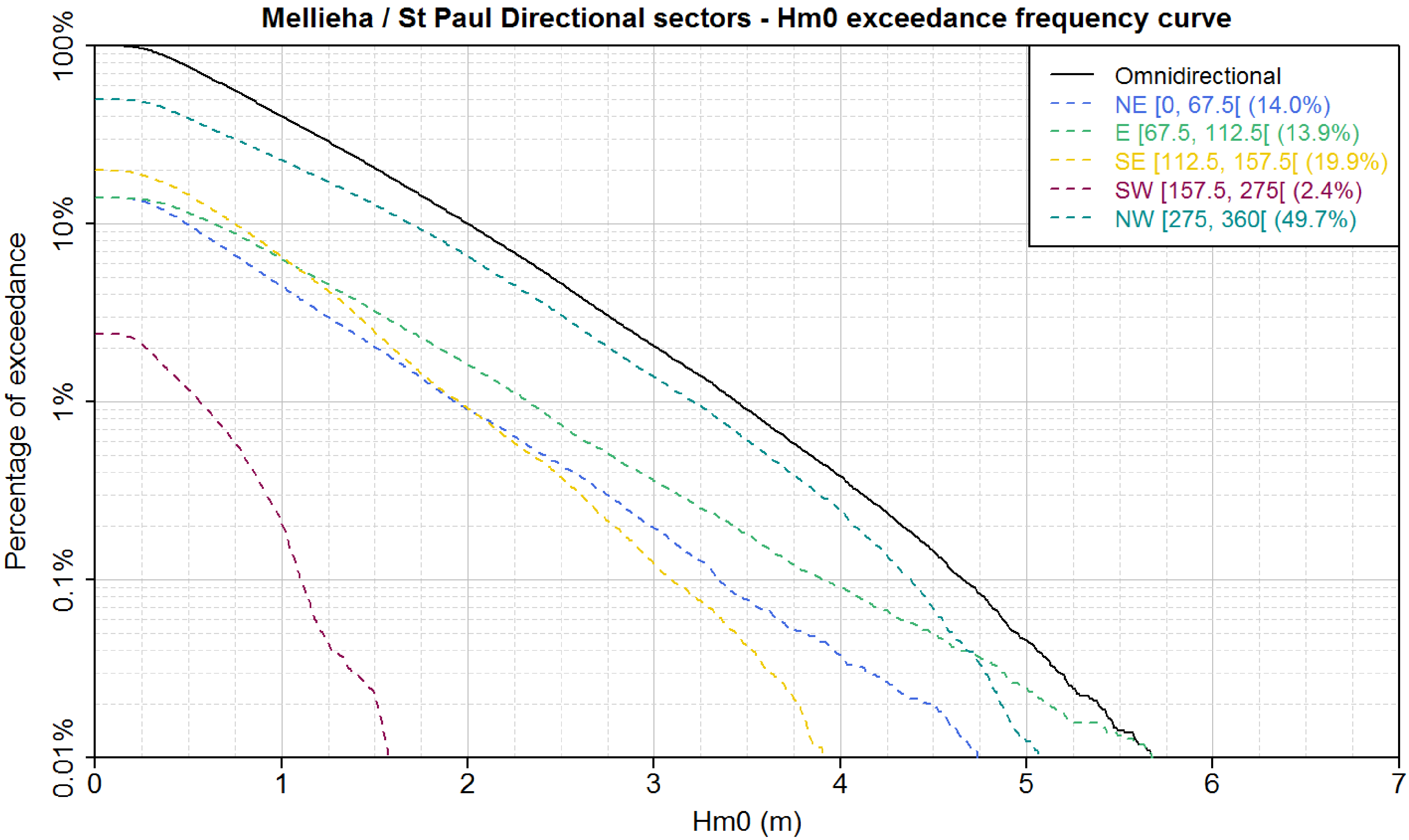
Peak period (s)

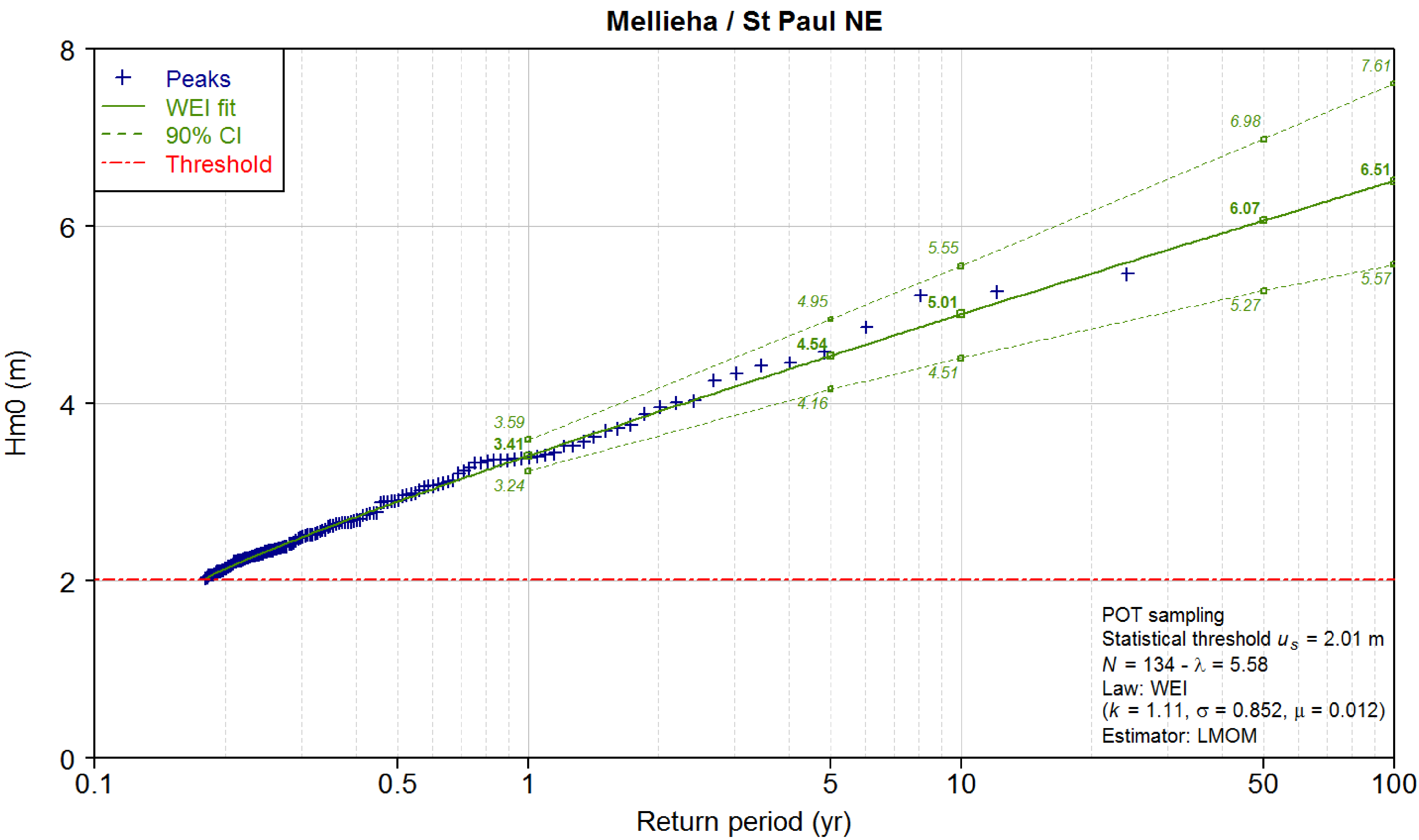
Mellieha / St Paul - Tp / Dirp correlogram

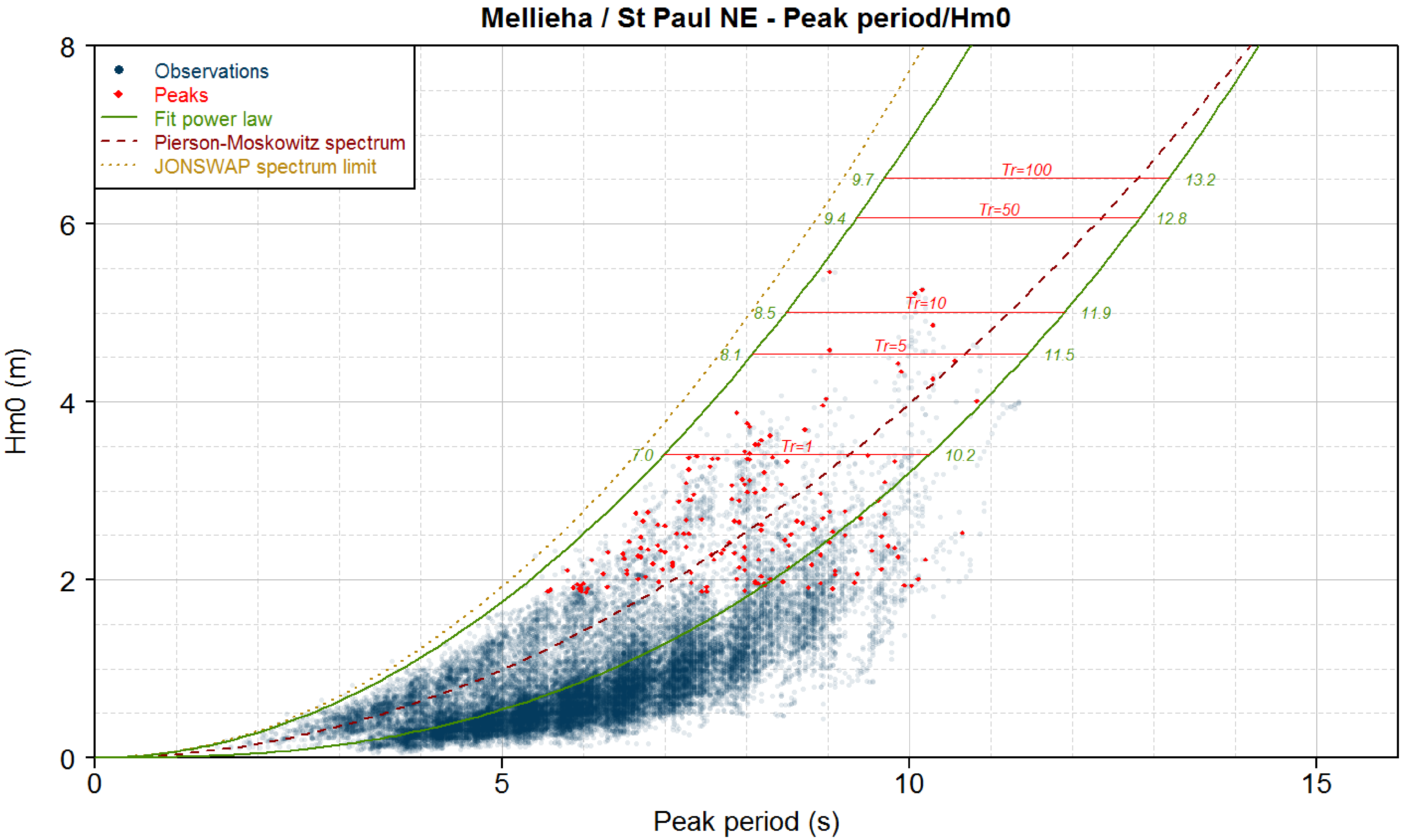
Peak period (s) / Peak direction (°N)

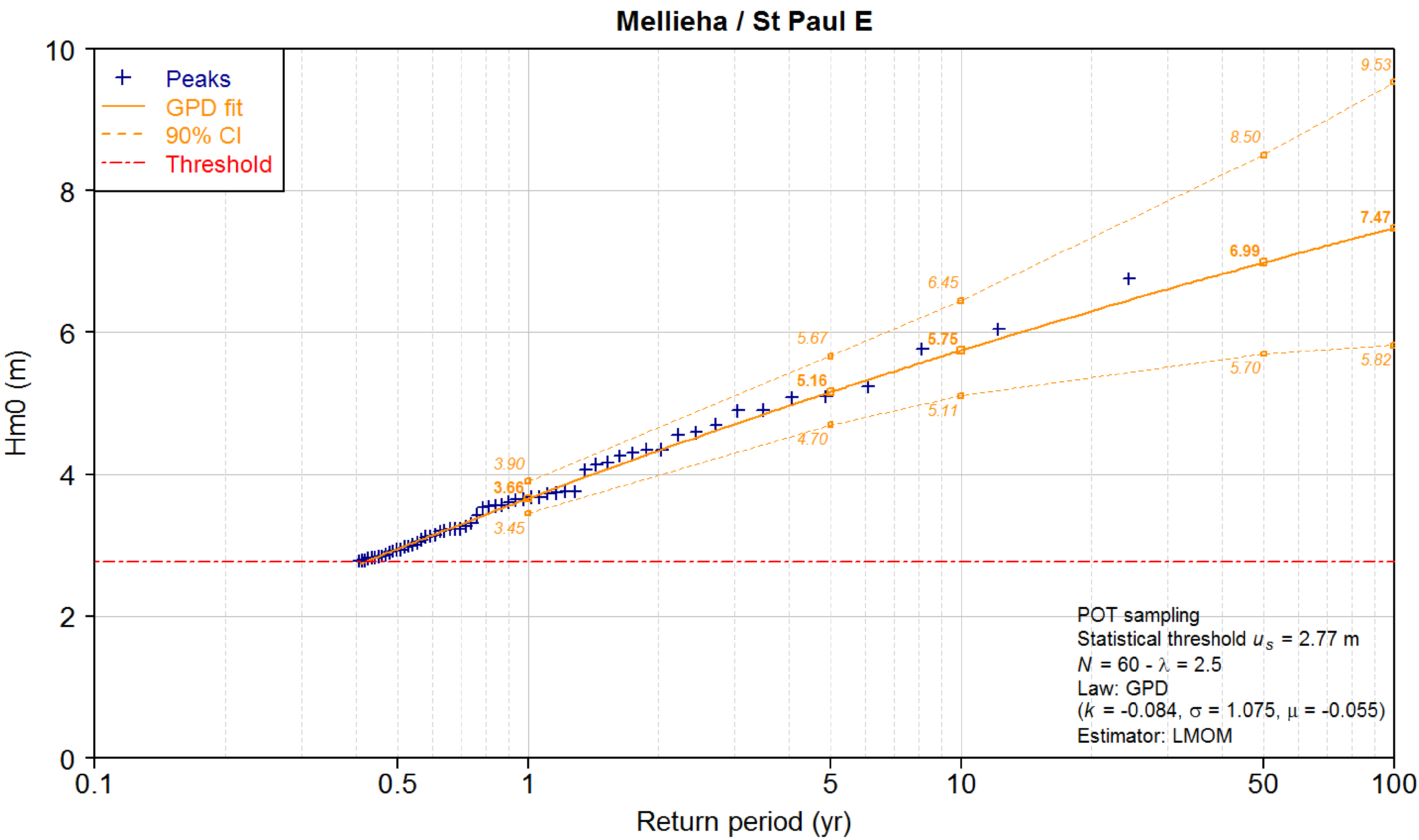
	0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total %
]0,1]																	
]1,2]	0.01	0.00		0.00	0.00	0.01	0.16	0.01	0.02	0.03	0.21	0.12	0.08	0.06	0.07	0.01	0.79
]2,3]	0.01	0.00	0.08	0.08	0.1	0.12	1.68	0.03	0.05	0.02	0.69	0.38	0.25	0.35	1.07	0.09	5
]3,4]	0.00	0.01	0.76	0.44	0.44	0.26	3.03	0.00	0.00	0.00	0.19	0.21	0.15	0.44	4.37	0.1	10.41
]4,5]	0.01	0.00	2.13	0.75	1.01	0.42	4					0.01	0.00	2.01	6.67	0.07	17.08
]5,6]	0.00	0.00	2.84	0.68	2.21	0.57	4.19							3.83	7.5	0.02	21.83
]6,7]			2.66	0.51	2.45	0.54	2.86							2.59	7.32	0.00	18.94
]7,8]			1.81	0.34	2.51	0.33	1.92							1.46	6.3		14.66
]8,9]			0.87	0.31	2.02	0.2	0.6							0.3	3.49		7.8
]9,10]			0.28	0.1	0.84	0.08	0.08							0.02	1.2		2.6
]10,11]			0.03	0.05	0.35	0.01	0.00								0.31		0.75
]11,12]			0.00	0.00	0.07										0.06		0.13
]12,13]					0.00										0.01		0.01
>=13																	
Total %	0.03	0.02	11.45	3.28	12	2.53	18.53	0.03	0.07	0.04	1.09	0.73	0.49	11.05	38.35	0.29	100%

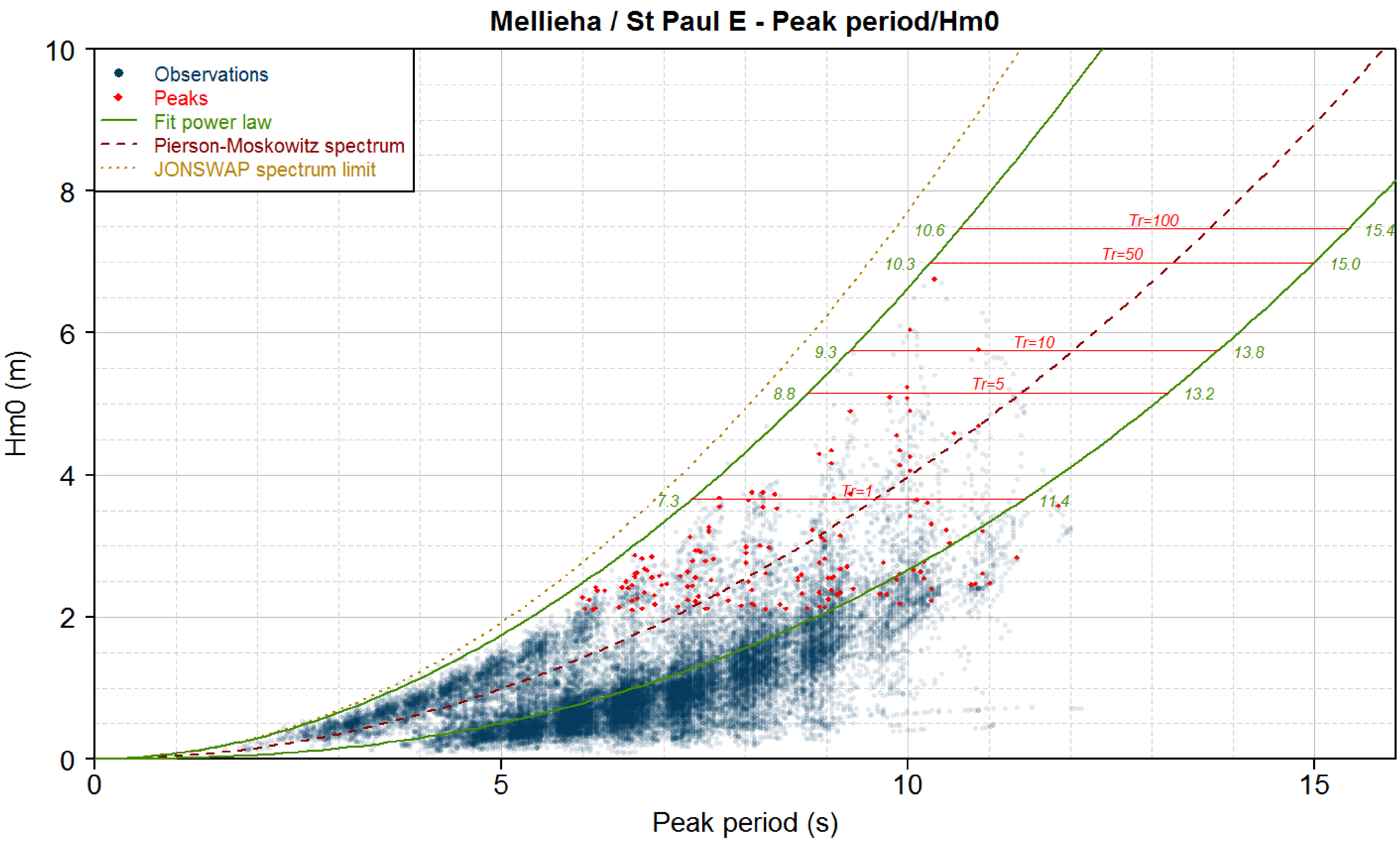
Dirp: 22.5 =]11.25,33.75]

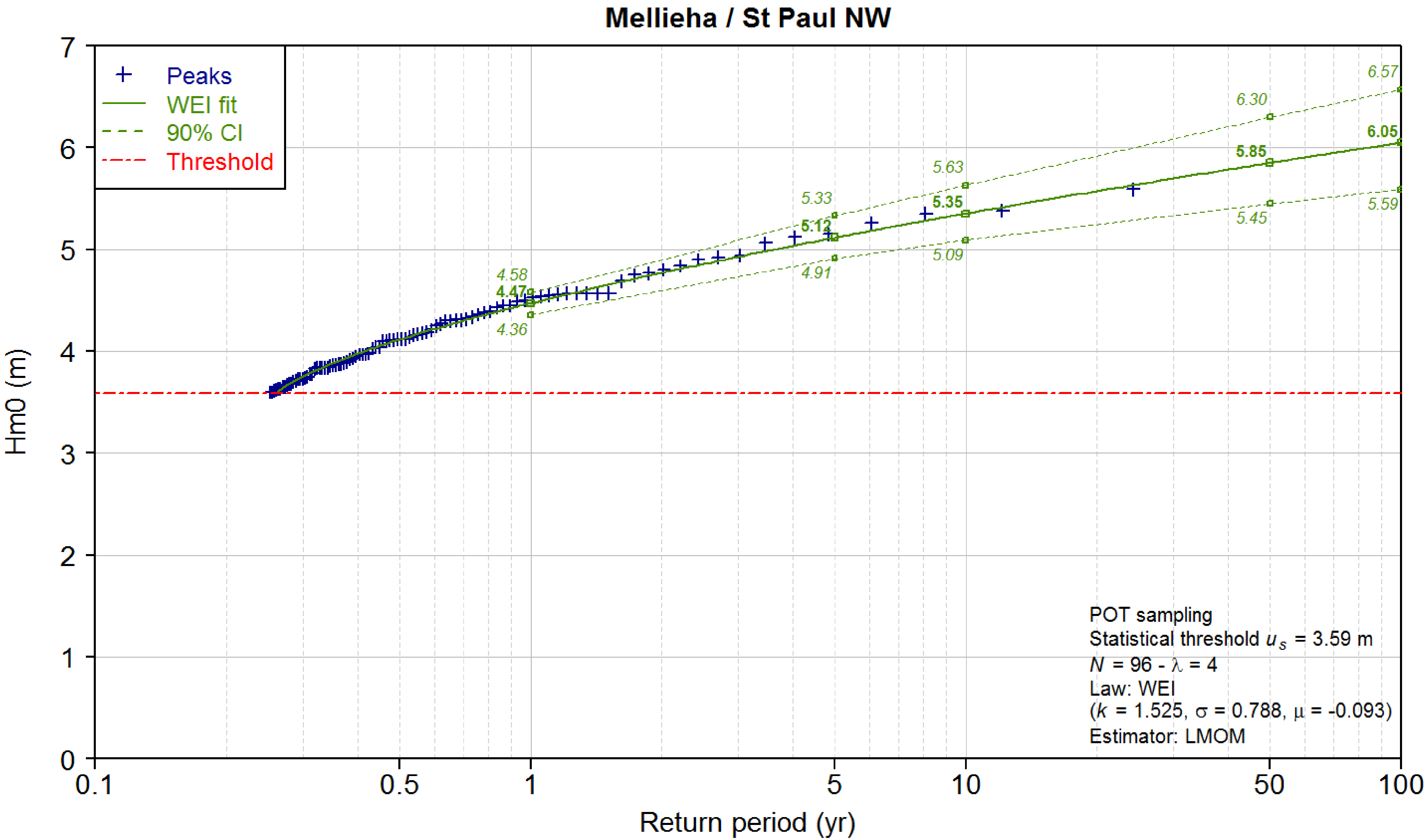

Mellieha / St Paul Directional sectors - Hm0 exceedance frequency curve
Percentage of exceedance
100%
10%
1%
0.1%
0.01%
0
1
2
3
4
5
6
7
Hm0 (m)
Omnidirectional
NE [0, 67.5[(14.0%)
E [67.5, 112.5[(13.9%)
SE [112.5, 157.5[(19.9%)
SW [157.5, 275[(2.4%)
NW [275, 360[(49.7%)

