A gap analysis of the research and monitoring of nutrient pressures affecting St Aubin's Bay, Jersey.

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Michelle Devlin[1] and David Sivyer[1]

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[1] Cefas, Lowestoft Laboratory, Pakefield Road. Lowestoft, UK NR33 0HT

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Glossary of terms

CPM	Combined Phytoplankton Macroalgal Model
DFI	Department for Infrastructure
DoE	Department of the Environment
EIA	Environmental Impact Assessment
EU	European Union
NVZ	Nutrient vulnerable zone
RoCs	Region of Concern
RRM	Regulatory Road Map
SAC	Special Area of Conservation
SOJ	States of Jersey
SPA	special protection areas
STW	Sewage Treatment Works
UWWTD	Urban Waste Water Treatment Directive
WFD	Water Framework Directive
WMP	Water Management Plan
WRS	Water Resources Section

I. Executive summary

- Nutrient issues in Jersey's water are longstanding and it is the responsibility of the Department of the Environment (DoE) to monitor, manage and regulate these issues through its local obligations under the Water Pollution (Jersey) Law 2000 and international obligations under OSPAR convention[1].

- Jersey uses standards set by EU Directives, when assessing water quality, specifically the Urban Waste Water Treatment Directive (UWWTD)[2] and Water Framework Directive [3] as these provide a mechanism with which to measure compliance.

- DoE has identified high levels of nutrients in its waters as a key pressure and is tackling the issue at source (where they enter the system) through a series of interlinked activities. These include working closely with the agricultural industry to reduce inputs of fertilisers, introducing catchment control measures (as detailed in the Water Management Plan (2017) (WMP))[4] and regulating the Sewage Treatment Work's (STW) treated effluent discharge and its future replacement.

- The work undertaken by DoE on the nutrient pressures effecting St Aubin's Bay is extensive and requires consolidation. It was considered by DoE that the outset of this project was the appropriate time for an external body to review and undertake a gap analysis of the research, monitoring and data gathered.

- This work will help ensure that informed and evidence based regulatory and policy decisions are made; in accordance with the regulatory road map (RRM) at this stage of the STW replacement process and prior to the implementation of catchment measures under the Water Management Plan. The outcome of this review will assist in:
  - Informing regulatory processes and STW infrastructure development needs relating to the quality of the treated effluent discharge.
  - Complying with legal obligations under the Water Pollution (Jersey) Law 2000.
  - Ensuring 'Best Practice' is followed in relation to European Directives and their associated standards.
  - Responding to public and political pressures on the occurrence of the opportunistic algae *Ulva* in nuisance quantities.
  - Targeting of resources to assist with the monitoring, management, control and over time reduction of *Ulva* in the Bay.

[1] OSPAR: The **Convention** for the Protection of the Marine Environment of the North-East Atlantic - https://www.ospar.org/work-areas/hasec/eutrophication/common-procedure

[2] The Urban Waste Water Treatment Directive (UWWTD) (91/271/EEC) is designed to reduce the pollution of freshwater, estuarine and coastal waters by domestic sewage and industrial wastewater collectively known as urban waste water.

[3] http://www.euwfd.com/html/what-is-the-wfd-.html - The Water Framework Directive is the most substantial piece of water legislation ever produced by the European Commission, and requires that all inland and coastal waters within defined river basin districts must reach at least good status by 2015 and defines how this should be achieved through the establishment of environmental objectives and ecological targets for surface waters.

[4] Water Management Plan for Jersey 2017 – 2021 - The WMP is based on an integrated water management planning approach, with all stakeholders working together towards a common goal to achieve improvements in water quality through sustainable management.

- The Centre for Environment Fisheries & Aquaculture Science (Cefas) were selected to undertake this work. They were tasked to provide a technical report, not only on the gap analysis, but also on the proposed future regulatory and monitoring approaches.