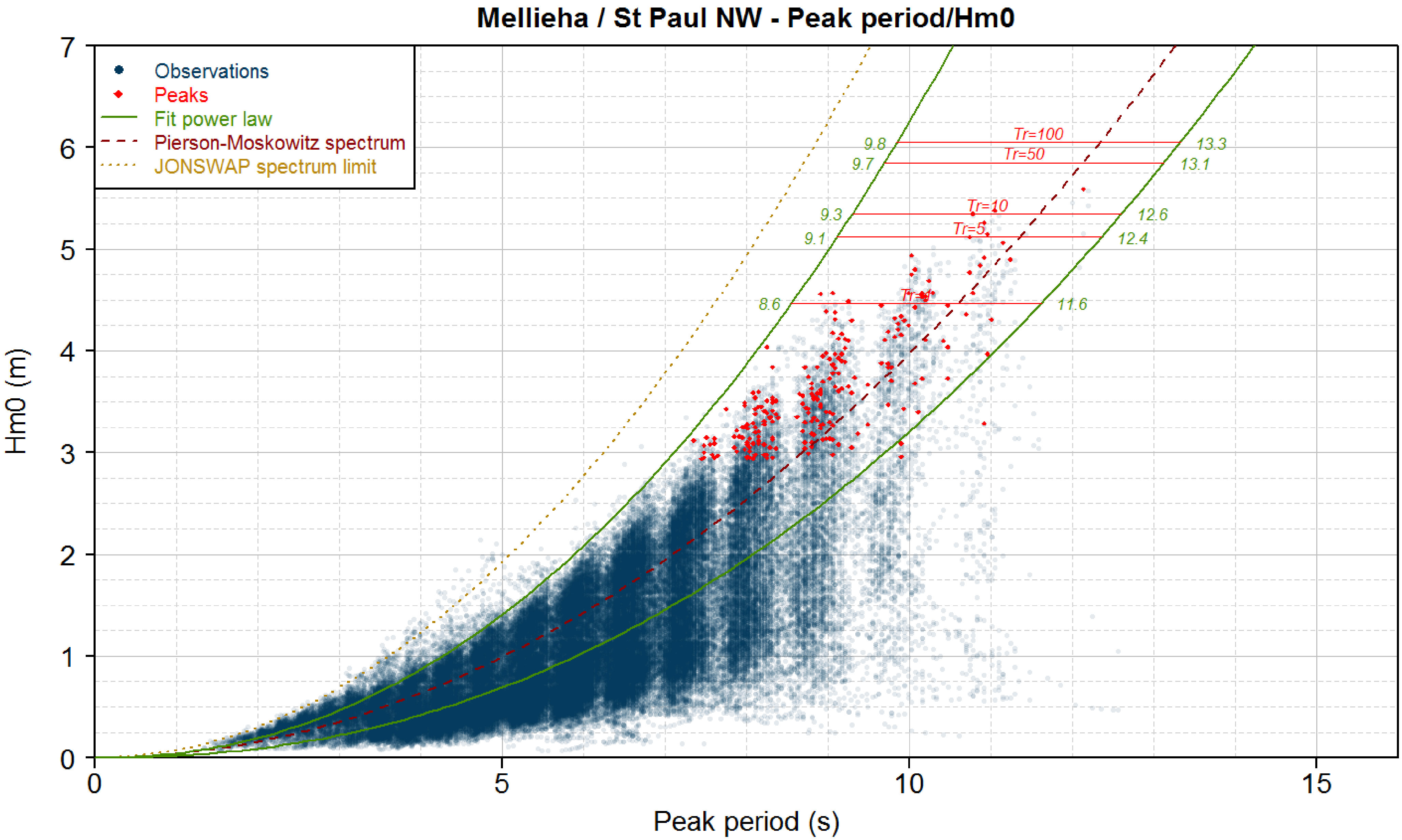

Mellieha / St Paul NE
Peaks
WEI fit
90% CI
Threshold
Hm0 (m)
Return period (yr)
0
2
4
6
8
0.1
0.5
1
5
10
50
100
3.59
3.41
3.24
4.95
4.54
4.16
5.55
5.01
4.51
6.98
6.07
5.27
7.61
6.51
5.57
POT sampling
Statistical threshold u_s = 2.01 m
N = 134 - λ = 5.58
Law: WEI
(k = 1.11, σ = 0.852, μ = 0.012)
Estimator: LMOM


Mellieha / St Paul NE - Peak period/Hm0
Observations
Peaks
Fit power law
Pierson-Moskowitz spectrum
JONSWAP spectrum limit
Tr=100
9.7
13.2
Tr=50
9.4
12.8
Tr=10
8.5
11.9
Tr=5
8.1
11.5
Tr=1
7.0
10.2
Hm0 (m)
Peak period (s)
0
2
4
6
8
0
5
10
15


Mellieha / St Paul E
Peaks
GPD fit
90% CI
Threshold
9.53
8.50
7.47
6.99
6.45
5.67
5.75
5.16
5.82
5.70
5.11
4.70
3.90
3.66
3.45
POT sampling
Statistical threshold u_s = 2.77 m
N = 60 - λ = 2.5
Law: GPD
(k = -0.084, σ = 1.075, μ = -0.055)
Estimator: LMOM
Hm0 (m)
Return period (yr)
0
2
4
6
8
10
0.1
0.5
1
5
10
50
100


Mellieha / St Paul E - Peak period/Hm0
Observations
Peaks
Fit power law
Pierson-Moskowitz spectrum
JONSWAP spectrum limit
Tr=100
Tr=50
Tr=10
Tr=5
Tr=1
10.6
15.4
10.3
15.0
9.3
13.8
8.8
13.2
7.3
11.4
Hm0 (m)
Peak period (s)
0
2
4
6
8
10
5
15


Mellieha / St Paul NW
Peaks
WEI fit
90% CI
Threshold
6.57
6.30
6.05
5.85
5.63
5.35
5.33
5.12
5.59
5.45
5.09
4.91
4.58
4.47
4.36
POT sampling
Statistical threshold u_s = 3.59 m
N = 96 - λ = 4
Law: WEI
(k = 1.525, σ = 0.788, μ = -0.093)
Estimator: LMOM
Hm0 (m)
Return period (yr)
0
1
2
3
4
5
6
7
0.1
0.5
1
5
10
50
100


Mellieha / St Paul NW - Peak period/Hm0
Observations
Peaks
Fit power law
Pierson-Moskowitz spectrum
JONSWAP spectrum limit
Tr=100
Tr=50
Tr=10
Tr=5
Tr=1
9.8
9.7
9.3
9.1
8.6
13.3
13.1
12.6
12.4
11.6
Hm0 (m)
Peak period (s)
0
1
2
3
4
5
6
7
0
5
10
15

PA 02175/18

Proposal to consolidate temporary tuna farming area at a parcel of sea approximately 5 kilometers from the shore (in general area approved for PA/03072/17 and PA/05858/17) for a total biomass of 3,300 tonnes of fish

Technical Appendix 4

MARINE ECOLOGY BASELINE REPORT

Prepared by Ecoserv Ltd (Malta)

Supporting Documents for

Environmental Impact Assessment Report

Signed Declaration

Attn: Director of Environment and Resources
Environment and Resources Authority
Malta

I, Joseph A. Borg, who carried out the study (or part thereof) on marine ecology for the EIA for the proposed extension to an existing tuna farm operation off the Northeast coast of Malta, hereby declare that such study was solely carried out by me on behalf of Ecoserv Ltd, and the company takes responsibility for any statement and conclusion contained therein.

13 July 2018

Date

Signature

Report on an ecological assessment of an area off the northeastern coast of Malta, proposed for designation as an offshore tuna penning site, undertaken as part of the Environment Impact Assessment in connection with PA 02175/18: Extension to an existing tuna farm operation off the North East coast of Malta

Prepared by

Joseph A. Borg
BSc MSc PhD (Plymouth) CBiol MIBiol MMBA FIBMS

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ECOSERV'S REPORT REFERENCE NO: 068-18

JUNE 2018

Signed Declaration

Attn: Director of Environment and Resources
Environment and Resources Authority
Malta

I, Joseph A. Borg, who carried out the study (or part thereof) on marine ecology for the EIA for the proposed extension to an existing tuna farm operation off the Northeast coast of Malta, hereby declare that such study was solely carried out by me on behalf of Ecoserv Ltd, and the company takes responsibility for any statement and conclusion contained therein.

13 July 2018
Date

Signature

Signed Declaration

Attn: Director of Environment and Resources
Environment and Resources Authority
Malta

I, Sarah Debono, who carried out the study (or part thereof) on marine ecology for the EIA for the proposed extension to an existing tuna farm operation off the Northeast coast of Malta, hereby declare that such study was solely carried out by me on behalf of Ecoserv Ltd, and the company takes responsibility for any statement and conclusion contained therein.

13 July 2018

Date

Signature

1. INTRODUCTION

1. Adi Associates Environmental Consultants Ltd (hereafter 'ADI'), acting on behalf of their client AJD Tuna Ltd, have commissioned Ecoserv Ltd to undertake an ecological assessment of an area located off Mellieha Bay (northeastern coast of Malta); see Figure 1, which has been identified for potential designation as a tuna penning site. The main aims of the assessment are to collect and analyse data on general physico-chemical attributes of the sediments and water column, and on the ecological characteristics of the site, and to provide ADI with the findings and assist the consultants with predicted potential impacts of the proposed activity on the ecology of the site. Ultimately, the present document will feed into the Environment Impact Assessment for the concerned project; i.e. PA 02175/18: Extension to an existing tuna farm operation off the North East coast of Malta by placing another 12 tuna cages without any increase in the tonnage of tuna fish caged.

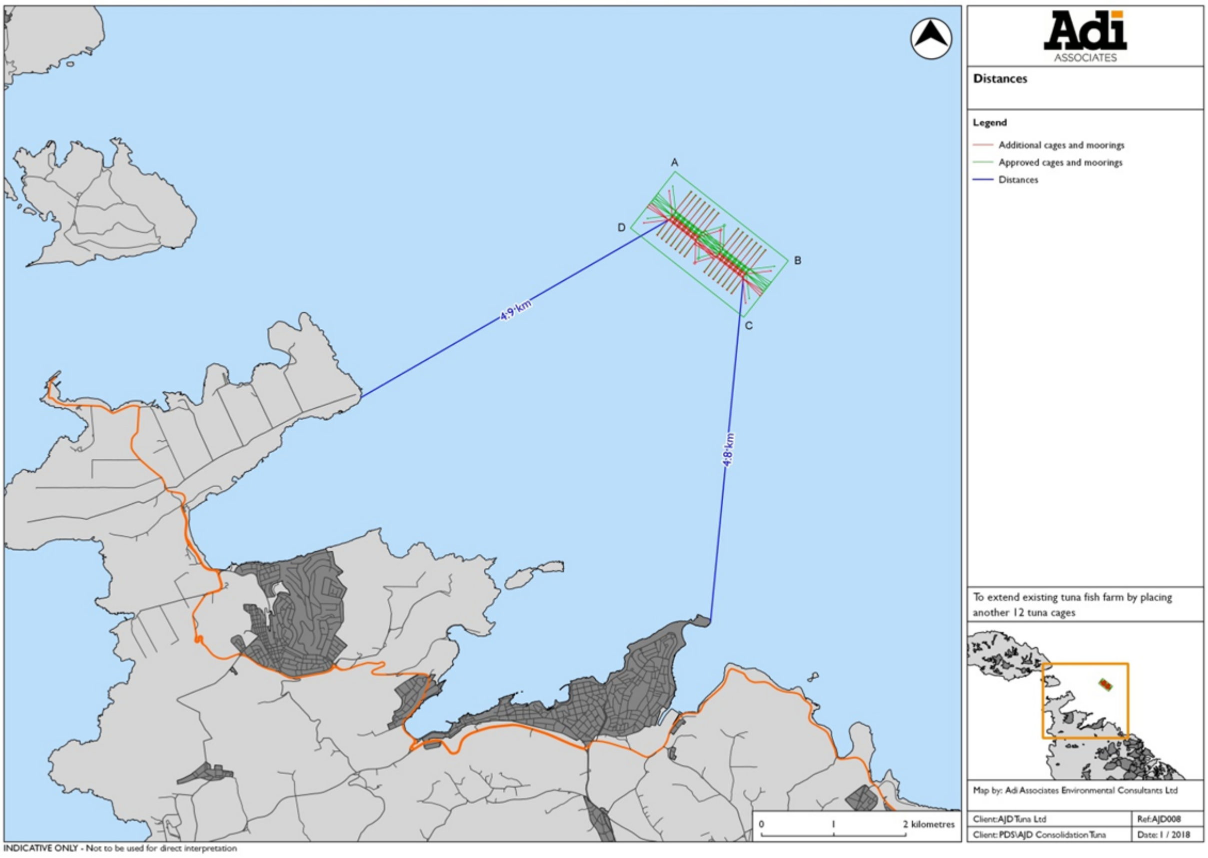

Figure 1. Map showing the site (area marked by points ABCD) off Mellieha Bay, which has been identified for potential designation as a tuna penning site. Cages indicated in green have already been deployed on site, while cages indicated in red are planned to be deployed on issue of the necessary permit. Map source: Adi Associates Environmental Consultants Ltd.

2. A survey of the marine benthic habitats present within an area that overlaps with the one that is the subject of the survey carried out in May 2018 for the present assessment was made in May 2017 (Borg & Evans, 2017); see the area enclosed by the blue boundary in Figure 2. Part of the area currently occupied by AJD Tuna Ltd's 12 tuna cages, and where a further 12 cages are planned to be deployed, falls within the area surveyed by Borg & Evans

in May 2017, however, the area bounded by the green line had not yet been surveyed (see Figure 2). A main aim of the present study was to map the marine benthic assemblages present within the area enclosed by the green boundary and adjacent areas using data from a survey by Seastar Survey Ltd undertaken in May 2018, and from Borg & Evans' survey made in May 2017. Furthermore, the present document also reports on data of physico-chemical attributes of the water column, and of the soft sediment seabed in the vicinity of area ABCD (Figure 1). A further aim was to sample the soft sediment habitat in the vicinity of the area ABCD (Figure 1) to establish the species of benthic flora and fauna present.

3. The findings from the survey made in May 2017 that was undertaken using a remotely operated vehicle (ROV) and which entailed collection of underwater footage of the seabed along transects within the survey area indicated the following (see Borg & Evans, 2017):

- In terms of physical characteristics, the bottom within the area surveyed consisted predominantly of coarse mobile sediments. A drop-off (some 10 m – 25 m high) is present just outside the study area on its northeastern side. What are usually referred to as 'maerl[1] beds' but which are more properly termed 'rhodolith beds' occupied a large part of the study area, which were more dense and continuous in the northeastern (and deeper) (outer) half of the survey area; in many places, the rhodolith beds were interspersed with a bare sand bottom that supported sparse rhodoliths[2]. "Rhodolith beds were densest in the central parts of the study area but the rhodolith density varied, such that they were less dense in the southwestern (shallower) parts of the survey area. A large stretch of predominantly bare sand was present in the southwesterly extreme part of the study area. Depth varied between 46 m and 72 m. The underwater visibility was good (25 – 30 m) throughout the study area, and an appreciable current was noted close to the seabed along some of the transects; as evidenced by debris and other material originating from benthic vegetation that were seen being moved rapidly on the bottom. Some anthropogenic items were observed during the survey; these included glass and plastic beverage bottles, fish traps and other unidentified items.
- In terms of biological characteristics, the following two main biotic assemblage types were recorded from the study area (see Figure 2):

  (i) Association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (EUNIS code A5.515)[3]

  (ii) Infralittoral coarse sediment (EUNIS code A5.13)[4]

  The association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents was present as two subtypes: one which was characterised by a rhodolith-rich bottom in which the proportion of rhodoliths covering the bottom was dense, constituting a well developed rhodolith bed, *sensu* Basso *et al*. (2016). This association subtype was present in the deeper parts (> 60 m) of the survey area (Figure 2). The other subtype consisted of a rhodolith bed in which the density of rhodoliths was

[1] 'Maerl' is a term used to describe calcareous sediments dominated by coralline algae. Maerl as used here describes sedimentary habitats in which living or dead unattached calcareous rhodophytes are a dominant component. These algae may take the form of nodules (rhodoliths) or fragmented thalli. However, according to Basso *et al*. (2016), 'rhodolith beds' should be identified and delimited as those areas of the sea floor with >10% cover of live rhodoliths over a minimum surface of 500 m^2, while the term "maerl" refers to a specific type of rhodolith bed that is composed of non-nucleated, unattached growths of branching, twig-like coralline algae. 'Maerl' as used here conforms to the definition of Basso *et al*. (2016).

[2] Rhodoliths consist either of free-living calcareous rhodophytes (red algae), or else of an inner nucleus, such as stone or shell, encrusted by calcareous rhodophytes.

[3] Equivalent to RAC/SPA 'Association with Rhodoliths'; code III.3.2.2.

[4] Equivalent to RAC/SPA 'Biocoenosis of coarse sands and fine gravels under the influence of bottom currents; code III.3.2.

sparser and in which the rhodoliths formed accumulations or were dispersed as single rhodoliths amongst other sediment components; this association subtype was present in areas having an intermediate water depth (50 m – 60 m); see Figure 2. Although no samples of rhodoliths were collected from the survey area, it is well established that a variety of coralline algal species that completely coat coarse sediment granules to form ‘cored rhodoliths’, contribute to local rhodolith beds; these include *Lithophyllum incrustans*, *Lithothamnion valens*, *Mesophyllum alternans* and *Sporolithon ptychoides*. Where present in the survey area, the rhodolith-rich bottom appeared to comprise a pseudo-hard substratum that supported macroalgae; the predominant alga being *Flabellia petiolata*. The main megafaunal species that was recorded from this association is the cidariid sea urchin *Stylocidaris affinis*. The rhodolith beds occupied the greater part of the area surveyed but the density of the rhodoliths varied greatly, with the general tendency being for the beds to be less dense with a decrease in water depth and on moving from the northeastern parts of the study area to the southwestern parts. Where dense, the rhodolith beds supported the alga *Flabellia petiolata* and, in places, an unidentified filamentous alga. The most abundant megafaunal species recorded from this association were the cidariid sea urchin *Stylocidaris affinis*, the Heart Urchin *Spatangus purpureus*, and the Long-Spined Urchin *Centrostephanus longispinus*. Individuals of the crinoid *Antedon mediterranea*, and single individuals of the seastar *Luidia ciliaris* and of the seaslug *Pleurobranchia meckeli* were also recorded from this assemblage. Burrows of the Common Octopus *Octopus vulgaris* were recorded in some places.

The infralittoral coarse sediment assemblage occurred at the southwestern part of the area surveyed, where the water depth was some 46 m – 50 m. In places, the sediment bottom supporting this assemblage type had current ripples; in places the trough of such ripples had small accumulations of rhodoliths or sparse rhodoliths. Detached algal and plant (seagrass) material was present in places on the seabed where this assemblage occurred but no attached fleshy algae or seagrasses were present. The epifauna associated with this assemblage was impoverished; the only recorded macrofauna comprised the Heart Urchin *Spatangus purpureus* and groups of the Purple Urchin *Sphaerechinus granularis*.

4. The present submission comprises a report of a survey of the main marine benthic habitats, benthic diversity and water quality, undertaken within the concerned study area. Video footage collected during the underwater videographic component of the present survey is appended to the present document and is titled ‘*Video transects of the seabed in an area off Mellieha Bay proposed for designation as an offshore tuna penning site, made in May 2018*.

2. METHODOLOGY

SEDIMENT AND WATER QUALITY

5. Fieldwork in relation to the water quality survey was undertaken on 4th April 2018. The day during which fieldwork was made was chosen at random but subject to good sea conditions to ensure successful undertaking of fieldwork and data collection. Fieldwork was carried out using a 12 m vessel equipped with hoisting jib and winch. The locations of the six sampling stations, A – D and R1 and R2, and shown in Figure 3, and their geographical coordinates and water depth are given in Table 1.

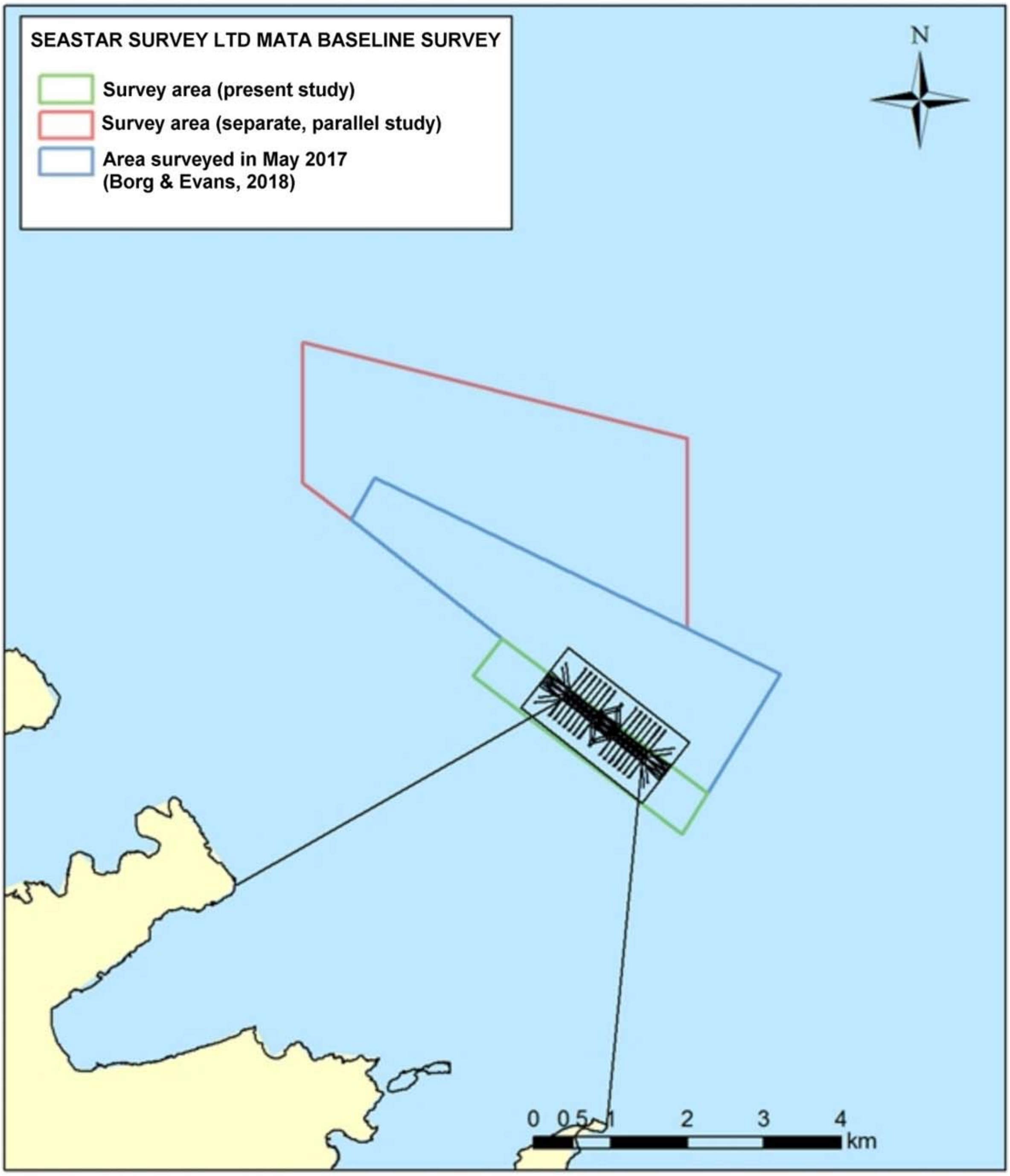

Figure 2. Map showing: the tuna farm site off Mellieha Bay that is currently used temporarily by AJD Tuna Ltd, and which has been identified for potential designation as a tuna penning site; the area used in the May 2017 benthic habitats survey (blue boundary); the area used in the present benthic habitats survey (green boundary); and the area used in a separate survey undertaken in parallel with the present study. Map source: Seastar Survey Ltd, UK.

6. The list of physico-chemical attributes that were included in the water quality survey are given in Table 2. Measurements of temperature, salinity, turbidity and dissolved oxygen in water were made *in-situ* at each of the ten stations using a YSI 650 MDS meter connected to a 6920 V2 multi-parameter probe. The meter was calibrated according to the manufacturer's

instructions immediately before use. Measurements using the *in-situ* meter were made at the surface (0.5 m below the surface). Two replicate measurements were taken at each of the six stations A – D, and R1 and R2. Two replicate samples of seawater were then collected from each of the same six stations; samples were collected at a depth of 0.5 m, from each of the six stations using a standard Van Dorn water sampler of 3 L volume. All water samples were transported in a cooler box and maintained at a temperature of 4^{o}C.

7. Estimates of current velocity and direction at the two reference stations (R1 and R2; see Figure 3) were made using drogues according to the La Grange method. The drogues employed for this purpose had four rectangular perspex vanes, each of which has a surface area of 0.2 m^2. The drogues were suspended from an inflatable surface float by means of a length of twine which was 1 m long. The position of the release point (determined using the GPS) and time of the release were recorded. After allowing the drogues to float for a given period of time, the position of the collection point and the time of collection were recorded.

8. For sediment granulometric and chemical studies, samples were collected using a 0.1 m^2 van Veen grab that was deployed from a 12 m vessel equipped with hoisting jib and winch. Two replicate grab samples were collected from each of six stations A – D, and R1 and R2; see Figure 3 and the corresponding geographical coordinates given in Table 1. The list of physico-chemical attributes that were included in the water quality survey are given in Table 3.

BENTHIC DIVERSITY

9. To collect data for benthic diversity studies, a grab sample was taken from each of the four stations A – D using a 0.1 m^2 Van Veen grab that was deployed from a 12 m vessel equipped with hoisting jib and winch. After the grab was brought on board, surplus seawater was drained from the sample by placing it on a 1mm-mesh sieve; the retained sediment and biota were temporarily preserved in 10% formaldehyde in seawater. In the laboratory, each sample was first washed to remove the fine sediment (<0.5 mm fraction) and the preservative, and it was then sorted to separate out all macrofauna (animals larger than 0.5 mm). The motile macrofauna was then identified as far as possible. Where identification to species level was not possible, the different species present were labelled using an alphabetical code (e.g. Mysidacea sp. A, etc.).

BENTHIC HABITATS MAP

10. Fieldwork in relation to the videographic survey to map the distribution of benthic habitats in those parts of the study area which had not been mapped by Borg & Evans (2017) was undertaken by personnel from Seastar Survey Ltd (UK) using the Maltese registered vessel MV Awrata, a 14 m steel workboat owned and operated by Azzopardi Fisheries. During the survey, a towed underwater camera system was used, which had the following specifications:
    - Kongsberg 14-208 camera and flash
    - Four video LED lights
    - Seastar Survey camera frame
    - EdgeDVR Digital video recorder with overlay
    - 300 m umbilical

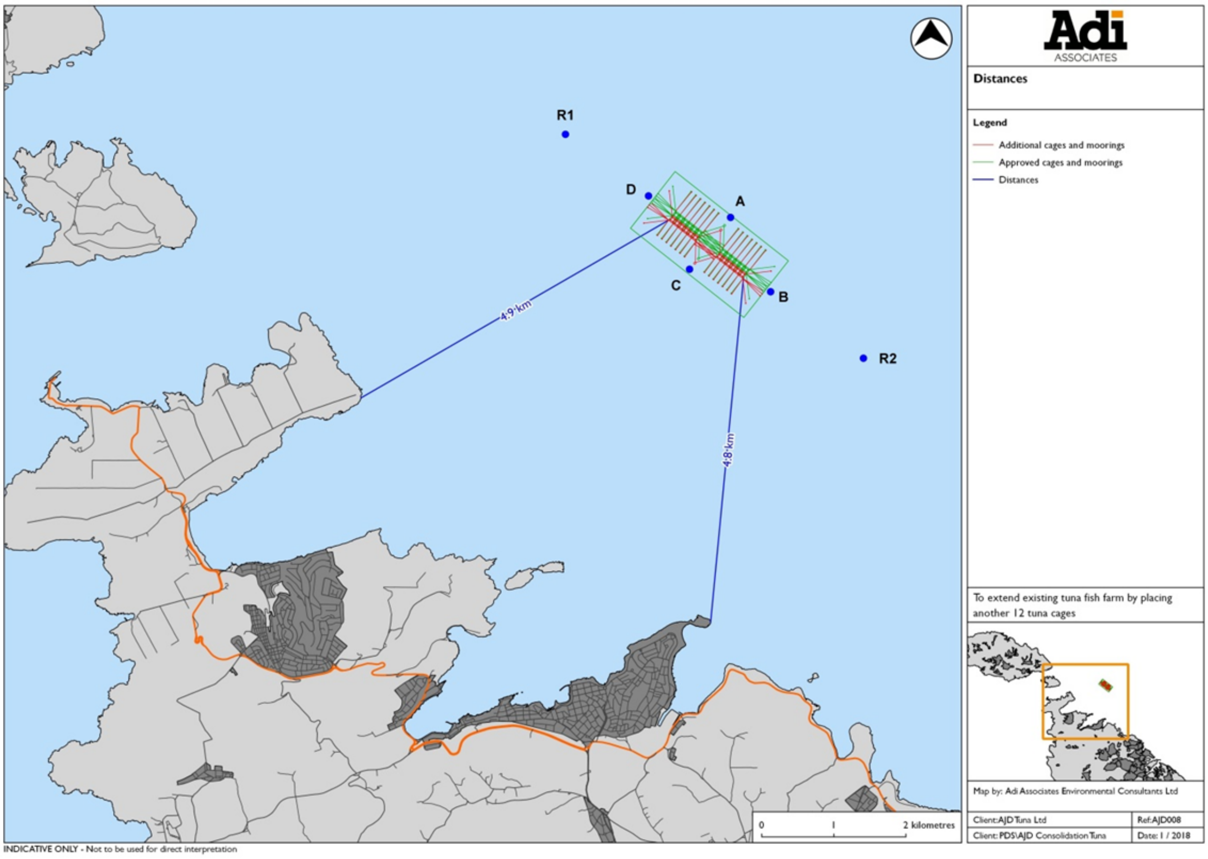

Figure 3. Map showing the study site off Mellieha Bay, and the six stations used for collecting samples for sediment and water quality, and benthic diversity. Stations A – D are located in the vicinity of the farm cages, while Stations R1 and R2 are reference sites. Map source: Adi Associates Environmental Consultants Ltd.

Table 1

Latitude/longitude coordinates and depth of the six sampling stations shown in Figure 3. In the field, readings were taken using the boat's Global Positioning System (GPS)[5] set.

Station	Latitude / Longitude	Depth (m)
A	36° 00.584' / 14° 25.780'	50 m
B	36° 00.131' / 14° 26.127'	48 m
C	36° 00.163' / 14° 25.508'	45 m
D	36° 00.567' / 14° 25.367'	48 m
R1	36° 00.848 / 14 24.474'	46 m
R2	35° 59.597 / 14 26.815'	48 m

[5] Chart datum set to European 1950; accuracy degeneration = *ca* 15m.

11. The camera and lights were set up on the camera frame so as to optimise field of view and video lighting. At each site, the vessel was manoeuvred to the transect position and first taken out of gear so as to determine the direction and speed of drift. Once the drift direction was determined, the vessel was manoeuvred to a distance of around 300 m from the transect position in the direction of drift, and then turned so that the camera transect was driven into the current. The positions of the video transects are shown in Figure 4; a total of ten transects were used in the survey. No transects were made within the area occupied by AJD Tuna Ltd's cages since the cages and mooring lines prevented deployment of the video camera along transects, but in any case most of the area had already been surveyed in 2017 (Borg & Evans, 2017). At the start of a transect, the vessel slowed to between 0.5 and 1.0 knot. The camera frame was deployed using the DT winch, wire tow-line and the vessel's crane, and the camera umbilical was bulldog taped to the winch wire at regular intervals to prevent it streaming out in the water column. During deployment, a layback position was calculated and recorded in Hypack, and an output of layback position and GPS time (GMT) was sent to the video overlay and recorded along with the video using EdgeDVR software. At regular intervals (approximately every minute), the camera frame was landed on the seabed and a high resolution still image was taken of the seabed. The still images were saved on the camera and downloaded at the end of each survey day. The position of the still images was recorded by noting the time of the photograph with the layback position from the navigation log for the same time.

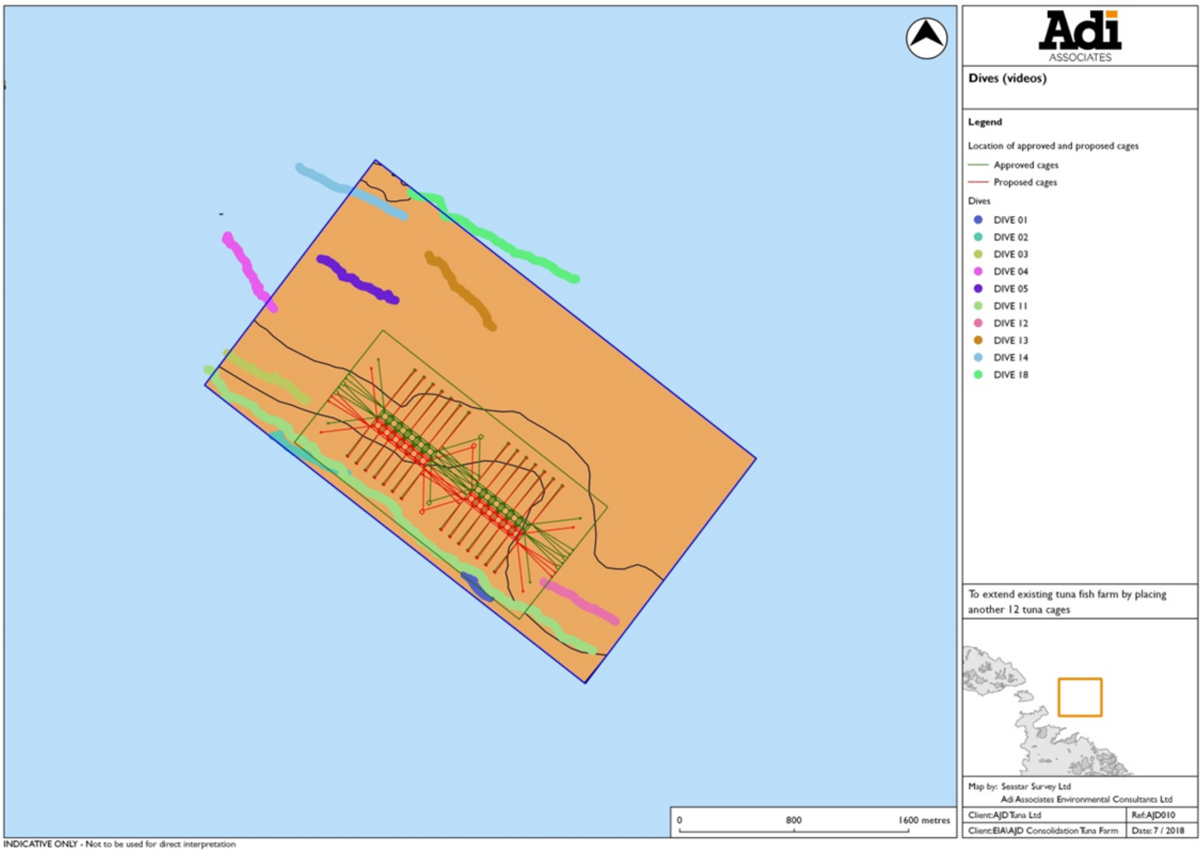

Figure 4. **Map showing the survey area (blue boundary) and locations of the ten video transects (referred to as 'Dives' in the figure key) that were used to survey the marine benthic habitats present in the area of interest. Map source: Seastar Survey Ltd (UK) and Adi Associates Environmental Consultants Ltd.**

12. Video footage and photographs of the benthic assemblages and species encountered along the transects were recorded on a PC hard drive and later analysed in the laboratory. Photographs taken during the survey were used to illustrate the present report.

13. Characterisation of the benthic assemblages was made using the scheme of Borg *et al*. (2013), which is based on the EUNIS typology that has been adapted for local use.

Table 2. List of physico-chemical attributes, together with the corresponding method of analysis, which were considered in the water quality studies.

Parameter	Method	Units
Temperature	In-situ / Portable Meter	°C
Salinity	In-situ / Portable Meter	psu
Dissolved Oxygen	In-situ / Portable Meter	%, mg/l
Turbidity	In-situ / Portable Meter	NTU
Turbidity (Secchi Depth)	Secchi Disk	m
pH	pH meter	pH units
Chlorophyll a	APAT CNR IRSA 9020 Man 29 2003	µg/l
Total Nitrogen	APAT CNR IRSA 5030 Man 29 2003 + APAT CNR IRSA 4040 A1 Man 29 2003 + APAT CNR IRSA 4050 Man 29 2003	µg/l
Total Phosphorus	APAT CNR IRSA 4110 Man 29 2003	µg/l
Total Carbon	UNI EN 1484:1999	µg/l
Total suspended matter	APAT CNR IRSA 2090 B Man 29 2003	mg/l

Table 3. List of physico-chemical attributes, together with the corresponding method of analysis, which were considered in the sediment quality studies.

Parameter	Method	Units (on D.M.)
Granulometry	Buchanan 1984	g
Total Organic Carbon (TOC)	UNI EN 13137:2002	%
Redox Potential	CNR IRSA 2 Q 64 Vol 3 1985	mV
Sulphide	CNR IRSA 12 Q 64 Vol 3 1986	µg
pH	CNR IRSA 1 Q 64 Vol 3 1985	pH units
Total Nitrogen	CNR IRSA 6 Q 64 Vol 3 1985	mg/g
Total Phosphorus	DM 13/09/1999 SO n°185 GU n°248 21/10/1999 Met XV.I	mg/g

3. RESULTS

14. Ecoserv's laboratory report reference for the present document is **068-18**.

15. The sample reference codes for the water quality and sediment surveys are as follows:
    - Water in-situ parameters: W-158-18
    - Secchi depth readings: W-159-18
    - Water chemical parameters: W-160-18 to W-171-18
    - Sediment chemical parameters: S-063-18 to S-074-18
    - Sediment granulometry: S-051-18 to S-062-18
    - Benthic diversity: S-075-18, S-077-18, S-079-18 and S-081-18
    - Video footage: D-025-18 to D-031-18

SEDIMENT AND WATER QUALITY

16. The results of the water quality survey are given in Tables 4 to 6, while those for the sediment quality survey are given in Table 7. The results of granulometric analysis are given in Table 8.

17. The results of *in situ* measurement of physico-chemical parameters of the water column indicate temperature values and levels of salinity, water transparency and dissolved oxygen that are expected of local pristine offshore coastal waters during spring. The Secchi Disc measurements indicated a high water transparency of between 24 m and 29 m.

18. Detectable but low levels of total organic carbon (TOC), total suspended solids (TSS), total nitrogen, and total phosphorous were recorded from the sampling stations, while levels of Chlorophyll *a* were below the limit of detection, thereby indicating a low phytoplankton abundance.

19. A weak southeasterly surface sea current having a speed of between 0.11 m/s and 0.13 m/s was recorded at the two reference stations R1 and R2.

20. The results of chemical analysis of sediments from the sampling stations indicated detectable but low levels of total organic carbon (TOC), total nitrogen, and total phosphorous, while levels of sulphide were below the limit of detection. Values of pH and redox potential were of an order that is expected of background levels for local offshore sediments.

21. The results of granulometric analysis indicate that the sediments characterising the six sampling stations comprise poorly sorted coarse sand having a mean grain size of between 0.55 mm and 0.95 mm.

Table 4. Mean values (± standard deviation) of physico-chemical attributes recorded from the water column at the six sampling stations.

Parameter	Temperature (°C)		Salinity (ppt)		Turbidity (NTU)		Dissolved Oxygen (%)	
Station	**Mean**	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**
SA1	15.82	0.02	37.80	0.28	0.28	0.00	99.94	0.09
SA2	15.79	0.00	37.81	0.00	0.28	0.00	99.80	0.07
SB1	15.89	0.03	37.95	0.01	0.36	0.04	100.32	0.08
SB2	15.86	0.02	37.95	0.01	0.36	0.04	100.30	0.10
SC1	15.91	0.01	37.96	0.00	0.32	0.09	100.38	0.08
SC2	16.05	0.11	37.97	0.02	0.28	0.00	100.60	0.23
SD1	15.96	0.03	37.96	0.01	0.18	0.07	100.40	0.10
SD2	15.92	0.01	37.95	0.00	0.26	0.04	100.30	0.00
R1a	15.83	0.00	37.94	0.00	0.28	0.00	100.16	0.05
R1b	15.83	0.00	37.94	0.00	0.28	0.00	100.10	0.00
R2a	15.86	0.00	37.95	0.02	0.00	0.63	100.06	0.05
R2b	15.85	0.00	37.88	0.01	0.26	0.04	100.00	0.07

Table 5. Mean values (± standard deviation) in metres for water transparency recorded from the six sampling stations using the Secchi Disc method.

Station A		Station B		Station C		Station D		Station R1		Station R2	
Mean	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**
24.00	0.00	29.25	0.35	25.00	0.00	26.00	0.00	26.00	0.00	26.25	0.35

Table 6. Mean values (± standard deviation) of chemical parameters recorded from water samples collected from the six sampling stations.

Parameter	Units	Station A		Station B		Station C		Station D		Station R1		Station R2	
		Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
TOC	mg/L	0.75	0.35	0.50	0.00	0.55	0.35	0.60	0.14	0.90	0.14	0.60	0.14
TSS	mg/L	0.20	0.00	0.20	0.00	0.20	0.00	0.20	0.00	0.20	0.00	0.20	0.00
pH		8.50	0.00	8.50	0.00	8.55	0.07	8.55	0.07	8.55	0.07	8.45	0.07
Chlorophyll a	µg/L	< 0.01	0.00	< 0.01	0.00	< 0.01	0.00	< 0.01	0.00	< 0.01	0.00	< 0.01	0.00
Total Nitrogen	mg/L	3.94	0.43	4.30	0.58	4.03	0.71	3.50	0.10	3.51	0.07	3.96	0.15
Total Phosphorus	µg/L	6.90	0.85	10.10	0.42	10.85	0.35	12.95	2.05	8.25	0.07	7.00	0.42

Table 7. Mean values (± standard deviation) of chemical parameters recorded from sediment samples collected from the six sampling stations.

Parameter	Units	Station A		Station B		Station C		Station D		Station R1		Station R2	
		Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
pH	unit	8.75	0.07	8.75	0.35	9.30	0.00	9.00	0.14	8.90	0.14	8.85	0.21
TOC	%	0.45	0.00	1.90	0.99	0.80	0.71	0.36	0.04	0.58	0.47	0.63	0.40
Sulphide	mg/kg	< 2	0.00	< 2	0.00	< 2	0.00	< 2	0.00	< 2	0.00	< 2	0.00
Total nitrogen	% S.S.	0.04	0.00	0.04	0.00	0.04	0.00	0.04	0.00	0.05	0.00	0.06	0.00
Total Phosphorous	% S.S.	0.02	0.00	0.02	0.01	0.02	0.00	0.02	0.00	0.03	0.00	0.03	0.00
Redox Potential	mV	266.05	6.58	245.65	3.04	233.15	4.60	227.50	3.54	202.30	22.34	167.15	4.03

Table 8. Mean values (± standard deviation) of grain size and sorting, together with classification of sorting and sediment classification for sediment samples collected from the six sampling stations.

Station	Ecoserv sample ref.	Mean sediment grain size (mm)	Wentworth grade classification	Mean Sorting (Ø)	Degree of sorting
A	**S-051-18 / S-052-18**	0.716 ± 0.042	Coarse Sand	2.11 ± 0.09	Very Poorly Sorted
B	**S-053-18 / S-054-18**	0.550 ± 0.055	Coarse Sand	2.29 ± 0.04	Very Poorly Sorted
C	**S-055-18 / S-056-18**	0.751 ± 0.082	Coarse Sand	1.95 ± 0.10	Poorly Sorted
D	**S-057-18 / S-058-18**	0.693 ± 0.072	Coarse Sand	2.14 ± 0.05	Very Poorly Sorted
R1	**S-059-18 / S-060-18**	0.763 ± 0.023	Coarse Sand	1.74 ± 0.10	Poorly Sorted
R2	**S-061-18 / S-062-18**	0.937 ± 0.222	Coarse Sand	2.14 ± 0.33	Very Poorly Sorted

BENTHIC DIVERSITY

22. A classified list of species, and respective abundance, recorded from the four grab samples collected from Stations A – D (Figure 3) is given in Table 9. A total of 1,897 individuals comprising 111 macrofaunal species were recorded. The Polychaeta and Crustacea were the most common taxonomic groups, both in terms of total number of species and in abundance of individuals.

Table 2

Classified list of species recorded from the respective stations, and respective abundance (number of individuals per 0.1 m^2 grab sample).

Classified Species List	**Station**			
	A	**B**	**C**	**D**
Ecoserv Sample no.	**S-075-18**	**S-077-18**	**S-079-18**	**S-081-18**
SIPUNCULIDA				
Aspidosiphon muelleri		2		1
MOLLUSCA				
Gastropoda				
Ascobulla fragilis		1		
Caecum armorium		1		
Caecum auriculatum				2
Cerithidium submamillatum	1	1		
Euspira nitida	1			
Haminoea hydatis	3			
Opistobranchia sp.	3			
Parthenina interstincta	1	1		
Parvioris ibizenca	1			
Sticteulima jeffreysiana	2		2	
Vitreolina sp.		1		
Volvarina mitrella		2		
Polyplacophora				
Acanthochitana fascicularis	7		1	
Callochiton calcatus	32			
Chiton corallinus	1			
Ischnochiton rissoi	1			
Leptochiton cancellatus	5	6		
Parachiton africanus	4			5
Bivalvia				
Astarte fusca	2		2	4
Coripia corbis		2	3	6

Table 2. Continued…

Classified Species List	Station			
	A	B	C	D
Ecoserv Sample no.	**S-075-18**	**S-077-18**	**S-079-18**	**S-081-18**
Digitaria digitaria	4			
Diplodonta trigona	1			
Gari costulata		1		
Glans trapezia	1			
Gonilia calliglypta		2	2	2
Hiatella arctica		2		
Loripes orbiculatus				1
Modilula phaseolina	2	1		
Musculus costulatus	2			
Papillicardium papillosum		1		
Thracia phaseolina				1
Timoclea ovata	1	1	1	1
NEMERTEA				
Nemertea sp.	1		3	5
POLYCHAETA				
Ampharetidae sp.				1
Aphroditidae sp.			1	
Lepidonotus	2	5		
Capitellidae sp.	30	23	41	14
Cirratulidae sp.	5	3	6	
Dorviliidae sp.	11	21	7	8
Eunice sp.		5	5	4
Marphysa sp.	4			
Glycera sp.	1	5	1	5
Glyceridae sp.	1	2		
Lacydoniidae sp.	13	52	35	9
Lumbrineridae sp. A	2	1		
Lumbrineridae sp. B		1		1
Lumbrineridae sp. C		1		
Maldanidae sp. A				1
Maldanidae sp. B		1		
Nematonereis unicornis	5	4	3	
Nephtydae sp. A	38	38	29	15
Nephtydae sp. B		3	7	10
Nephtydae sp. C				1
Nereidae sp.			1	
Nereis rava	7	1		1
Notomastus sp.	11	9	3	2
Opheliidae sp.	1			16

Table 2. Continued…

Classified Species List	Station			
	A	B	C	D
Ecoserv Sample no.	**S-075-18**	**S-077-18**	**S-079-18**	**S-081-18**
Orbiniidae sp.		3		
Paraonidae sp.	33	26	65	41
Pectinaridae sp.	1	1		
Phyllodocidae	10	5	4	5
Polychaeta sp.	6	9	17	26
Polynoinae sp.			1	
Sabellidae	20	16	3	9
Scalibregmidae sp.	1	3	1	1
Sthenlais sp.				2
Syllidae	56	38	28	68
Terebellidae sp.	2	14		2
CRUSTACEA				
Leptostraca				
Nebalia bipes			1	
Decapoda				
Achaeus sp.		1		
Alpheus dentipes	1			
Anapagurus sp.		1	3	
Cestopagurus timidus	3	3	2	2
Galathea intermedia	2	2	1	
Ilia nucleus	1			
Liocarcinus sp.	1			
Parthenope sp.	5		1	
Processa sp.		1		
Mysidacea				
Mysidacea sp. B	1	1		1
Tanaidacea				
Apseudes sp.	9	1		
Leptochelia savignyi	28	47	20	18
Isopoda				
Anthuridae sp.	4	1	1	6
Cymodoce sp.	39	1	2	2
Eurydice sp.	3	1		
Gnathia sp.		2		1
Janiridae sp.	13	10	10	3
Synisoma sp.	1	2		
Amphipoda				
Amphilochus sp.	4	1	4	2
Aoridae sp.		2	6	4
Apherusa bispinosa		1		1
Caprellidae sp.		17	7	11

Table 2. Continued…

Classified Species List	Station			
	A	B	C	D
Ecoserv Sample no.	**S-075-18**	**S-077-18**	**S-079-18**	**S-081-18**
Cheirocratus sundevallii	4	1	1	
Elasmopus sp.	39	24	33	18
Harpinia sp.	1		1	
Hippomedon oculatus	18	9	8	3
Leptocherius sp.	15	2	8	10
Leucothoe spinicarpa	7	6	7	1
Lysianassa sp.	13	3	3	1
Maera sp.	8	2	9	3
Melita sp.	1	2	5	2
Monoculodes sp. F			1	
Pereionotus testudo	6	3	1	2
Phoxocephalidae sp.	5	10	13	11
Socarnes filicornis	10	1	7	
Stenothoe sp.	1			
Urothoe sp.		1		
Cumacea				
Cumacea sp.	1	2	2	1
ECHINODERMATA				
Echinoidea				
Genocidaris maculata	5	6	1	14
Spatangus purpureus			1	
Stylocidaris affinis	1	1		
CEPHALOCORDATA				
Branchiostoma sp.		3	2	2

VIDEO SURVEY

Physical characteristics of the seabed

23. The bottom within the area surveyed consisted predominantly of coarse mobile sediments. A drop-off (some 10 m – 25 m high) that is characterised by rock exposed to sedimentation is present at the northwestern part of the study area.

24. What are usually referred to as 'maerl[6] beds' but which are more properly termed 'rhodolith beds' occupy a large part of the study area, which were more dense and continuous in the northeastern (and deeper) half of the survey area. In many places, the rhodolith beds were interspersed with a bare sand bottom that supported sparse rhodoliths[7]. In the southwestern half of the survey area, the rhodolith density varied such that they are less dense in the shallower part (45 m – 50 m) of the survey area, where large expanses of bare sand that supported little or no rhodoliths were present. Overall, the seabed had physical features that corresponded with the bathymetry: coarse sand with sparse accumulations of rhodoliths (0 % - 20 % rhodolith cover) was present at a water depth of between 43 m and 50 m; between a water depth of 50 m and 55 m, the seabed comprised coarse sediment having denser rhodolith accumulations (20 % - 50 % rhodolith cover); and in waters deeper than 55 m, the seabed mainly consisted of dense rhodolith beds (50 % - 100 % rhodolith cover). Beyond the rocky drop-off, at water depths exceeding 100 m, the seabed mainly consisted of bare muddy sand.

25. Depth varied between around 43 m and just over 100 m. The underwater visibility was good (25 – 30 m) throughout the study area but flocculate material was noted in the water column along some of the transects.

26. A current was present in places close to the seabed, as evidenced by debris and other material originating from benthic vegetation that were seen being moved on the bottom.

27. Some anthropogenic items were observed during the survey. These included glass and plastic beverage bottles, abandoned fish traps and fishing lines, and other unidentified items. However, no remains of tuna, feed fish used in tuna farming or any other item that may have originated from tuna farming activities, was recorded on the seabed during the survey.

BENTHIC ASSEMBLAGES

28. The main outcome of the benthic survey carried out in May 2018, in combination with data from the survey carried out by Ecoserv in May 2017 (Borg & Evans, 2017) is a map showing the distribution of the main benthic habitats and assemblages (Figures 4 and 5) present in the area surveyed.

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[6] 'Maerl' is a term used to describe calcareous sediments dominated by coralline algae. Maerl as used here describes sedimentary habitats in which living or dead unattached calcareous rhodophytes are a dominant component. These algae may take the form of nodules (rhodoliths) or fragmented thalli. However, according to Basso *et al*. (2016), 'rhodolith beds' should be identified and delimited as those areas of the sea floor with >10% cover of live rhodoliths over a minimum surface of 500 m^2, while the term "maerl" refers to a specific type of rhodolith bed that is composed of non-nucleated, unattached growths of branching, twig-like coralline algae. 'Maerl' as used here conforms to the definition of Basso et al. (2016).

[7] Rhodoliths consist either of free-living calcareous rhodophytes (red algae), or else of an inner nucleus, such as stone or shell, encrusted by calcareous rhodophytes.

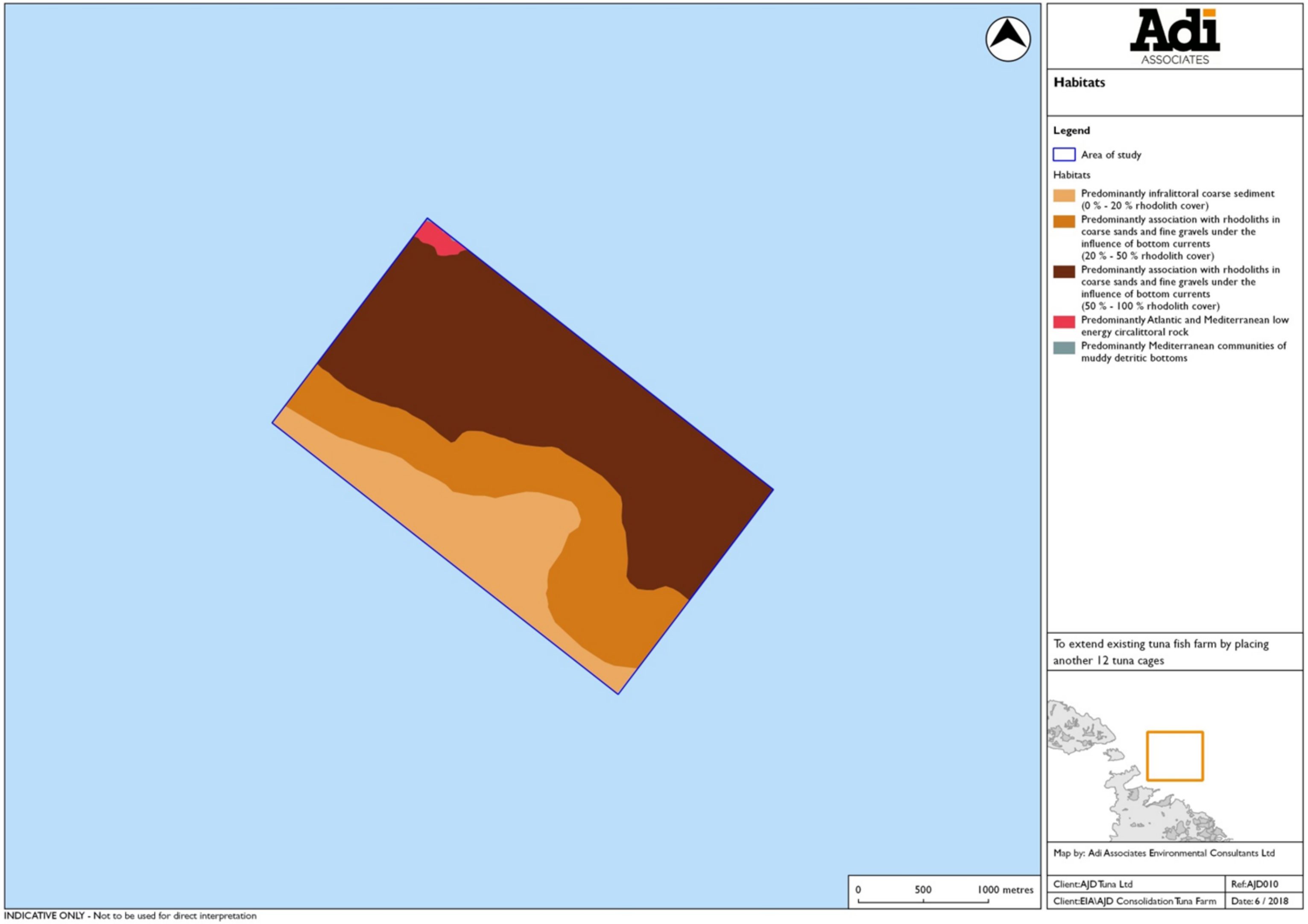

Figure 4. **Map showing the main benthic habitats present in the survey area.**

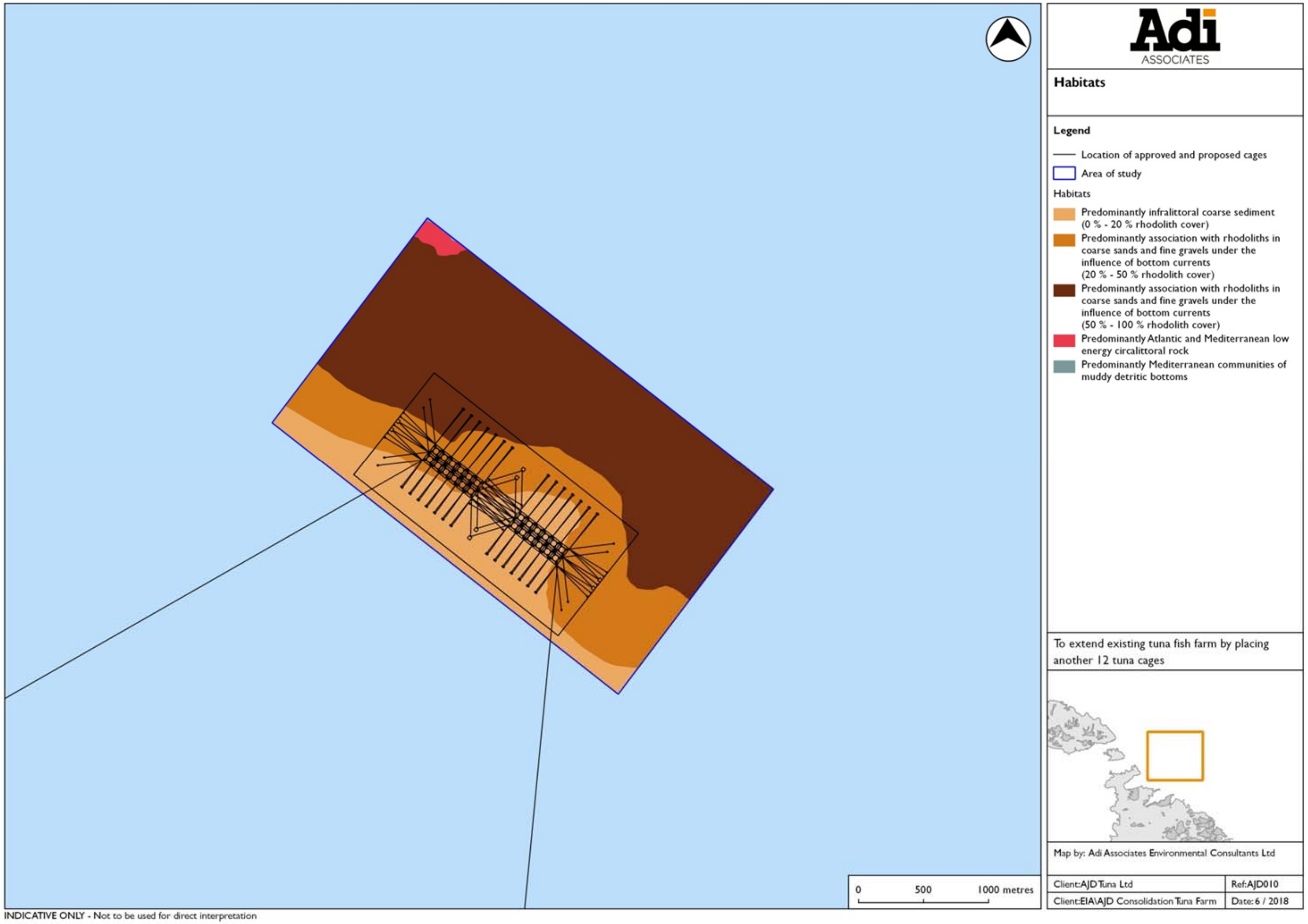

Figure 5. Map showing the main benthic habitats present in the survey area. The area currently occupied by AJD Ltd's 12 Tuna Cages and which has been identified for deployment of 12 additional pens is also shown. Map: Adi Associates Environmental Consultants Ltd.

29. The following two main biotic assemblage types were recorded from the study area:
    (i) Association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (EUNIS code A5.515)
    (ii) Infralittoral coarse sediment (EUNIS code A5.13)
    (iii) Mediterranean communities of muddy detritic bottoms (EUNIS code A5.38)
    (iv) Atlantic and Mediterranean low energy circalittoral rock (EUNIS code A4.3)

    A description of each of the above four assemblage types follows.

Association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents

30. This association was present as two subtypes: one which was predominantly characterised by a rhodolith-rich bottom in which the proportion of rhodoliths covering the bottom was dense (50 % - 100 % cover; see Figure 6) and constituted a well developed rhodolith bed, *sensu* Basso *et al*. (2016). This association subtype was mostly present in the deeper, northeastern half of the survey area (see the brown shaded area in Figures 4 and 5) within the 55 m – 80 m water depth range. The other subtype mainly consisted of a rhodolith bed in which the density of rhodoliths was sparser and predominantly formed accumulations such that the overall rhodolith cover was around 20 % - 50% (see Figure 7); this association subtype was mainly present as a band in the central parts of the survey area (see the orange shaded area in Figures 4 and 5) within the 50 – 55 m water depth range.

31. Preliminary examination of rhodoliths that were retrieved from sediments collected by grab from Stations A, B and D (see Figure 3) indicated that the algal species that contribute to the rhodoliths include species from the following genera: *Lithophyllum, Lithothamnion*, *Mesophyllum* and *Sporolithon* (see Lanfranco *et al*., 1999; Borg and Schembri 2002; Sciberras *et al*., 2009).

32. Where present, the dense rhodolith beds appeared to comprise a pseudo-hard substratum that supported macroalgae; the predominant alga being *Flabellia petiolata* (Figure 6) and *Zonaria tournefortii* but other algae including *Halimeda tuna*, *Peyssonnelia squamaria*, *Dictyota* sp. and unidentified filamentous forms, were also recorded in places.

33. The most abundant megafaunal species that were recorded from this association are the cidariid sea urchin *Stylocidaris affinis* and the Purple Heart Urchin *Spatangus purpureus* (Figure 8); other megafaunal species that were recorded during the survey included several species of sponges and bryozoans (including *Sertella* sp.), the Long-spined Urchin *Centrostephanus longispinus* (Figure 9), the Red Seastar *Echinaster sepositus* (Figure 10), the crinoid *Antedon mediterranea*, the crab *Inachus* sp., and the seastar *Luidia ciliaris*. Furthermore, the presence of openings to numerous burrows in places indicated an associated rich infauna.

Infralittoral coarse sediment

34. This assemblage type occurred as a band at the southwestern part of the study area (see the yellow-brown shaded area in Figures 4 and 5), where the water depth was some 43 m – 50 m. In places, the sediment bottom supporting this assemblage type had small accumulations of rhodoliths or sparse rhodoliths, such that where these were present their cover was some 1 –

20% (see Figures 11 - 14). Detached algal and plant (seagrass) material was present in places on the seabed where this assemblage occurred but no attached fleshy algae or seagrasses were present. The epifauna associated with this assemblage was impoverished; the most abundant macrofaunal species was the Purple Heart Urchin *Spatangus purpureus* (Figure 15) and groups of the Purple Urchin *Sphaerechinus granularis*. However, the presence of openings to burrows present in many places indicated the presence of a rich infauna.

Figure 6. Photograph of the seabed taken at a point along Transect 5, showing a close-up of a dense rhodolith bed. The green alga visible in the photo is *Flabellia petiolata*.

Figure 7. Photograph of the seabed taken at a point along Transect 12, showing a close-up of a sparse rhodolith bed.

Figure 8. Photograph of the seabed taken at a point along Transect 5, showing a close-up of a rhodolith bed intermixed with bare sediment. The five orange coloured long-spined urchins visible in the photo are individuals of *Stylocidaris affinis*. The large purple coloured urchin on the right hand side of the photo is an individual of the Purple Heart Urchin *Spatangus purpureus*.

Figure 9. Photograph of the seabed taken at a point along Transect 3, showing a close-up of a rhodolith bed. An individual of the Long-spined Urchin *Censtrostephanus longispinus* is visible at the top right hand corner of the photo adjacent the alga *Flabellia petiolata* (green).

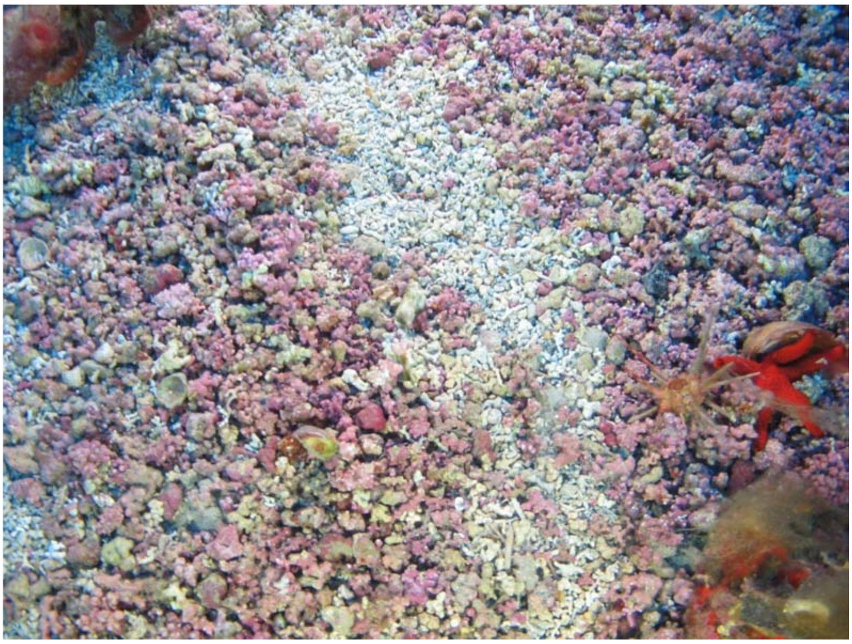

Figure 10. Photograph of the seabed taken at a point along Transect 5, showing a close-up of a rhodolith bed. An individual of the urchin *Stylocidaris affinis* and another of the Red Seastar *Echinaster sepositus* are visible on the right side of the photo.

Figure 11. Photograph of the seabed taken at a point along Transect 2, showing a close-up of an assemblage of infralittoral coarse sediment.

Figure 12. Photograph of the seabed taken at a point along Transect 2, showing a close-up of an assemblage of infralittoral coarse sediment. An individual rhodolith is visible at the centre of the photo.

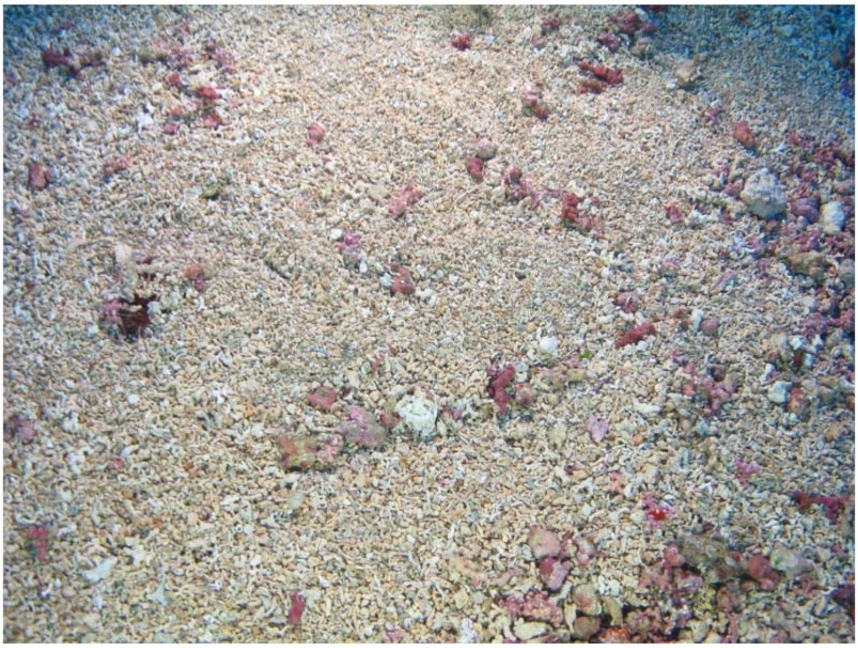

Figure 13. Photograph of the seabed taken at a point along Transect 11, showing a close-up of an assemblage of infralittoral coarse sediment. Individual rhodoliths are visible in places in the photo.

Figure 14. Photograph of the seabed taken at a point along Transect 11, showing a close-up of an assemblage of infralittoral coarse sediment. Three narrow strips with rhodoliths are visible in the photo.

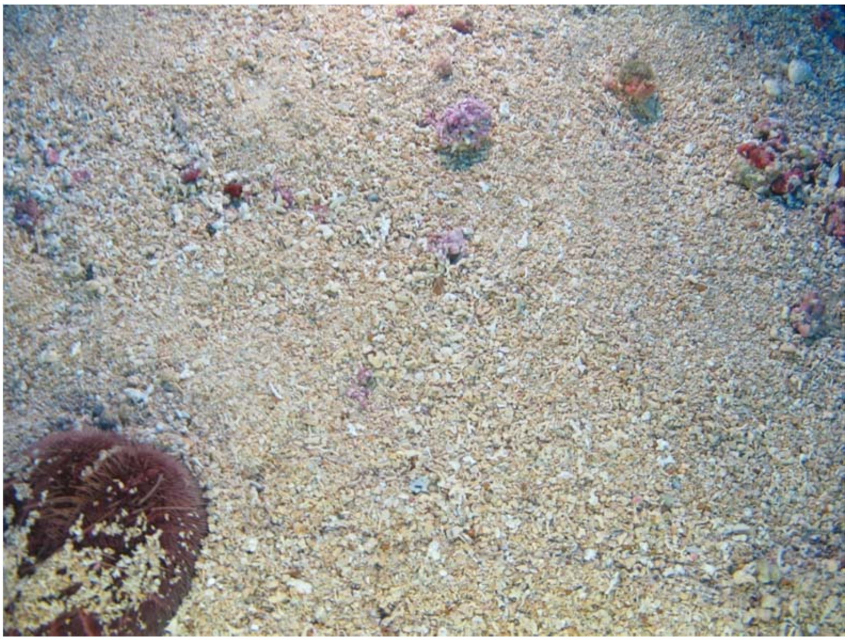

Figure 15. Photograph of the seabed taken at a point along Transect 11, showing a close-up of an assemblage of infralittoral coarse sediment. A few individual rhodoliths (Purple colour) – most of them having a very small size (few mm) – and an individual of the Purple Heart Urchin *Spatangus purpureus*, are visible in the photo.

35. Although in general the area surveyed mainly supported the assemblage types and subtypes as described above and as depicted in Figures 4 and 5, parts within the shaded areas shown in the habitat map (Figures 4 and 5) supported patches with a different assemblage type, such that:

- The area which supported the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (dense rhodolith bed) had, in places, patches with the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (sparse rhodolith bed) ;
- The area which supported the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (sparse rhodolith bed) had, in places, patches with the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (dense rhodolith bed) or patches with the assemblage of coarse infralittoral sediment;
- The area which supported the assemblage of coarse infralittoral sediment had, in places, the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (sparse rhodolith bed).

Furthermore, comparison between data from video transects made during Borg & Evans' 2017 survey and data from the survey made by Seastar Survey Ltd in May 2018 indicate some differences in the spatial distribution of the assemblage of coarse infralittoral sediment and the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (sparse rhodolith bed); these differences are discussed in the discussion section below.

Mediterranean communities of muddy detritic bottoms

36. This assemblage type was recorded from the extreme northwestern corner of the study area (Figures 4 and 5) at a water depth exceeding 100 m and occurred at the base of the 10 m – 25 m high drop-off from where it extended further into deeper waters (Figure 16). No macroflora was recorded from this assemblage type, although detached macroalgae (mainly *Zonaria tournefortii*) were present on the sediment surface in various places. No macrofauna was recorded from this assemblage type but the presence of openings to burrows indicated an associated rich infauna.

Atlantic and Mediterranean low energy circalittoral rock

37. This assemblage type was recorded from the extreme northwestern corner of the study area (Figures 4 and 5) and formed part of the drop-off some 10 m – 25 m high that separated the assemblage of coarse sands and fine gravels under the influence of bottom currents and the assemblage of infralittoral coarse sediments (Figure 17). The associated macroalgae mainly comprised *Zonaria tournefortii* and unidentified coralline algae (Figure 17). The associated macrofauna mainly comprised sponges, bryozoans, and other sessile macrobenthic species. Individuals of the echiuran worm *Bonellia viridis* were recorded in places from this assemblage type.

Figure 16. Photograph of the seabed taken at a point along Transect 21, showing a close-up of a Mediterranean community of muddy detritic bottoms.

Figure 17. Photograph of the seabed taken at a point along Transect 21, showing a close-up of a Mediterranean community of muddy detritic bottoms.

Demersal and pelagic fauna

38. The demersal fish fauna recorded during the survey mainly comprised large shoals of Picarel *Spicara* sp. and individuals of the Comber *Serranus cabrilla*. Several individuals of the Mauve Stinger *Pelagia noctiluca* were recorded in the water column during the survey.

4. APPRAISAL

SEDIMENT AND WATER QUALITY

39. The results of the sediment and water quality surveys indicate physico-chemical characteristics that are typical of marine waters and the seabed off the northeastern coast of Malta. Water depth varies between around 43 m and just over 100 m. The underwater visibility was good (25 – 30 m) throughout the study area but flocculate material (of unknown origin) was present in the water column along some of the transects. A weak southeasterly surface sea current having a speed of between 0.11 m/s and 0.13 m/s was present in the study area.

40. The bottom within the area surveyed consists predominantly of coarse mobile sediments; in the vicinity of the site currently used by AJD Tuna Ltd, the seabed comprises poorly sorted coarse sand having a mean grain size of between 0.55 mm and 0.95 mm. A drop-off, some 10 m – 25 m high, and characterised by rock exposed to sedimentation is present in the northwestern part of the study area. The base of this drop-off is characterised by a bare muddy sand bottom. A large part of the seabed in the study area comprises rhodolith beds, which are more dense and continuous in the northeastern (and deeper) half of the survey area. In many places, the rhodolith beds are interspersed with a bare sand bottom that supports sparse rhodoliths, while in the southwestern half of the survey area, the rhodolith density varies such that they are less dense in the shallower part (45 m – 50 m) of the survey area, where large expanses of bare sand that supported little or no rhodoliths are present. Overall, the seabed has physical features that correspond with the bathymetry: coarse sand with sparse accumulations of rhodoliths (0 % - 20 % rhodolith cover) is present at a water depth of between 43 m and 50 m; between a water depth of 50 m and 55 m, the seabed comprises coarse sediment having denser rhodolith accumulations (20 % - 50 % rhodolith cover); and in waters deeper than 55 m, the seabed mainly consists of dense rhodolith beds (50 % - 100 % rhodolith cover). A current was present in places close to the seabed, as evidenced by debris and other material originating from benthic vegetation that were seen being moved on the bottom.

41. Some anthropogenic items were observed during the survey. These included glass and plastic beverage bottles, abandoned fish traps and fishing lines, and other unidentified items. However, no remains of tuna, feed fish used in tuna farming, or any other item that may have originated from tuna farming activities, was recorded on the seabed during the survey.

BENTHIC DIVERSITY

42. Analysis of the grab samples showed the presence of macrofauna that is typical of the benthic biotic assemblages that characterisize the lower infralittoral to circalittoral transition zone and the upper circalittoral zone that occurs off the northeastern coast of the Maltese islands. (cf. Borg *et al.*, 1998; Schembri 1998; Sciberras *et al.*, 2009). A high diversity of macrobenthic fauna was recorded from the grab samples; the two most represented taxonomic groups, in terms of species richness and abundance, were the polychaetes and the crustaceans. No protected species were recorded from any of the grab samples.

BENTHIC ASSEMBLAGES

43. Overall, the benthic biotic assemblages in the study area are characteristic of ones present in the infralittoral and circalittoral zones off the northeastern coast of the Maltese Islands (e.g. Borg *et al*., 1998; Schembri 1998; Sciberras *et al.,* 2009; Schembri, 2011).

44. Four main biotic assemblage types were recorded from the study area: (i) Association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (EUNIS code A5.515); (ii) Infralittoral coarse sediment (EUNIS code A5.13); Mediterranean community of muddy detritic bottoms (EUNIS code A5.38); and Atlantic and Mediterranean low energy circalittoral rock (EUNIS code A4.3). The former association was present as two assemblage subtypes: (i) dense rhodolith beds (having a rhodolith cover of between 50 % and 100 %), some of which may possibly be classified as maerl (sensu Basso *et al*., 2016), which occupy a large part of the northeastern half of the study area; and (ii) sparser rhodolith beds (having a rhodolith cover of between 20 % and 50 %), which occupy the central parts of the area surveyed. The assemblage of infralittoral sediment was present in the shallower, southwestern parts of the study area and in places supported sparse rhodolith accumulations (having a rhodolith cover of between 1 % and 20 %). The Mediterranean community of muddy detritic bottoms and the assemblage of Atlantic and Mediterranean low energy circalittoral rock were present in the northwestern corner of the study area.

45. It is emphasised that although the area surveyed mainly supported the assemblage types and subtypes described above, parts within the different areas that represent different habitats (Figures 4 and 5) support patches with a different assemblage type, such that:

- The area which supported the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (dense rhodolith bed) had, in places, patches with the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (sparse rhodolith bed) ;
- The area which supported the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (sparse rhodolith bed) had, in places, patches with the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (dense rhodolith bed) or patches with the assemblage of coarse infralittoral sediment;
- The area which supported the assemblage of coarse infralittoral sediment had, in places, the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (sparse rhodolith bed).

Furthermore, differences in the spatial distribution of the assemblage of coarse infralittoral sediment and of the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (sparse rhodolith bed) were evident when comparing data from video transects made during Borg & Evans' 2017 survey with data from the survey made by Seastar Survey Ltd in May 2018. These differences, which are mostly applicable to the shallower (43 m – 55 m) parts of the study area indicate that the soft sediment seabed there is dynamic and undergoes changes that involve shifting of accumulations of rhodoliths from one place to another, possibly even over large distances of several hundred metres. Such changes would happen during very strong wave action, typically during strong northeasterly winds, such as ones that characterised autumn 2017 and winter 2018. As a result, the spatial distribution of the aforementioned two habitat types changes.

46. Although video footage collected from the present survey enabled recording of several macroalgal species, including *Flabellia petiolata* and Zonaria tournefortii which appeared to be the most abundant, several other algal species are known to be associated with the association with rhodoliths in coarse sands and fine gravels under the influence of bottom currents (see Borg *et al*., 1998; Borg & Schembri, 2008; Schembri, 2011). Likewise, apart from the megafauna, including the urchin *Stylocidaris affinis,* the Heart Urchin *Spatangus purpureus,* the crinoid *Antedon mediterranea* and the Needle-Spined urchin *Centrostephanus longispinus*, and other species recorded from the present survey, numerous other mega- and macrofaunal species occur in association with the rhodolith habitats (see Borg *et al*., 1998; Borg & Schembri, 2008; Schembri, 2011). Apart from these mega- and large macrofaunal species, rhodolith beds support numerous small macrofaunal species including polychaete, mollusc, crustacean, and echinoderm taxa (e.g. Schembri, 2011).

47. No fleshy algae were recorded from the assemblage of infralittoral sediment but very sparse accumulations of rhodoliths or single rhodoliths were present in places, especially in the troughs formed by the current ripples. The megafauna recorded from this assemblage type comprised the Heart Urchin *Spatangus purpureus* and the Purple Urchin *Sphaerechinus granularis.* However, this assemblage undoubtedly supports a rich infauna as evidenced by the macrofaunal species (Table 9) recorded from the grab samples collected from Stations A – D (Figure 3). The recorded species are typical of the assemblage of infralittoral to circalittoral coarse sediment assemblages present of the northeastern coast of Malta within the 45 m to 80 m depth range.

48. The study area is located within the boundaries of the '*MT0000105 Marine Area in the Northeast of Malta*' Special Area of Conservation of International Importance declared by Government Notice 851 of 2010[8] under the provisions of the *Flora, Fauna and Natural Habitats Protection Regulations, 2006*. This area forms part of the European Union's NATURA 2000 network.

49. In Maltese waters, the main rhodolith-forming algae in rhodolith/maerl beds are *Lithothamnion corallioides* and *Phymatolithon calcareum/Lithothamnion minervae*[9] with *Peysonnelia rosa-marina*, *Mesophyllum* sp., and *Neogoniolithon brassica-florida* constituting a minor component (Lanfranco *et al*., 1999). Associations with rhodoliths are a habitat type that qualifies sites for inclusion in national inventories of natural sites of conservation interest as required by the Protocol for Specially Protected Areas and Biodiversity in the Mediterranean (SPA/BD) of the Barcelona Convention[10]. Furthermore, the coralline algae *Lithothamnion corallioides* and *Phymatolithon calcareum* are listed in Annex V (Animal and plant species of Community interest whose taking in the wild and exploitation may be subject

[8] *Malta Government Gazette* No.18,633, 17 August 2010.

[9] It is not possible to distinguish between *Phymatolithon calcareum* and *Lithothamnion minervae* using gross morphology alone.

[10] The *Convention for the Protection of the Mediterranean Sea against Pollution* (the Barcelona Convention) was adopted on 16th February 1976. A number of protocols were adopted under this convention, amongst which is the *Protocol concerning Mediterranean Specially Protected Areas* done at Geneva on 3 April 1982. The parties later amended this protocol and its name changed to *Protocol for Specially Protected Areas and Biodiversity in the Mediterranean* (SPA/BD). Malta ratified this new Protocol on 28th October 1999. A draft reference list of habitat types for the selection of sites to be included in the National Inventories of Natural Sites of Conservation Interest was drawn up at the Fourth Meeting of National Focal Points for Specially Protected Areas (Tunis, 12-14 April 1999) [see UNEP(OCA)/MED WG.154/7]. The most recent '*Classification of benthic habitat types of the Mediterranean*' dated 2006 is available from the UNEP RAC/SPA at http://rac-spa.org/sites/default/files/doc_fsd/lrhm_en.pdf

to management measures) of the European Union's 'Habitats Directive' as amended[11]. Both species probably occur in the rhodolith beds in the present study area; however, only microscopic examination of samples of rhodoliths collected from the area will confirm this.

50. *Lithothamnion corallioides*, *Phymatolithon calcareum*, together with *Lithothamnion minervae* are listed in Schedule III (Animal and plant species of national interest whose conservation requires the designation of Special Areas of Conservation), and the first two named also in Schedule VII (Animal and plant species of Community interest whose taking in the wild and exploitation may be subject to management measures) of the *Flora, Fauna and Natural Habitats Protection Regulations, 2006* as amended[12], which transpose the requirements of the EU's Habitats Directive to local legislation.

32. Rhodolith and maerl beds are included in the UNEP/MAP/RAC-SPA "Reference list of marine habitat types for the selection of sites to be included in the national inventories of natural sites of conservation interest" (UNEP/MAP/RAC-SPA, 2006) while an action plan for their conservation has been formulated (UNEP/MAP/RAC-SPA, 2008), both within the ambit of the Barcelona Convention. Within European legislation, Council Regulation (EC) 1967/2006, concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, bans the use of specific fishing gear (trawl nets, dredges, shore seines or similar nets) on coralligenous or maerl beds[13]. In order to conform to the requirements of EC 1967/2006, the local 'Implementation and Enforcement of Certain Fisheries Management Plans Order' (Legal Notice 354 of 2013) amends Zones C and G referred to in Annex V of EC 1967/2006 that originally overlapped with rhodolith beds as well as closed to trawling all areas where conclusive evidence exists for the presence of such beds (see Figure 44 in LN 354/2013).

32. The Needle-spined sea-urchin, *Centrostephanus longispinus* is listed in the Habitats Directive under Annex IV (Animal and plant species of Community interest in need of strict protection), in Appendix II of the Bern Convention[14], and in Annex II of the SPA/BD Protocol)[15]. This

[11] The European Union's *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora* is known as the 'Habitats Directive'. Annexes I and II of this Directive have been amended by Council Directive 97/62/EC of 27 October 1997. Annex I of the Habitats Directive lists natural habitats whose conservation requires the designation of Special Areas of Conservation. Annex II lists species of plants and animals whose habitats must be protected for their survival. Annex III lists criteria for selecting sites eligible for consideration as "Sites of Community Importance" and designation as Special Areas of Conservation, while Annex IV lists species of Union interest in need of strict protection. Annex V lists species of plants and animals of Union interest whose taking from the wild and exploitation is subject to management, and Annex VI lists prohibited methods and means of capture and killing of mammals and fish, and prohibited modes of transport. In anticipation of the 2004 enlargement of the EU, the Annexes of the Habitats Directive were modified by the Act of Accession signed in Athens on 16th April 2003, to take into account the expanded geographical area of the EU15+10. The annexes were further amended by Council Directive 2006/105/EC of 20 November 2006 in anticipation of Bulgaria and Romania joining the European Union in 2007 and then again by Council Directive 2013/17/EU of 13 May 2013 due to the accession of the Republic of Croatia.

[12] These regulations were last amended by the Flora, Fauna and Natural Habitats (Amendment) Regulations, 2013 (Legal Notice 322 of 2013).

[13] According to this Regulation, "Mäerl is a collective term for a biogenic structure due to several species of coralline red algae (Corallinaceae), which have hard calcium skeletons and grow as unattached free living branched, twig-like or nodule corallines algae on the seabed, forming accumulations within the ripples of mudflats or sandflats seabed. Maerl beds are usually composed of one or a variable combination of red algae, in particular, *Lithothamnion coralloides* and *Phymatolithon calcareum*". In this definition, 'maerl' is used in the wider sense to refer to 'rhodolith beds' as defined by Basso *et al.* (2016); true maerl is a particular type of rhodolith bed.

[14] The Bern Convention is the *Convention on the Conservation of European Wildlife and Natural Habitats*. Malta acceded to this Convention on the 26th November 1993. Appendix II of the Bern Convention lists strictly protected species of fauna

species is also protected locally under the *Flora, Fauna and Natural Habitats Protection Regulations, 2006* as amended, where it is listed in Schedule V (Animal and Plant Species of Community Interest in need of Strict Protection).

5. IMPACTS ON MARINE ECOLOGY

51. The present assessment of impacts will consider the following phases:
   (i) Cage deployment phase
   (ii) Operational (tuna farming) phase

   Where details on the proposed activity are not available or insufficiently detailed, hence resulting in a degree of uncertainty, the 'precautionary principle' is applied and the worse case scenario is considered. The present assessment of impacts considers the study area within which the ecological assessment described above was made.

52. In making the present assessment of impacts, the procedure will be as follows:
   - The main source of impact will be identified and described, and specifically established as adverse or beneficial.
   - The likely severity and extent, as well as the receptors and sensitivity of the latter will be described.
   - Any possible mitigation measures will be indicated.
   - The following criteria will be used to determine the level of overall impact:
     - **Insignificant**: no impact or change is predicted in space and time;
     - **Low**: low level of impact that is localised in space, i.e. within the area of interest (AoI), and occurring over a short time period of a few days to a few weeks, and which may be mitigated.
     - **Moderate:** moderate level of impact that may extend beyond the area of influence and occurring over a longer time period of several months, and which may not necessarily be mitigated.
     - **High**: high level of impact that may extend well beyond the area of influence, which will probably leave some permanent/residual effects, and which may not necessarily be mitigated.
   - The duration of the impact and residual effects will be considered.

   The above procedure will be adopted using knowledge of marine ecology of the study area as baseline.

and the Convention prohibits the deliberate capture, the destruction of breeding or resting sites, the deliberate destruction, and the deliberate killing of, and trade in, these species.

[15] A number of species are listed in annexes to the SPA/BD Protocol: Annex II lists endangered or threatened species and Annex III lists species whose exploitation is regulated.

POTENTIAL IMPACTS DURING THE CAGE DEPLOYMENT PHASE

<u>**Source of impact**</u>

- **Disturbance to marine fauna resulting from increased vessel activity during deployment of cage moorings, ropes and tuna pens**
- **Accidental and/or deliberate spillage of toxic substances and contaminants from vessels used to deploy cage moorings**
- **Deployment of cage moorings**

Disturbance to marine fauna resulting from increased vessel activity during deployment of cage moorings, ropes and tuna pens

53. An increase in vessel activity is envisaged in the vicinity of the tuna penning site to enable deployment of the cage moorings, mooring ropes and tuna pens. This is expected to result in disturbance to pelagic fauna present in the general area where the new tuna pens will be deployed. Although detailed data on the pelagic fauna that occur within the study area are lacking, it is expected that several species of pelagic fish, turtles and cetaceans migrate in its vicinity. Such fauna will be exposed to disturbance from the increased vessel activity and from deployment of the cage moorings, ropes and tuna pens. However, the fauna that are expected to be affected are mobile and will swim away from the affected area such that there will be a small deviation of the migratory route without significant adverse effects to the animals.

54. Good practice and measures to reduce disturbance to a minimum are the only mitigation measures to reduce potential adverse impacts.

55. Taking the above into consideration, the overall level of impact is predicted to be **insignificant to low**.

56. With respect to the duration of impact and residual effects; the impacts will be temporary and effective during deployment of the cage moorings, ropes and tuna pens.

Accidental and/or deliberate spillage of toxic substances and contaminants from vessels used to deploy cage moorings

57. Given that vessels, including ones used to deploy the cage moorings, ropes and tuna pens, will be used during installation of the pens, there is a potential for introduction of hazardous substances and chemicals, whether deliberate, accidental or indirect into the marine environment. However, excepting an accident, whether such introduction of hazardous substances and chemicals into the marine environment will actually occur will largely depend on good management and work practices, and effectiveness of environmental protection measures.

58. The introduction of hazardous substances and chemicals (for example, fuel and lubricants, amonsgt others) may have toxic effects on the marine flora and fauna, which could include reduction in reproductive potential and capacity, fertilisation success, development and physiological function. However, the site concerned is located in deep offshore waters that are characterised by a high hydrodynamic regime, hence any small spillage of hazardous

substances and chemicals will be rapidly dispersed and are not expected to have a significant impact on the marine biota present in the vicinity.

59. Any introduction of toxic substances and contaminants will depend heavily on application of precautionary measures, and on the toxicity and levels of substances and contaminants potentially introduced to the marine environment. Therefore, good practice and measures to reduce spillage into the marine environment, hence ones that prevent the introduction of toxic substances and contaminants to the marine enviroment will be important to mitigate potential adverse impacts.

60. Taking the above into consideration, the overall level of impact is predicted to be **insignificant** unless there is large accidental or deliberate spillage, in which case the level of impact is predicted to be **low to medium.**

61. With respect to the duration of impact and residual effects; the impact of potential introduction of toxic substances and contaminants will be temporary and of very short duration (few days), as long as there is no large accidental or deliberate spillage.

Deployment of cage moorings

62. Deployment of the cage mooring is expected to impact the benthic habitat when the concrete block ends up resting on the seabed as there will be direct physical contact with the latter, although the area of the seabed that will be significantly impacted is that which will be occupied by the mooring block. All benthic flora and fauna, the latter mostly comprising sessile and slow moving invertebrates, that will end up underneath the mooring block will be decimated. The more motile fauna, such as fast moving invertebrates and fishes are expected to move away rapidly from a mooring block that is being deployed and will not be affected adversely.

63. On making contact with the soft sediment seabed, disturbance of the latter will lead to suspension of sediment in the water column. Settling of the suspended sediment on the bottom will lead to smothering of flora and sessile fauna, resulting in potential adverse effects on such organisms, although the concerned species are usually adapted to disturbance from suspended sediment and will recover quickly, while the high energy environment of the area will help rapid removal of any sediment particles that may have been deposited on the biota.

64. Good practice and measures to reduce the adverse impact of deployment of the mooring on the seabed, for example, by avoiding dragging the mooring block on the seabed during deployment, are the only mitigation measures to reduce potential adverse impacts.

65. Taking the above into consideration, the overall level of impact is predicted to be **high** within the area that will be occupied by the mooring block, but **insignificant to low** on the sessile benthic species present in the vicinity (a few metres away) of the deployed mooring block.

66. With respect to the duration of impact and residual effects; the impact on the flora and fauna that will end up beneath the mooring clock will be permanent, while impacts on the flora and sessile fauna present in the immediate vicinity of the block will be temporary and of very short duration (few days).

POTENTIAL IMPACTS DURING THE OPERATIONAL (TUNA FARMING) PHASE

<u>Source of impact</u>

- **Disturbance to marine fauna resulting from increased vessel activity during tuna farming**
- **Accidental and/or deliberate spillage of toxic substances and contaminants from vessels used in connection with the tuna penning operations**
- **Decreased light reaching the seabed as a result of shading by the tuna cages**
- **Increased nutrient input, originating from the farmed tuna's waste and feed fish, to the water column**
- **Deposition of organic matter, originating from the farmed tuna's waste and feed fish, on the seabed**
- **Generation of a surface slick comprising fish oils released from the feed fish**
- **Littering of the seabed underneath the tuna cages and in their vicinity**
- **Attraction of wild fauna to the tuna farm**

Disturbance to marine fauna resulting from increased vessel activity during tuna farming

67. An increase in vessel activity is envisaged in the vicinity of the tuna penning site in connection with the tuna farming activity. A number of vessels are expected to operate in the vicinity of the tuna penning site in connection with the farming activity. These include work boats that will be used to transport the feed fish and to feed the caged tuna, boats used for general maintenance of the tuna pens, and vessels used during the period when the tuna are harvested. The latter vessels will be the largest ones used in connection with the tuna farming activity but will only be present during the 2 – 3 month period during which harvesting of the tuna will be carried out and normally anchor some distance offshore from the tuna farm. The presence of vessels is expected to result in disturbance, mainly through generation of underwater noise, to pelagic fauna present in the general area where the new tuna pens will be deployed. Although detailed data on the pelagic fauna that occur within the study area are lacking, it is expected that several species of pelagic fish, turtles and cetaceans migrate in its vicinity. Such fauna will be exposed to disturbance, mainly through generation of underwater noise, from the increased vessel activity in the vicinity of the tuna farm. However, the fauna that are expected to be affected are mobile and will swim away from the tuna penning site such that there will be a small deviation of the migratory route without significant adverse effects to the animals.

68. Good practice and measures to reduce disturbance to a minimum are the only mitigation measures to reduce potential adverse impacts.

69. Taking the above into consideration, the overall level of impact is predicted to be **insignificant to low**.

70. With respect to the duration of impact and residual effects; the impacts will be effective throughout the period when tuna farming is carried out.

Accidental and/or deliberate spillage of toxic substances and contaminants from vessels used in connection with the tuna penning operations

71. A number of vessels are expected to operate in the vicinity of the tuna penning site in connection with the farming acvitiy. These include work boats that will be used to transport the feed fish and to feed the caged tuna, boats used for general maintenance of the tuna pens, and vessels used during the period when the tuna are harvested. The latter vessels will be the largest of the ones used in connection with the tuna farming activity but will only be present during the 2 – 3 month period during which harvesting of the tuna will be carried out. Because of the regular presence of such vessels in the vicinity of the tuna penning site, there is a potential for accidental or deliberate introduction of hazardous substances and chemicals (for example, fuel and lubricants, amonsgt others), whether deliberate, accidental or indirect, into the marine environment. However, excepting an accident, whether such introduction of hazardous substances and chemicals into the marine environment will actually occur will largely depend on good management and work practices, and effectiveness of environmental protection measures.

72. The introduction of hazardous substances and chemicals may have toxic effects on the marine flora and fauna, which could include reduction in reproductive potential and capacity, fertilisation success, development and physiological function. However, the site concerned is located in deep offshore waters that are characterised by a high hydrodynamic regime; hence, any small spillage of hazardous substances and chemicals will be rapidly dispersed and are not expected to have a significant impact on the marine biota present in the vicinity.

73. Any introduction of toxic substances and contaminants will depend heavily on application of precautionary measures, and on the toxicity and levels of substances and contaminants potentially introduced to the marine environment. Therefore, good practice and measures to reduce spillage into the marine environment, hence ones that prevent the introduction of toxic substances and contaminants to the marine enviroment, will be important to mitigate potential adverse impacts.

74. Taking the above into consideration, the overall level of impact is predicted to be **insignificant** unless there is a large accidental or deliberate spillage, in which case the level of impact is predicted to be **low to medium.**

75. With respect to the duration of impact and residual effects; the impact of potential introduction of toxic substances and contaminants will be temporary and of very short duration (few days), as long as there is no large accidental or deliberate spillage.

Decreased light reaching the seabed as a result of shading by the tuna cages

76. Tuna cages typically have a diameter of around 50 m and support a cage net that is some 35 m high. The cage net and the tuna they hold are expected to produce a shading effect and reduce the amount of light reaching the seabed. The reduced light availability will have an adverse effect on any rhodoliths present on the seabed, even if these are present in small accumulations or are sparsely distributed on the bottom, given that the photosynthetic capacity of the algae making up the rhodoliths will be decreased such that they will stop growing or die. With regard to any associated megafauna and macrofauna; the sparse rhodolith accumulations recorded from the site identified for tuna penning are not known to support a high diversity of associated fauna, at least compared to dense rhodolith beds,

while the fauna that occurs in association with such habitat is more typical of lower infralittoral and upper circalittoral coarse sediments. Therefore, the main adverse impact is expected to be mostly on the rhodoliths.

77. The shading effect cannot be mitigated unless the cages are removed and is a consequence of the presence of a floating structure – the tuna pen - which cannot be modified or replaced by another structure that does not cause shading.

78. Taking the above into consideration, the overall level of impact is predicted to be **high** on any rhodoliths present within the area that will be occupied by a tuna cage, but **insignificant** in other areas at the tuna penning site.

79. With respect to the duration of impact and residual effects; the impact will be effective throughout the period when the tuna pens are in place (c. 6 months); however, once the latter are removed, recovery (which will require at least a few months) is expected since coralline algae will rapidly recolonise any rhodoliths whose algal component would have demised.

Increased nutrient input, originating from the farmed tuna's waste and feed fish, to the water column

80. The tuna farming operations are expected to result in some nutrient and organic loading of the water column; the nutrients and organic matter will mainly originate from faecal matter excreted by the farmed tuna and from decomposition of any uneaten feed fish that will end up on the seabed. Water quality surveys have been carried out at local tuna penning sites since the early 2000's. During these surveys, standard water quality attributes, namely dissolved oxygen, temperature, salinity, turbidity, nitrates, phosphates, Chlorophyll *a*, ammonia, and counts of intestinal bacteria, as well as sea currents, were measured at a number of sampling stations located in the immediate vicinity of the tuna farms and at up-current and down-current reference stations. The results of such surveys indicate that, very rarely, lowered levels of oxygen, reduced water transparency and elevated nutrient (nitrates and/or phosphates and/or ammonia) levels were recorded from the tuna penning sites during the farming season (July – December). However, the observed changes in the monitored attributes were often sporadic and not statistically significant, and have not resulted in appreciable alteration of water quality. Elevated counts of intestinal bacteria have also been occasionally recorded but since such organisms do not originate from the tuna but from sewage, their presence were not attributed to the tuna penning activities *per se*, although there is the possibility that large ships (e.g. the processing ships present during harvesting of the tuna) may be the source of such contamination through discharge of sewage from their holding tanks. Such favourable results with respect to water quality are attributed to the high energy environment, particularly strong sea currents present, that characterise the offshore area where the proposed tuna penning site is located, and which lead to rapid and effective dispersal of nutrients that may originate from the tuna farming activity.

81. Nevertheless, good practice and measures to reduce loading of the water column with nutrients and organic matter are recommended; in particular excessive loading by organic matter can be reduced by ensuring that overfeeding is avoided, such that the amount of uneaten feedfish that are introduced to the marine environment will be minimal.

82. Taking the above into consideration, the overall level of impact of nutrient and organic matter loading of the water column on water quality and associated biota (e.g. plankton) is predicted to be **insignificant to low**.

83. With respect to the duration of impact and residual effects; the impact will be effective throughout the period when tuna farming is carried out (4 - 6 months), with progressively reduced effects as the tuna is harvested and the reared biomass reduced.

Deposition of organic matter, originating from the farmed tuna's waste and feed fish, on the seabed

84. The tuna farming operations are expected to result in organic loading of the seabed; the organic matter will mainly originate from decomposition of uneaten feed fish that may end up on the seabed. Such organic loading is expected to have a large impact on benthic habitat, which would result in changes to sediment quality and to the species composition of biotic assemblages associated with lower infralittoral/upper circalittoral coarse sediment habitat. In cases where the impact is large and adverse, loss of habitat and biodiversity may occur.

85. Video surveys of the seabed underneath tuna cages have been undertaken regularly at local tuna since the early 2000's. The main aim of such surveys was to gather qualitative and semi-quantitative data, using direct observation, on the physical and biological characteristics of the seabed underneath the tuna pens. The results of these surveys have indicated that towards the end of each penning season (in autumn) considerable amounts of uneaten feed fish littered the seabed in the area lying directly below the tuna pens, but not in areas beyond the perimeter of the tuna pens. This resulted in alterations in the physical and biological characteristics of the seabed under the pens, namely: (i) changes in biological characteristics, which typically consist of high population densities of detritus-feeding and scavenging benthic (i.e. associated with seabed) fauna, and whose occurrence is unusual considering the benthic habitat type present at the tuna penning sites surveyed; (ii) alterations in physical characteristics, which typically consist of the presence of large quantities of fish bones and baitfish that are gradually consumed by scavengers or eventually decompose. The results of the video surveys also indicated that the amount of uneaten feed fish present varied considerably between the different pens, and between different farms, with some only having a few feed-fish beneath them and others having multiple layers of decomposing feed-fish. Once the tuna farming season is over (late winter), a negligible amount of uneaten feed-fish remain on the seabed below the pens. However, thick layers of fish bones and of decomposing organic material persist under some of the pens. These observations indicate a consistent pattern, with the volume of uneaten feed-fish on the seabed decreasing only when the tuna have been harvested (and therefore there is no further addition of feed-fish). Any uneaten fish remaining on the seabed at this time will continue to decompose slowly and, if present in large numbers, form a continuous layer of decomposing organic material. Sometimes, following storms and possibly due to strong bottom currents, this layer is admixed with the underlying mobile sediment. In places where the decomposition process is complete, the only remains are fish bones that eventually disperse in the sediment leaving little or no trace of the original uneaten fish on the surface. Once the source of the impact (periodic addition of new uneaten food) is removed, slow recovery to the original state is characterised by the re-appearance of certain megafaunal

species (e.g. the irregular sea urchin *Spatangus purpureus* and the crinoid *Antedon mediterranea*) that form part of the original fauna that characterise the bare muddy sand bottom of the areas where the tuna farms are located.

86. Monitoring of sediment quality at local tuna penning sites has also been carried out regularly since the early 2000's. The main aim of such monitoring is to assess the levels of organic carbon content and organic nitrogen content of the sediments, as well as sediment granulometric characteristics. Moreover, at least one survey involving assessment of levels of pollutants, including heavy metals and organic pollutants, was carried out at some of the extant tuna penning sites. The monitoring design of the surveys to assess organic carbon content and organic nitrogen content of the sediments, and sediment granulometric characteristics, was based on a Beyond **BACI**[16] layout, in which the results of quantitative analyses of sediment samples collected from the tuna farming site and from a number of control sites before the start of the farming operations are compared with those obtained after a farming season using advanced statistical analyses. Overall, the findings from surveys that were aimed at assessing organic carbon content and organic nitrogen content of the sediments, and sediment granulometric characteristics, indicated 'pulse' (i.e. short duration) changes in the physico-chemical properties of the sediment following some but not all of the tuna penning seasons; when these changes were recorded they were restricted to the seabed area located in the immediate vicinity of the tuna pens and/or in the general area occupied by the pens but no significant permanent alterations of the sediment characteristics at the operational sites have been recorded to date. Where significant changes were detected, these appeared to have resulted from accumulation of large amounts of uneaten feed-fish in the vicinity of the tuna pens, which decompose slowly causing alterations in the physico-chemical properties of the sediments. The results of the surveys aimed at assessing levels of heavy metals and pollutant organics indicated that no elevated levels were present in the sediments in the vicinity of the tuna farms.

87. Monitoring of benthic diversity at local tuna penning sites has also been carried out regularly since the early 2000's. The main aim of such monitoring is to assess for potential changes in benthic species populations and habitat that may result from the tuna penning activities. The monitoring design was based on assessing total species richness and total abundance of selected benthic faunal species, as these are deemed good indicators of the overall state of species and habitats associated with the seabed. As in the case of the physico-chemical attributes monitoring component, the design for monitoring of benthic diversity was based on a Beyond **BACI** layout, in which the results of quantitative analyses of samples collected from the tuna farming site and from a number of control sites **before** the start of the farming operations are compared with those obtained **after** a farming season using advanced statistical analyses. Overall, the findings from monitoring of benthic diversity indicate a significant 'press' (i.e. long-lasting) adverse impact (manifested as a significant decrease in total macroinvertebrate species richness and/or decrease in the abundance of one or more of the indicator species) following some but not all of the tuna penning seasons; when these changes were recorded they were restricted to the seabed area located in the immediate vicinity of the tuna pens and/or in the general area occupied by the pens. Furthermore, enhanced productivity in the general area of the tuna farms and beyond, as a result of the

[16] **B**efore **A**fter **C**ontrol **I**mpacted; see Underwood (1992): Underwood, A. J. (1992) Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. *Journal of Experimental Marine Biology and Ecology* 161: 145 –178.

tuna-penning activities, was evident from significant increases in the abundance of some of the indicator species recorded in some of the monitoring sessions. These observations are a strong indication that, where present, adverse impacts on the benthic macroinvertebrate assemblages and habitat at the tuna penning sites have resulted from processes that are mainly attributed to accumulation of large amounts of uneaten feed-fish and slow decomposition of same, in the vicinity of the tuna pens. The uneaten feed-fish attract scavengers and other opportunistic fauna that cause changes to the original species composition of the benthic assemblages, while slow decomposition of the accumulated material causes alterations in the physico-chemical properties of the sediments, and presumably of the sediment-water interface, leading to adverse conditions for the biota originally present. A number of scientific publications, which present detailed results – mainly as described above - of the influence of local tuna penning activities on marine benthic habitat, are available; see Manion *et al* (2014; 2017; 2018).

88. Good practice and measures to reduce excessive loading of the seabed by organic matter are the main mitigation measures that can be adopted to avoid or at least reduce adverse impacts on the benthic biota and habitat present in the vicinity of the tuna penning site. Essentially, good feed management procedures will be very important to mitigate adverse impacts resulting from organic loading of the seabed. The following measures are deemed particularly important: (i) Feeding of the tuna should be carefully monitored and stopped as soon as the fish are satiated, in order to avoid as much as possible uneaten feed ending up on the bottom. The tuna operators may want to implement a procedure to ensure proper feed management by having random checks of the seabed below the tuna pens made by an independent environmental monitor; (ii) In the case of accident, should an inordinate amount of dead uneaten feed-fish end up on the bottom, every attempt should be made to recover as much of the material as possible using techniques that do not have an adverse effect on the seabed habitat.

89. Taking the above into consideration, the overall level of impact of organic matter loading of the seabed, and hence on benthic biota and habitats present at the tuna penning site, is predicted to be **medium to high** within the seabed area directly underneath the cages; and **insignificant to low** in the seabed area beyond.

90. With respect to the duration of impact and residual effects; the impact will be effective throughout the period when tuna farming is carried out.

Generation of a surface slick comprising fish oils released from the feed fish

91. The tuna farming activity is expected to generate oils and fats that are released from the thawing feed-fish when these are fed to the tuna. Release of such substances occurs when the semi-frozen feed fish are introduced in the tuna pens, and when uneaten feed-fish end up outside the fish cages. The resulting floating slick of fatty substances that accumulate on the surface may be transported offshore or inshore, depending on sea current strength and direction. Such substances, commonly known as ‘fish farm slime’, have caused much public concern and outcry. Although they are not deemed to have any toxic effects on pelagic marine species and habitats, they are aesthetically unpleasing and a nuisance to bathers, divers and coastal recreational activities, because of their sheer presence in the water and since they deposit on the shore and on artificial surfaces (e.g. boat hulls etc.). The deposition of such substances on the shore is not envisaged to have any large adverse effects on marine

species and habitats, given that they will rapidly biodegrade; however, this has not yet been assessed given the complete lack of studies that deal specifically with this aspect.

92. Good practice and measures to reduce the release of oils and fats from the feed fish, restrict their presence to the immediate vicinity of the tuna farm (e.g. by using booms), and carrying out immediate collection of the substances (e.g. using skimmers) when appreciable amounts of them are released to the marine environment, are the main mitigation measures that can be adopted to avoid or at least reduce their presence on the surface in coastal areas close to the fish farms and inshore.

93. Taking the above into consideration, the overall level of impact when floating oily and fatty substances originating from the feed fish end up on the surface in offshore waters and are potentially transported inshore, is predicted to be **medium to high** from the aesthetics and water quality for recreational activities points of view, but **insignificant to low** with respect to adverse impacts on marine ecology, including shore habitat where they may be deposited.

Littering of the seabed underneath the tuna cages and in their vicinity

94. The results of video surveys made below tuna cages at local tuna penning sites have indicated that, in places, a considerable amount of anthropogenic items is present below the pens that appear to originate from the farm operations; these include concrete weights with ropes attached, sheets and sacks of fabric and other material, car tyres, lengths of rope and other unidentified items. While plastic items are known to be hazardous to marine life, items deposited on the seabed lead to physical alteration of the bottom leading to potential changes to the benthic habitat present in the vicinity of the fish farm.

95. Good practice and measures to reduce littering of the seabed by anthropogenic items originating from the tuna penning activities are the main mitigation measures that can be adopted to avoid littering of the seabed. Should any items originating from the fish farm accidentally end up in the sea, whether floating or deposited on the seabed, these should be recovered immediately.

96. Taking the above into consideration, the overall level of impact when anthropogenic items originating from the fish farm end up in the sea, whether floating or deposited on the seabed, is predicted to be **low** to **medium**.

Attraction of wild fauna to the tuna farm

97. Fish farms, including tuna ranches, are known to attract a variety of wild marine pelagic fauna. These include: shoals of small pelagic fish (such as Clupeid species) which eat the fragments of feed fish that are released in the water, and the biota growing on the tuna pen nets; medium-sized predators such as *Coryphaena hippuris* and *Seriola dumerilii* which feed on the small pelagic fish that aggregate in the vicinity of the tuna cages; large pelagic predators including cetaceans (namely dolphins), which feed on the medium-sized predators and uneaten feed fish present outside the tuna pens; and wild tunas that are attracted to the caged tuna and also feed on uneaten feed fish that end up outside the tuna pens. Such aggregations of wild pelagic fauna are not envisaged to be adversely affected by the tuna penning activities *per se*, since they will be acquiring food that will potentially lead to enhanced local production. However, the aggregations tend to attract fishermen who carry

out fishing activities in the vicinity of tuna farm such that they will harvest the wild fish present there; indeed because of such 'facilitated' harvesting of wild fish, fish farms have been described by marine ecologists as serving as 'ecological traps'. The problem at local tuna farms gets more complicated since fishermen who target the wild tunas and carry out their activities in the vicinity of the farms may actually be the cause of whole dead tunas ending up on the seabed in the vicinity of the tuna farms. This problem is highlighted in Arechavala-Lopez *et al*. (2015); fishermen deploy fishing lines in the vicinity of the tuna farms with an aim to catch wild tuna that aggregate there. Any tunas that are caught may: (i) either break free but will have the hook and a length of fishing line attached to their mouth, which may eventually become entangled against the cage mooring ropes, such that the fish will be restricted in its ability to swim or get exhausted trying to break free but in both cases will end up dying; or (ii) become entangled against the cage mooring ropes and, being unable to retrieve them, the fishermen[17] cut them free, however, the hook and length of fishing line attached to their mouth may, again, eventually become entangled against the cage mooring ropes, leading to (i) as stated previously. Fishermen have also been observed to clean tunas they would have caught and discard the head and offal overboard.

98. Prohibition/strict control of fishing activities in the vicinity of the tuna farms is the main mitigation measure that can be adopted to avoid detrimental (and sometimes) illegal harvesting of wild fish, including tunas) in the vicinity of the fish farms.

99. Taking the above into consideration, the overall level of impact of uncontrolled fishing activities that are aimed at harvesting pelagic wild fauna, including tunas, which aggregate in the vicinity of the tuna farms, leading to the adverse effects described in para 100 above, is predicted to be **low**.

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PA 02175/18

Proposal to consolidate temporary tuna farming area at a parcel of sea approximately 5 kilometers from the shore (in general area approved for PA/03072/17 and PA/05858/17) for a total biomass of 3,300 tonnes of fish

Technical Appendix 5

AVIFAUNA BASELINE REPORT

Prepared by John J. Borg

Supporting Documents for

Environmental Impact Assessment Report

An Environmental Impact Statement (EIS) is to be prepared *for GF00250/07: Proposal for a new aquaculture zone in the North of Malta, Zone offshore Malta*

Baseline study on Avifauna

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APRIL 2018

Ecoserv Report Reference: 046-18

Signed Declaration

Attn: Director of Environment and Resources
Environment and Resources Authority
Malta

I, John J. Borg, who carried out the study (or part thereof) on avifauna for the EIA for the proposed extension to an existing tuna farm operation off the Northeast coast of Malta, hereby declare that such study was solely carried out by me and take responsibility for any statement and conclusion contained therein.

30 April 2018

Date

Signature

CONTENTS

1.1 TERMS OF REFERENCE

An Environmental Impact Statement (EIS) is to be prepared *for GF00250/07: Proposal for a new aquaculture zone in the North of Malta, Zone offshore Malta* as required by Schedule IA Section 6.3.1.1 of the Environmental Impact Assessment Regulations, 2007 (S.L. 549.46). May 2017

3.3 to 3.7 Light, noise and vibration: with respect to possible impacts on avifauna

The impacts on avifauna including (but not restricted to) disturbance, noise, vibration, loss of habitat, shadow flicker and lighting, collision risks.

The impact of the fish pens as barriers/hazards to movement shall be assessed in terms of the seabird colonies and other marine avifauna. The impact on prey availability for breeding and “visiting” seabirds shall also be assessed.

The assessment shall analyze the disruption of ecological links between feeding, breeding and roosting areas. An assessment of collision risks for seabirds shall be taken into account.

The assessment shall also investigate the annual change in populations of birds if necessary through modeling and the decline in territory occupancy.

1.2 SCOPE OF THIS WORK

The scope of this work is to present an updated report on any possible direct and indirect interactions and impacts by the fish pens on the avifauna, particularly the breeding pelagic seabirds. If any such impacts are identified, the report will propose mitigation measures.

1.3 Area of influence

The North Aquaculture Zone will be located at a minimum distance of 4.5 km from the shore and the main scope of the zone would be for capture-based aquaculture. The area lies in a straight line of sight from two Natura 2000 shearwater colonies which are; Ramla tat-Torri/Rdum tal-Madonna area MT0000009, Kemmuna, Kemmunett, il-Ħaġriet ta' Bejn il-Kmiemen u l-Iskoll ta' Taħt il-Mazz MT0000017 and il-Gzejjer ta' San Pawl (Selmunett) MT0000022 as well as two Marine N2K sites; il-Bahar madwar Ghawdex MT0000112 and il-Bahar tal-Grigal MT0000107.

1.4 Competence of consultant

This report was prepared by John J. Borg:

- Senior Curator of the Natural History Unit (Heritage Malta);
- Member of the Royal Society of Biologists UK (2013 -)
- Licensed Bird Ringer BirdLife Malta (1981 -) ISPRA (Italian Ringing Scheme 2010 -)
- Researcher in the fields of Ornithology and animal ecology, author of over 100 scientific papers and books;
- Participated in numerous local and foreign E.I.A.s and technical reports related to Ornithology and other vertebrates; and
- Holds a number of posts in local and foreign scientific institutions.

2. Study Methodology

2.1 Desk Study:

This assessment is based on accumulated data obtained from long-term observations on the breeding biology and ecology of Malta's breeding seabirds (1982-2018).

Published and unpublished reports from three EU LIFE funded projects:

EU LIFE+ Progett Garnija (2006-2010)

EU LIFE+ **Malta Seabird Project** (201**2**-2016) and

EU LIFE funded **Arcipelagu Garnija** (2016-2020)

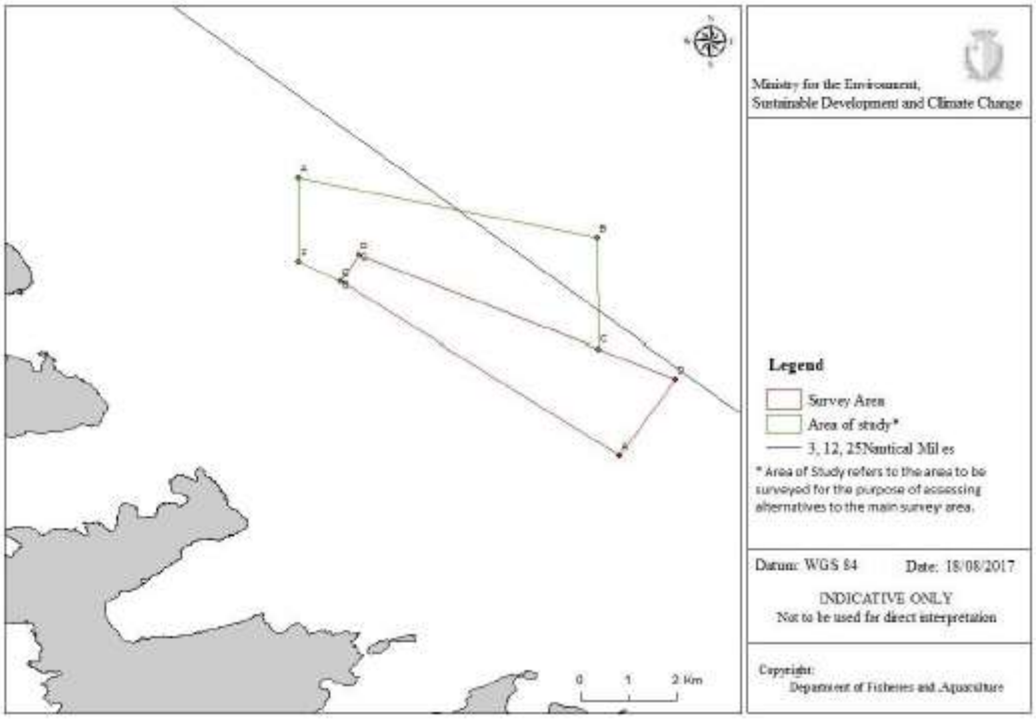

Fig. 1 Area of influence.

3 Study Area

Ramla tat-Torri/Rdum tal-Madonna area MT0000009

Rdum tal-Madonna (35°59'28.76"N, 14°22'15.02"E) is located along the north-east coast of Malta, situated on the l-Ahrax tal-Mellieha promontory. The geological formations are composed entirely of Upper Coralline Limestone formations, with the result that the cliffs are honey-combed with caves, crevices and fissures as well as extensive rubble scree. There are stretches of karst garrigue and patches of woodland. One also finds remnants of sand-dune habitat at White-tower bay. The are holds the most important Yelkouan Shearwater *Puffinus yelkouan* colony in the Maltese Islands as well as a small colony of Scopoli`s Shearwater *Calonectris diomedea*. In 2016 the Mediterranean Storm-petrel *Hydrobates pelagicus melitensis* was found breeding inside one of the numerous caves in the area. Other breeding bird species are the Blue Rock Thrush *Monticola solitarius*, Short-toed Lark *Calandrella brachydactyla* Sardinian Warbler *Sylvia melanocephala* and Spectacled Warbler *Sylvia conspicillata*.

Fig 2. Area of influence at Ramla tat-Torri and Rdum tal-Madonna

Kemmuna, Kemmunett, il-Ħaġriet ta' Bejn il-Kmiemen u l-Iskoll ta' Taħt il-Mazz MT0000017

Kemmuna u l-Gzejjer ta' Madwarha (Comino and its islets) Kemmuna is a small island lying mid-way between Malta and Gozo surrounded by a number of small islets known as Kemmunett, Il-Hagriet ta' Bejn il-Kmiemen and l-Iskoll ta' Taht il-Mazz. The cliff sides in the southern area of Kemmuna are characterised by scarps and boulders. The cliffs, especially areas that are shady, support the Cliff Groundsel (Senecio leucanthemifolius - a very rare species having a restricted distribution in the Maltese Islands as well as the Mediterranean, protected under national legislation. Cliffs are colonised by typical rupestral vegetation. The coastline between the northern and western areas of Kemmuna is indented with coves and inlets. The eastern coast is of particular interest for this study as it supports breeding colonies of Yelkouan and Scopoli`s Shearwaters.

Fig.3 = *C.diomedea & P. yelkouan* = *P. yelkouan*

il-Gzejjer ta' San Pawl (Selmunett) MT0000022

Il-Gzejjer ta' San Pawl (Selmunett) (35°57'54.40"N; 14°24'06.35"E) lie about 85 metres off the coast of Malta. The "islands" are linked by a shallow and narrow isthmus whose depth varies according to the sea level. Geologically the island is made up of Upper Coralline Limestone. The vegetation consists of a mixture of maritime garigue dominated by Golden Samphire, Maltese fleabane and various other species. The eastern side is more exposed and has less vegetation than the main island. A population of the land snail *Trochoidea spratti* can be found on the islands. Wild rabbits used to live on the island but the population died off due to Myxomatosis and overhunting. The endemic population of the Maltese wall lizard *Podarcis filfolensis kieselbachi* has not been recorded since 2005. In the last decade, a small colony of Yelkouan Shearwaters has been re-discovered breeding on the island.

Fig 4. Il-Gzejjer ta` San Pawl / Selmunett

- il-Bahar madwar Ghawdex MT0000112
- il-Bahar tal-Grigal MT0000107.

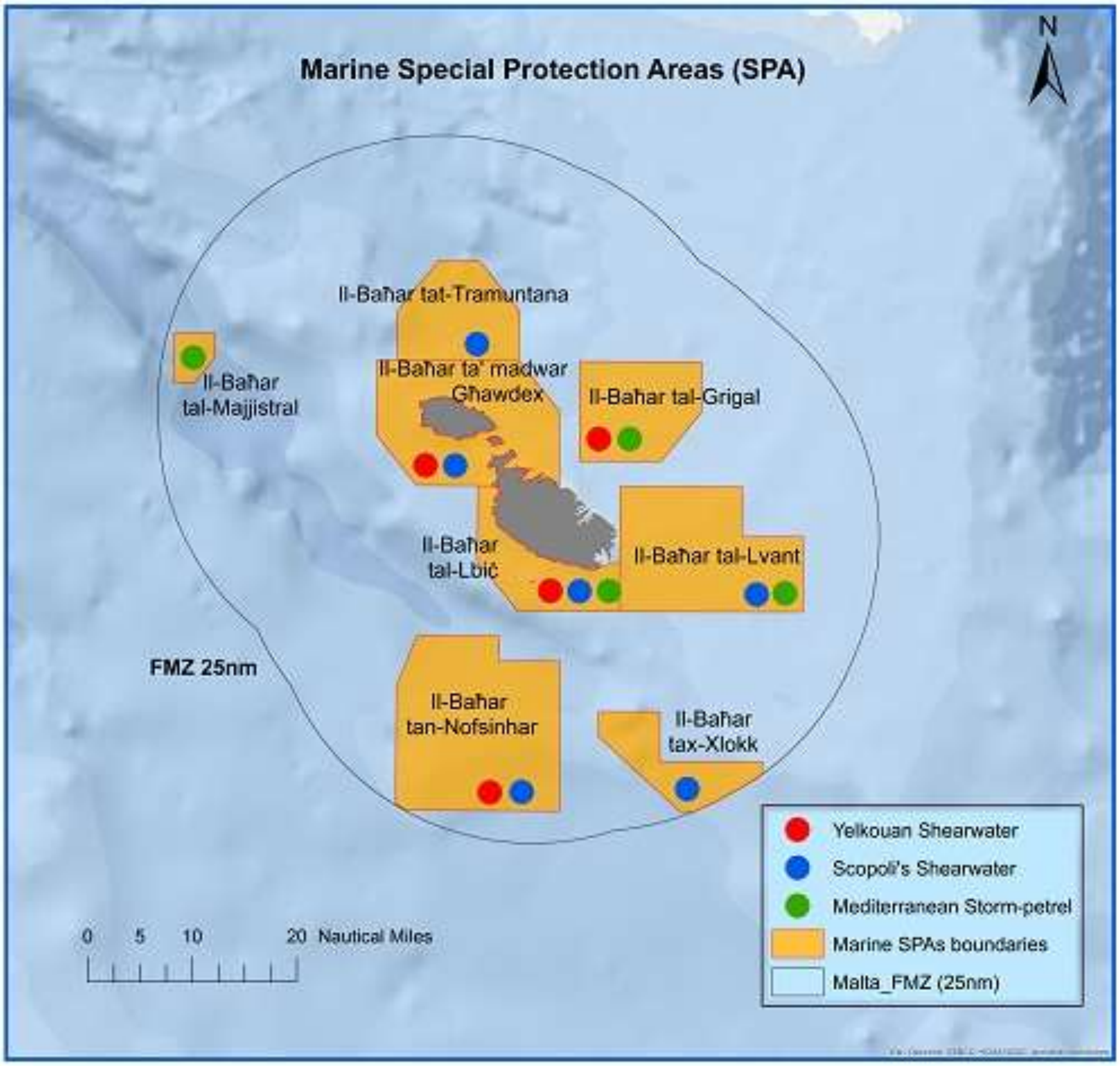

Fig 5. Marine Special Protection Area (SPA), designated under Govt. Notice 1311 of 2016.

4. Marine IBAs

Seabirds face a wide range of threats during their lifecycles and have undergone one of the most rapid declines of any bird group in the past 20 years (Lascelles 2007). This has been recognised by the European Union and consequently, all Member States have a duty to designate Marine Special Protection Areas (SPAs) under the Birds Directive by 2008 (European Commission 2004).

Malta is a particular hotspot for seabirds. The island of Filfla is home to the largest colony of breeding European Storm-petrels1 in the Mediterranean. The Maltese Islands also host approximately 10% of the world's population of breeding Yelkouan Shearwaters and approximately 5% of the Mediterranean population of Cory's Shearwaters. This gives Malta a high global responsibility for the conservation of seabirds. Furthermore, the Gozo Channel is very important for Ferruginous Ducks (*Aythya nyroca*), with over 1% of the global population passing through the channel annually, as well as a range of other species of conservation concern (Coleiro, unpublished data). *Aythya nyroca* is classified as globally Near Threatened by BirdLife International, the official authority on birds for the IUCN Red List.

In order to assist the Government in the task of identifying and designating Marine SPAs, one of the primary outputs of the EU LIFE Yelkouan Shearwater Project is to produce a report outlining the mechanisms being used to develop Marine SPA programmes across Europe. The report will also propose a roadmap for the designation of Marine SPA sites in the Maltese Islands, in order to protect these critically important seabird populations. The following document presents this research. The scope of the report includes Marine SPAs only and does not address Marine Special Areas of Conservation (SACs).

For both marine and terrestrial IBAs, the function of the Important Bird Areas (IBAs) programme of BirdLife International is '*to identify and protect a network of sites, at a biogeographic scale, critical for the long-term viability of naturally occurring bird populations, across the range of those bird species for which a sites-based approach is appropriate*'.

IBAs are chosen using quantitative, standardised, globally agreed criteria (in the case of Marine IBAs this is still in the process of being agreed – see Annex One for a full description of current criteria). The selection of IBAs has been a particularly effective way of identifying terrestrial conservation priorities across Europe. Marine IBAs are intended to extend this protection to the marine environment. Marine IBAs will do one (or more) of three things:

- Hold significant numbers of one or more globally threatened species
- Be one of a set of sites that together hold a suite of restricted-range species or biomerestricted species
- Have exceptionally large numbers of migratory or congregatory species (Lascelles & Fishpool 2007)

Malta already has 11 terrestrial IBAs of European importance (five of which are of international importance, namely Filfla, Ta'Cenc, Rdum tal-Madonna, Buskett and Comino), nine of which are identified for breeding seabirds. Marine IBAs are the next step and will provide protection for shearwaters, petrels and migratory seabirds in Maltese waters.

4.1. Marine SPAs

SPAs are areas of international importance for the conservation of wild birds, classified under the EU Directive on the Conservation of Wild Birds (the 'Birds Directive'). They are usually, but not always, based on IBAs. To date, only terrestrial SPAs have been designated in Malta. Marine SPAs will provide protection to marine birds in accordance with the provisions of the Birds Directive2 in the inshore and offshore marine environment.

Once a site is designated as an SPA the legal protective requirements defined in Article 6 (2) (3) and (4) of the Habitats Directive apply to it. Member States must send to the Commission all relevant information so that it may take appropriate initiatives to ensure that the SPA network forms a coherent whole

4.2 Types of Marine IBA / SPA

The classification for Marine SPAs by BirdLife International currently focuses on four types of Marine IBAs:

- Seaward extensions of breeding colonies
- Non-breeding coastal concentrations
- Migratory bottlenecks
- Areas for pelagic species

(BirdLife International 2007c)

Annex One presents a full description of the current proposed Marine IBA criteria.

4.3 Why Marine IBAs/SPAs?

Seabirds are under pressure worldwide from human activity and consequently many species are now threatened with extinction. They face a multitude of threats both at sea and during their land-based breeding period (BirdLife International 2007a). As a group, seabirds have deteriorated in IUCN Red List status faster than other group of bird species.

Until recently, seabird protection across Europe, as in Malta, has tended to focus principally on land-based threats such as habitat loss, introduced predators and disturbance, because these threats are easier to identify and address than issues in the wider marine environment.

However, while legal protection has been extended to some breeding seabird colonies on land through the terrestrial SPA network, birds using the marine environment have remained unprotected. Since most seabirds spend the vast majority of their time away from breeding sites at sea, and with pressures increasing in the marine environment, there is an urgent need to move towards protecting areas of importance for birds at sea (SPEA 2007, Lascelles 2007).

One of the primary threats at sea is by-catch by long-line fisheries. There is insufficient data on levels of seabird by catch in the Mediterranean, but preliminary results suggest that this could be a serious threat particularly for Scopoli`s Shearwaters (Dimech et al 2008, Cooper et al 2003). However, this can be addressed relatively easily using existing technology if the political will to do so exists (Ardron & Burfield 2006). Marine IBAs/SPAs can contribute to solving this problem through the requirement of appropriate fisheries management within SPA boundaries.

Seabirds utilising the marine environment adjacent to colonies face direct threats such as oil pollution and fishing gear entanglement. There are also indirect threats such as disturbance due to recreational activities (Harding & Riley 2000, Tasker & Leaper 1993, Borg & Cachia-Zammit 1998). In Malta in particular, hunting at sea is a serious threat (Sultana 1986, Armed Forces of Malta 2008). Unless action is taken to limit these threats, many seabird populations are likely to continue to seriously decline (Lascelles 2007). Again, Marine IBAs/SPAs will identify the key areas that require additional protection and will suggest which areas are inappropriate for heavy recreational use or offshore wind-farms for example.

The identification of Marine IBAs will make a vital contribution to global initiatives to gain greater protection and sustainable management of the oceans, including towards the designation of Marine Protected Areas (MPAs) of which Marine SPAs will form a large part. The intention is that Marine IBAs will be the precursors for Marine sites of the Natura 2000 network (Lascelles 2007).

There is a clear obligation that EU Member States classify appropriate SPAs in the marine environment (see sections 4 & 5). In Malta, the identification of Marine SPAs is of particularly pressing importance because the limited land resources and high population density of the Maltese Islands have made the coastal zone and adjacent contiguous marine area a focal point for resource use conflicts (MEPA 2005). To ensure that these conflicts are resolved in a sustainable way, Marine SPAs and SACs will be an invaluable tool.

Figure 6. Following years of field work and data compiling, BirdLife Malta in 2012 presented to BirdLife International a report in proposing the highlighted area for the Malta-Gozo Channel Marine Important Bird Area.

PRIORITISATION AND ZONATION MODELLING FOR THE THREE PROCELLARIIFORMES (From Metzger *et al* 2015)

Figure 6-8 present the results of the prioritisation modelling of core areas of seabird distribution inside the Maltese EFZ, including the zonation approach with a moderately low 0.01 border length penalty. Shown are the 10% and 15% core areas within the Maltese EFZ resembling the areas of highest importance for each of the three species.

For the Maltese breeding population of *P. yelkouan*, three main hotspot areas are identified, one around Gozo, including the Gozo Channel and along the west- and southwest coast of Malta, a second one offshore in the northeast of Malta and a third one offshore in the southwest of Malta (see Fig. 7). For the Maltese breeding population of *C. diomedea*, we identified five priority areas in the Maltese EFZ, the first one around and north of Gozo and a second one along the west and southwest coast of Malta. Additionally to that, three offshore areas are found east, southeast and south of Malta (see Fig. 8). For *H. pelagicus melitensis* breeding in the Maltese islands the core area is covering a coastal zone around Malta and a larger area of sea east of the island. Additionally, a small area is found in the Pantelleria channel northwest of Gozo and several fragmented squares are spread over an area southwest of Malta (see Fig. 9).

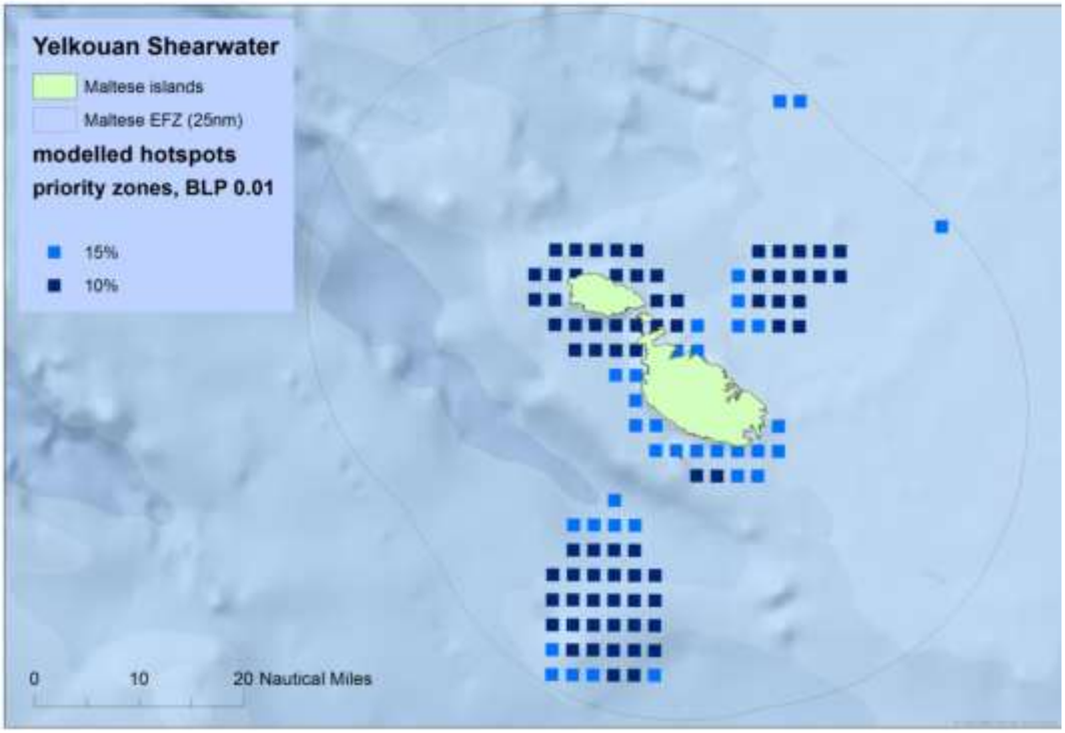

Fig 7. Priority areas for *P. yelkouan* within the Maltese EFZ, dark blue squares: 10%, light plus dark blue squares: 15%.

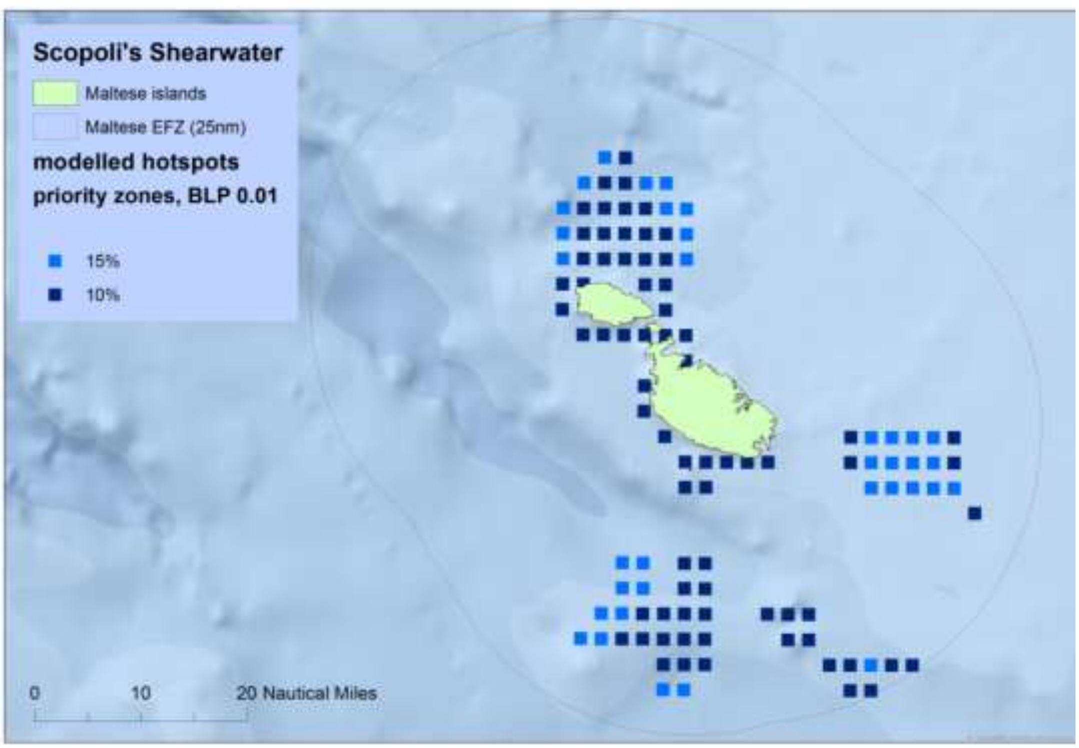

Fig 8. Priority areas for *C. diomedea* within the Maltese EFZ, dark blue squares: 10%, light plus dark blue squares: 15%.

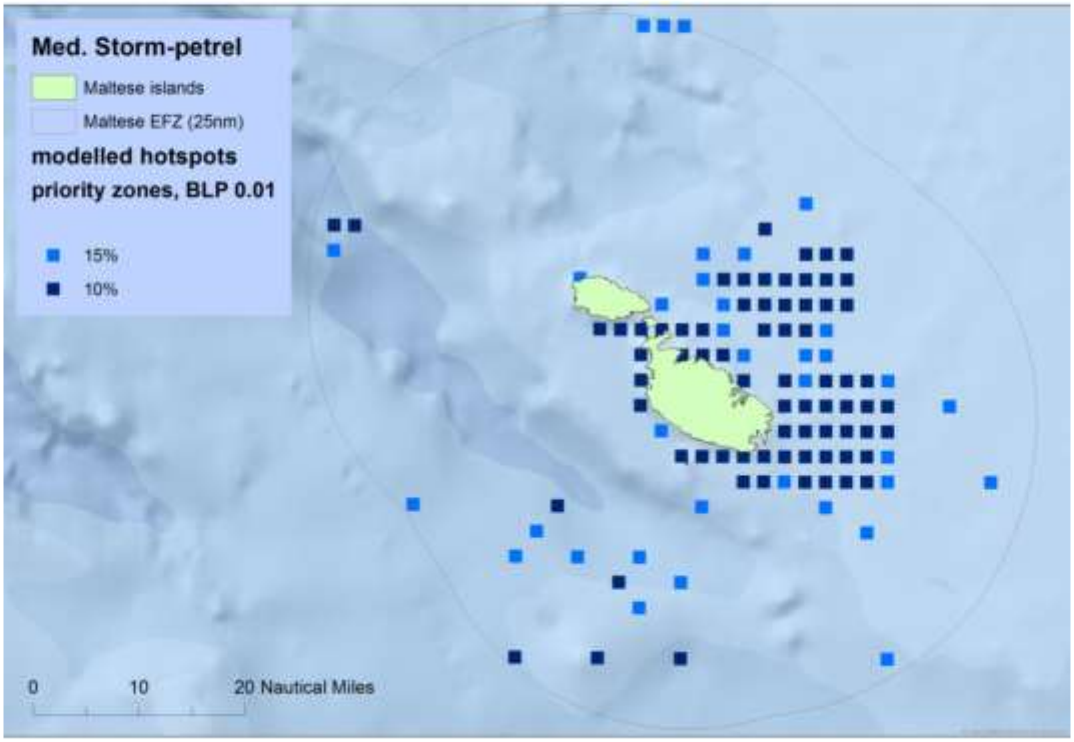

Fig 9. Priority areas for *H. pelagicus melitensis* within the Maltese EFZ, dark blue squares: 10%, light plus dark blue squares: 15%.

5.1 Breeding Species

The Maltese coastal cliffs support four seabird species, namely: Scopoli's Shearwater *Calonectris diomedea*, Yelkouan Shearwater *Puffinus yelkouan*, Mediterranean Storm-petrel *Hydrobates pelagicus melitensis*, and the Yellow-legged Gull *Larus michahellis*.

The Storm Petrel and the Yellow-legged Gull have not been recorded breeding in the Ghar Lapsi area in the last 50 years but both the Scopoli's and the Yelkouan shearwaters still breed in the area.

Shearwaters are members of the Order Procellariformes which includes also the albatrosses and petrels. They are pelagic species with the characteristic tube-noses on the base of the upper mandible. They visit land during the breeding season and do so under cover of darkness. A single egg is laid in a deep crevice or burrow or under loose boulders and vegetation. Sometimes, rabbit burrows are also used as breeding sites.

5.1 Scopoli's Shearwater *Calonectris diomedea*

Scopoli's Shearwater is a breeding visitor to the Maltese islands. The first birds make landfall in the last ten days of February. The single egg is laid in a crevice, fissure, or under boulders and vegetation in the latter half of May. Incubation lasts 52 day (Cachia-Zammit & Borg 1986) and the chicks hatch in mid-July. By the end of October all the colonies are deserted (Tab 1). The estimated breeding population of this bird in the Maltese Islands has been estimated at less than 5,000 pairs (Sultana *et al*. 2011) and the Ghar Lapsi cliffs and boulder scree hold about 51-100 breeding pairs (Borg & Sultana 2002, Raine et al 2009). Because of increasing human pressure (direct persecution, noise and lights pollution on the cliffs) these birds are being pushed down the more inaccessible cliff sites. In the last 10 years several "accessible" nest sites located on the top parts of the cliffs have been deserted.

Every evening from March to October, streams of flying birds, coming from their feeding grounds, pass within 1-4km offshore on their way to their breeding colonies. The distance from land is conditioned by climatic factors mainly the presence or absence of strong winds. At certain times of the year; especially during the incubation and the fledging period, the two species of shearwaters frequent specific areas for feeding and these areas lie primarily off the south-eastern coast of Malta at distances ranging from 12 to 500km away.

Fig 10 Scopoli`s Shearwater *Calonectris diomedea*

5.2 Yelkouan Shearwater *Puffinus yelkouan*

The Yelkouan Shearwater is endemic to the central and eastern Mediterranean. The world population is estimated at 13.000-33,000 breeding pairs with Malta holding an estimated population of 1,500 pairs that is 10% of the global population (Borg *et al* 2010). The population at Ghar Lapsi has been estimated at 10 to 50 pairs (Borg & Sultana 2004, Raine et al 2009).

The first birds start to visit the colonies in October and egg laying takes place from the last days of February through the first two weeks of March. Chicks hatch in mid-May and by the third week of June the chicks start to abandon the nesting sites. The colonies are deserted by mid-July (Tab.1). Ringing recoveries and satellite tracking of young birds, have shown that Maltese birds head towards the Aegean and Black Seas in the post breeding period while observations confirmed that an unknown number of adult birds remain around the Maltese Islands to moult their feathers (Borg *et al*. 2002).

Fig 11. Yelkouan Shearwater *Puffinus yelkouan*

5.3 European Storm-petrel *Hydrobates pelagicus melitensis*

Filfla island lies just 5km off the Ghar Lapsi shore and holds the largest known breeding population of this tiny seabird in the Mediterranean with an estimated breeding population of 5,000 to 8,000 pairs (Raine et al 2009, Sultana et al 2011).

Birds visit the colonies at night, from February to late October (Tab.1), and like its larger cousins, under the cover of darkness. On Filfla, egg laying is asynchronous which is quite unusual in the procellariiformes. On Filfla the Yellow-legged Gull is the main predator of Storm petrels while rats influence the breeding on the main islands (Sultana *et al*. 2011).

Fig 12. Mediterranean Storm-petrel *Hydrobates pelagicus melitensis*

Arrival at colonies		Egg laying	Hatching	Fledging
Puffinus yelkouan	mid October	early February	early May	mid June/early July
Calonectris diomedea	end February	end May	mid July	mid October
Hydrobates pelagicus	end February	April-June	May-August	August to October

Table 1: Synthesis of breeding biology and ecology of *P.yelkouan, C.diomedea & H.pelagicus*

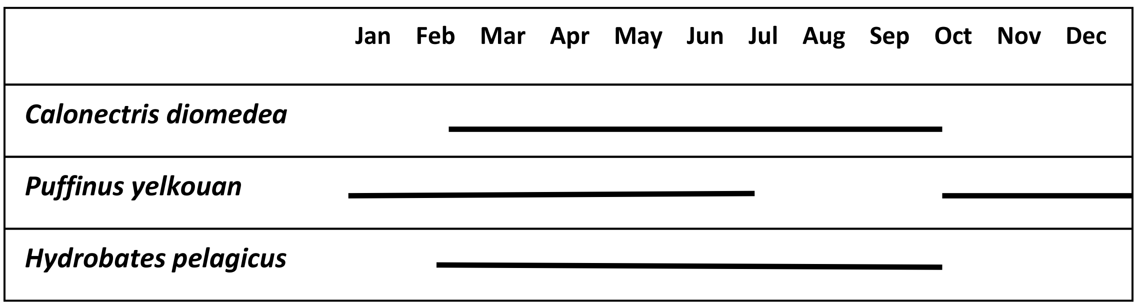

Table 2 Presence in Colonies by the three pelagic seabird species

5.2. Daily movements by Procellariiformes

Shearwaters travel vast distances to and from their breeding colonies in search of food. During the breeding season of *P. diomedea*, large numbers can be seen flying offshore in an east to west direction. Distance from land is conditioned by wind direction and strength. During strong North-westerly winds the shearwaters can be seen flying at a distance of less than 50 metres from the coast.

The same area is also used by Yelkouan Shearwaters, especially birds originating from the Rdum tal-Madonna colony (Borg *et al* 2002, Borg *et al* 2010, Raine *et al* 2010, 2011 and 2012).

Another regular visitor to the study area and immediate whereabouts is the Yellow-legged Gull *Larus michahellis*. This resident breeding is present almost all year round and double figures normally congregate in and around the fish farm off the South-west coast of Comino. The terminal area is frequented by birds coming from the breeding colonies at Filfla and Dingli Cliffs, heading towards the fish farm and *vice-versa*.

Fig 12. Daily evening movements by the two Procellariids from their feeding grounds to the breeding colonies.

5.3. Rafting

Rafting is the convergence of birds on water, normally in the vicinity of their breeding colonies. During calm afternoons these congregations of birds can reach impressive numbers with several hundreds of birds waiting for darkness. Birds start assembling about two to three hours before sunset and commence to dissipate around dusk when the whole congregation is within a few hundred metres from the cliffs.

Fig 13 Rafting *C. diomedea*

5.4 Fish Pens: Supplementary food source for seabirds

Borg (2012) presented some preliminary results on Tuna farms as a supplementary food source for Storm-Petrels. In July and August of 2006, very small numbers of storm-petrel were reported to the author, while an increase was noted in July 2007, but with fewer numbers in autumn. In the summer of 2008, again in the months of July and August, single birds where noted almost daily with up to 30 counted on several occasions. The use of raw, unwashed fish food is fundamental in attracting storm petrels closer to these tuna pens. The same food supply has attracted a constant presence of small fish around the pens which in-turn attract gulls and terns, especially the Black Tern *Chlidonias niger*.

Observations have shown that the majority of storm petrels frequenting the area are adult birds undergoing primary wing moult, suggesting breeders, probably not venturing far away from the colonies during the chick rearing period. The planned use of radio tags on storm petrels from the Filfla colony in summer of 2012 will provide more information on this aspect. A smaller number of birds seen during the site visits where juvenile birds covered in a fresh coat of dark plumage. These young birds are present from the latter part of August to early September. Tuna penning is locally carried out during the summer and autumn months (mid-July to December).

Further investigations will aim to identify if this reliable food source has any effect on the breeding success and fledglings survival in storm petrels. While adult storm petrels regularly fall prey to yellow-legged gulls on Filfla (Borg *et al*. 1992-94, Sultana *et al* 2011) no interactions between gulls and storm petrels were ever noted near the tuna pens. Further research is required to determine the extent of dependency by storm petrels on this food source, especially if feeding regulations are enforced and the baitfish is washed before fed to the tuna.

6. THREATS

6.1 LIGHT POLLUTION

The use of light sources from land and at sea is of particular concern. It is known that light interferes with the behaviour of birds and other animal groups, including bats. In those areas where electricity has been installed especially close to seabird colonies, birds have completely deserted the site. Birds and other animals found close to light sources are known to behave in an abnormal way; several species of birds remain active during night time. Light also disrupts the normal cycle of other vertebrates as well as numerous species of invertebrates making them susceptible to predation.

In some cases, seabird breeding colonies have been abandoned when electricity was introduced in the area, places like Xlendi Bay, Hal-Far, Ghar Lapsi and Wied iz-Zurrieq where colonies of both Scopol's and Yelkouan Shearwaters have been negatively effected

6.2 SOUND POLLUTION

Sound over water travels longer distances than on land; therefore, any noise generated during the operational phase needs to be minimised. Noise also affects the normal patterns of incoming shearwaters. When a boat passes close by to a breeding colony, all activity stops until the boat is out of "earshot".

6.3 POSSIBLE ENTANGLEMENT IN PENS

In some cases, as the larger members of the procellariiformes need a long "runway" for takeoff, sometimes they get entangled in the netting surrounding the fish pens, or in some cases, there is not enough space for take-off and so birds remain trapped inside the pens. This is most likely to occur during the fledging periods but in some cases can also affect adult birds as can be seen in Fig 14.

FIg 14. Streaked Shearwaters *Calonectris leucomelas* inside fish pens in the Sea of Japan.

6.4 MITIGATION MEASURES

Avoid the use of artificial lighting units whenever and wherever possible, in this particular case more so as the site is located in front of seabird colonies.

Avoid perimeter nets around the fish pens, thus reducing possible entanglement by the shearwaters.

7. SUMMARY OF IMPACTS

Impact type and Source		
Impact type	Light Pollution from land and sea Noise pollution from land and sea	
Specific intervention leading to impact	Un-shaded white shades spilling over and beyond the area of influence Maintain Low noise level	
Project phase	Construction/Installation works Yes	Operations Yes
Impact Receptor		
Receptor type		
Sensitivity and resilience toward impact	Installation works	Operations
	NA	Yes
Effect and Scale of Impact		
	Installation works	Operations
Direct/Indirect		Direct by disturbing the avifauna, especially the pelagic seabirds. Increase predation by Yellow-legged Gulls smaller avian species.
Cumulative		
Beneficial/Adverse		Adverse
Severity		High
Physical/geographic extent		
Short/Medium/Long Term		Long Term
Temporary/Permanent if temporary indicate duration		Permanent if not addressed
Reversible/Irreversible if reversible indicate ease of reversibility		Use of proper directional lamps and/or shading of lamps can significantly reduce impacts.

Probability – Significance – Mitigation – Residual Impacts – Other Requirements		
	Construction/Installation works	Operations
Probability of impact occurring Inevitable, likely, remote uncertain		Inevitable
Significance overall Impact		Medium to High

Proposed Mitigation Measures		Use of proper directional lamps and/or shading of lamps.
Significance Residual Impact		Abandonment of area by some species. Increase predation by Yellow-legged Gulls on Storm-petrels and other smaller avian species in the area
Monitoring		Monitoring program to be formulated, setup and implemented. Seasonal visits for all three seabird species
Authorizations	Development Permission under the Environment and Development Planning Act (Cap 504)	Development Permission under the Environment and Development Planning Act (Cap 504) (Operations Permit under the Industrial Emissions (Integrated Pollution and Control) Regulations (SL504.54; LN10/03) (Approval of major accident prevention policy document under the Control of Major Accident Hazard Regulations (SL424.19; LN37/03)

7.1 Criteria used to describe impacts

Beneficial/Adverse	
Level	**Criteria**
High	
Moderate	Disturbance marine avifauna during operational stages
Low	xxxxxxxxxxxxxx
Neutral	xxxxxxxxxxxxxx
Severity	
Level	**Criteria**
High	Light spill-off leading to disorientation by seabird fledglings
Moderate	xxxxxxxxxxxxxxx
Low	xxxxxxxxxxxxxxx
Neutral	xxxxxxxxxxxxxxx
Probability of impact occurring	
Level	**Criteria**
High	Unless mitigated both light and noise pollution will have a negative impact on the seabird colonies on both sides of the development.

Probability of impact occurring	
Level	Criteria
Moderate	Light and sound pollution as well as excessive noises over an extended period of time will have a negative effect on the avifauna present in the area and the immediate surroundings.
Low	xxxxxxxxxxxxxxx
Neutral	xxxxxxxxxxxxxxx

Significance: Overall Impact	
Level	Criteria
High	Light Pollution will affect the seabird colonies on the mainland as well as on St.Paul's Island and Comino. Including increased predation by Yellow-legged Gulls on Storm-petrels and other similar sized birds. Lighting also adds to the disorientation by fledging seabirds. Mitigation measures addressing this issue can reduce the overall impact on the seabirds.
Moderate	xxxxxxxxxxxxxxx
Low	xxxxxxxxxxxxxxx
Neutral	xxxxxxxxxxxxxxx

Significance: Residual	
Level	Criteria
High	Same as above. Shaded and directional lights should reduce the light pollution issue.
Moderate	

Impact type and source			Impact receptor		Effect and Scale							Probability of impact occurring	Overall impact significance	Proposed mitigation measures	Residual impact significance	Other requirements
6	Specific intervention leading to impact	Project phase	Receptor type	Sensitivity and resilience toward impact	Direct Indirect Cumulative	Beneficial Adverse	Severity	Physical geographic extent of impact	Short medium long term	Temporary Permanent	Reversible Irreversible					
		construction operation decommissioning								if temporary indicate duration	if reversible indicate ease of reversibility	Inevitable likely unlikely remote uncertain				Monitoring authorisations
Light spillage	Disruption of normal behaviour in avifauna Including predation by YLG on Storm-petrels and other small avian species.	Throughout all phases		High	Direct	Adverse	High	Immediate area as well as along the entire coastline	Long term	Permanent	Reversible if mitigation measures are taken and recommended lighting units are installed	inevitable	Moderate to high	Avoid light spillage		
Noise	Disruption of normal behaviour by seabirds.	Throughout all phases		Medium	Direct impacts on the local fauna	Adverse	Medium	Immediate area	Long term	Permanent	Reversible only if low noise generators are used.	inevitable	Moderate	Low noise generators		
Vibrations	Disruption of normal behaviour by seabirds.	Construction phase		High	Direct	Adverse	High	Immediate area	Medium term	Temporary but for some species it may be permanent		Inevitable	High	Operations are not prolonged over a long period of time		

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John J. Borg
Independent Consultant
18/04/2018

PA 02175/18

Proposal to consolidate temporary tuna farming area at a parcel of sea approximately 5 kilometers from the shore (in general area approved for PA/03072/17 and PA/05858/17) for a total biomass of 3,300 tonnes of fish

Technical Appendix 6

CULTURAL HERITAGE BASELINE REPORT

Prepared by Christian Dalton

Supporting Documents for

Environmental Impact Assessment Report

Cultural Heritage Baseline Study for

PA/0-2175/18

Report on Archaeology and Cultural Heritage for the proposed extension of the AJD Tuna Ltd tuna farm off the Northeast coast of Malta.

April 2018

Mr Christian Dalton

Signed Declaration in accordance with sub-regulation 17 (3)

Attn: Director of Environment and Resources

Environment and Resources Authority

Malta

I, Christian Dalton, who carried out the study (or part thereof) on archaeology and cultural heritage for the EIA for the proposed extension to the AJD Tuna Ltd tuna farm off the Northeast coast of Malta, hereby declare that I take responsibility for any statement and conclusion contained therein.

19 April 2018

Date | Signature

Table of Contents

Introduction

This report was commissioned by Adi Associates Environmental Consultants Ltd as part of an Environmental Impact Assessment requested by the Environment and Resources Authority (herein referred to as ERA) for the proposed development by AJD Tuna Ltd. AJD Tuna Ltd are requesting to increase the number of existing tuna cages from 12 to 24 at their temporary tuna farm off Malta's Northeast coast. This a temporary aquaculture site, which is being used until a permanent North Aquaculture Zone (which has been applied for by the Department of Fisheries and Aquaculture) is established in the North of Malta. The site is currently situated Northeast of the Sikka l-Bajda reef with no changes in the tuna cages placement occurring as a result of the proposed development.

Terms of Reference

The Terms of Reference provided by ERA for the marine archaeology topic area focus upon the quantification of cultural heritage assets within the area and the assessment of potential impacts of the proposed development (Sections 2.3 and 3.0).

> "The Environmental Impact assessment will: Describe the Cultural Heritage assets within the study area; assess the physical, spatial and visual impacts of the proposed development on the cultural heritage assets; and propose corrective measures for the protection of the cultural resources."

Area of Study

Since the proposal is for the extension of the existing temporary farm, the area of study will remain unchanged from the existing tuna cage operation and can be seen in Figure 1. Areas of archaeological significance in proximity to the study area and relevant to the proposed development will be mentioned. The study area lies approximately 4 km northeast of the closest landfall at Rdum tal-Madonna and less than 500 m northeast of the Sikka l-Bajda Reef.

Legislation and Statutory Protection

The protection and management of heritage in Malta is described by the Cultural Heritage Act (2002) and encompasses both terrestrial and underwater archaeological sites. The Act defines an object as a part of cultural heritage if it is "movable or immovable objects of artistic, architectural, historical, archaeological, ethnographic, palaeontological and geological importance and includes information or data relative to cultural heritage pertaining to Malta or to any other country"[1] (Part 1.2).

The two main international Conventions relevant to this study include:

1. UNESCO Convention on the Protection of the Underwater Cultural Heritage, Paris, 2001.

This Convention aims to better protect submerged cultural heritage. Despite Malta not having ratified the Convention, the management and protection of Underwater Cultural Heritage (UCH) as outlined by the Convention are applicable to submerged sites in Malta. The main aims of the Convention include the *in-situ* preservation of UCH as a first option and that "*recovered underwater cultural heritage shall be deposited, conserved and managed in a manner that ensures its long-term preservation*"[2] (Convention Objectives 5 & 6).

2. European Convention on the Protection of the Archaeological Heritage (Revised), Valletta, 16.I.1992.

This Convention was designed to "*protect the archaeological heritage as a source of the European collective memory and as an instrument for historical and scientific study*"[3] (Article 1.1). Significantly, archaeological remains underwater are included within the definition of the archaeological heritage (Article 1.3). Although Malta is yet to become a signatory to the Convention, much of the context is relevant to this study.

Aims of Assessment

The aim of this research is to identify potential archaeological or cultural heritage features in the Area of Study and to investigate the potential impacts on these assets and marine archaeology within the area of study. Furthermore, the potential material culture and subsequent archaeological importance of underwater targets identified by the remote sensing investigation will be considered.

Historical Background and Archaeological Context

The desk-based investigation did not discover any previous knowledge of archaeological finds or features present in the study area. This includes the Cultural Heritage Inventory Management System (CHIMS), the Malta Scheduled Property Register (MSPR) and Museums Annual Reports. The Malta Maritime Museum was also consulted in relation to any potential archaeological finds or known sites of cultural heritage interest within the study area.

Historically, the area would have served as a shipping route with access to several of Malta's bays. Indeed, the area is believed by some to be the site of St Paul's shipwreck, with a bay and island being named after the potential site of the shipwreck. Despite some disagreement on the location of the shipwreck it is conceivable that shipwrecks may have occurred in the area, possibly during storm conditions. Furthermore, archaeological evidence has been discovered in the nearby bays[4] suggesting previous use of the sea in proximity to the study area. Ancient anchors have also been found off Qawra, Għallis St Paul's Bay, and Salina Bay[5], yet all located outside of the study area.

The closest cultural heritage feature is that of the WW2 submarine remains of HMS *Stubborn*. This site lies less than a kilometre-and-a-half southeast of the area of study.

Baseline Survey

Methodology

In order to investigate the presence of any underwater archaeological features a Side Scan Sonar was employed to survey the seabed. This remote sensing survey was carried out in June 2017. The frequency of the side scan was 450kHz with a range of 100 m. The spacing for each line was 180 m. Previous seabed investigations in the study area have sought to undertake bathymetric or habitat mappings of the seabed but make no mention of any archaeological finds[6, 7].

Cultural Heritage Assets Inventory

The remote sensing survey has identified 1 target of interest on the 21st June 2017 within the Area of Study. Contact 0000 at coordinates (36° 0'35.02"N, 14°25'17.35"E) is likely of cultural significance (see Figures 2 and 3). No other cultural heritage assets of likely archaeological significance were identified.

Environmental Features

Sea Uses

The main environmental feature in proximity to the site is the Sikka l-Bajda reef, the largest reef in Malta and part of a marine Natura 2000 site. The reef is home to a number of fish species and colonised by *Posidonia oceanica* forming a seagrass matte[7]. Both the study area and the reef are located within marine protected areas (Special Area of Conservation: Żona fil-Baħar fil-Grigal ta' Malta, and Specially Protected Area: Il-Baħar ta' madwar Għawdex).

As described in the Project Description Statement, the new moorings for the additional cages will be aligned with the existing moorings. Regarding the benthic habitats, “the moorings to the north, west and east of the cages are positioned on a biocoenosis dominated by rhodoliths; those to the south are mostly set on sand” (p.27, Project Description Statement).

One of the largest human impacts in the area is the use of the reef as the largest bunkering zone in Malta. This reef is also visited by divers and fishermen[8].

Conclusions

The desk-based investigation discovered no knowledge of archaeological features or finds within the study area. This lack of knowledge was also reflected in the registers, reports and museum collections that were consulted.

The remote sensing investigation discovered one target of potential archaeological interest (see Figure 2), at 36° 0'35.02"N, 14°25'17.35"E towards the west side of the study area. It is considered that this target is likely to be of cultural significance, thus it is recommended that this area be avoided when positioning the new tuna cages. An avoidance zone of 100 m around the contact is therefore suggested to be established, with no mooring blocks for cages to be placed within this radius (see Figure 4).

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Figures

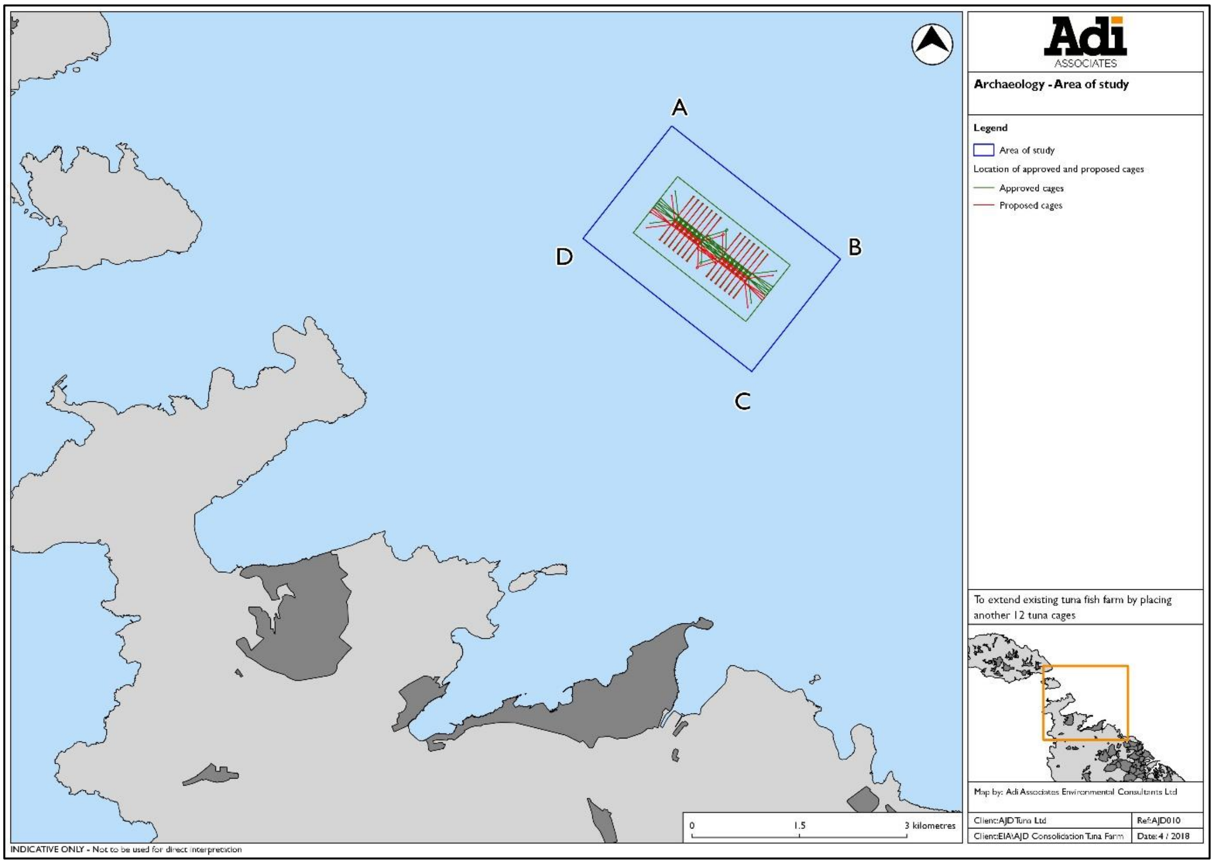

Figure 1. Location of the area of study.

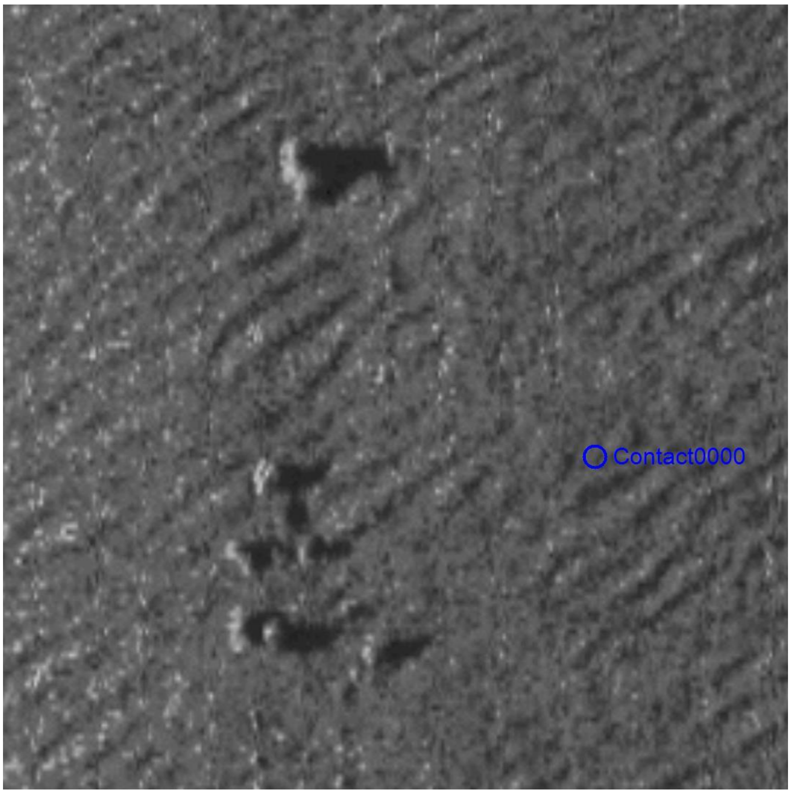

Figure 2. Side-scan data of target 0000 which is of likely cultural significance.

Figure 3. Location of target 0000 within the area of study.

Figure 4. Target 0000 with a recommended 100m avoidance zone.