- Four deliverables were identified to achieve the objectives of the review:
  - **Deliverable 1 (D1):** Produce a succinct high level 'overview' that ties together all relevant work relating to nutrient pressures and future regulation of St Aubin's Bay.
  - **Deliverable 2 (D2):** Assess the robustness of using the WFD water quality status assessment as part of a regulatory tool for discharge permits.
  - **Deliverable 3 (D3):** Review the current nutrient monitoring undertaken by the States of Jersey to assess DoE's ability to measure deterioration/improvement of the Bay's water quality/ecology; to assist in the regulation of the replacement STW using a cost-effective approach in accordance with the regulatory road map.
  - **Deliverable 4 (D4):** Assess whether the current nutrient monitoring of St Aubin's Bay can be used to measure the effectiveness of catchment management measures implemented under the WMP and RRM for Jersey.

II. Summary of findings and key recommendations

Deliverable 1: Produce a succinct high level 'overview' document that ties together all relevant work relating to nutrient pressures and future regulation of St Aubin's Bay.

- Over the past 15-20 years, a large volume of work has been undertaken to understand, monitor and regulate the nutrient pressures impacting St Aubin's Bay. The pressures the Bay faces are integrally linked to long standing issues surrounding inland nutrient pollution of Jersey's water resources. The consequences of excess nutrients (primarily from catchment run-off and treated sewage effluent discharge) entering the Bay are particularly visible with algal blooms of *Ulva* (green seaweed) now occurring annually.

- Many of the historic water quality reports/ monitoring relating to St Aubin's Bay were short term and developed to answer a single issue. These have built up an understanding of water quality issues and identified the cause and the effect of nutrient pollution. However, few offer a clear path to management prioritisation and targeted remediation.

- The consensus from these reports is that nutrient and other contaminant inputs need to be reduced through better catchment management and upgrading and increased efficiency of the STW.

- These issues now started to be addressed through the introduction of an integrated management approach, under the WMP (2016) and the approval for the replacement of the current STW.

- The water quality monitoring for both fresh and marine waters follow the WFD assessment tools. This provides a robust baseline dataset to assess the water quality status and to make informed management and regulatory decisions. This assessment uses a holistic and joined up approach to identify and manage water quality issues/data that involves all appropriate stakeholders, reducing the need for 'ad hoc' work in the future.

Deliverable 2 (D2): Assess the robustness of using the WFD water quality status assessment as part of a regulatory tool for discharge permits.

Deliverable 2 has two main aims:

1. To assess the robustness of using the WFD water quality status assessment as part of a regulatory tool for discharge permit compliance and whether other organisations use this approach?

- This was achieved by researching and providing case study examples of UK waterbodies that have faced similar water quality issues as identified in St Aubin's Bay. The case studies help show how organisations have used the WFD water quality assessment process to form part of policy and/or regulatory decisions by relating them to discharge permits or their equivalent.

- Research of these UK approaches identified that:
    - The WFD is not directly used within consent limits of discharge permits, however, EU Directives such as the WFD are used to identify problem areas and provide information to reach a required water quality standard or target.
    - The UK uses a combined set of management tools, including a modelling approach, to reduce nutrient loads and the effects of seaweed biomass.
    - The modelling outcomes, coupled with the in-situ monitoring and the application of assessment tools, (such as the WFD marine plant toolbox[5]) provide answers to different management questions.
    - These management tools use all available information in the development of a programme of measures to reduce the pollutant loads to achieve the most cost effective desirable outcomes, in partnership with water agencies and other stakeholders.
    - The outputs from the modelled approach does not provide discharge consent limits, neither does it provide direct quantitative input into the water quality assessment process.
    - The decisions around discharge permits will need to be developed based on regional knowledge, and input from the operators and water companies. However, the identification of the downstream issues, which can be assessed through directives such as the WFD, can be used as supporting information to derive discharge permits that are advantageous to the receiving environment.
    - Discharge permit limits should be set to ensure no further deterioration of the receiving water environment, and, where possible, look to improve and remediate problems or issues identified by the WFD assessment.

- DoE are proposing to use WFD status assessment as part of their regulatory tool for future decisions around additional treatment requirements at the STW and ongoing discharge permit compliance. It is therefore critical that they continue to apply the full ecological assessments provided by the WFD tool kit to monitor for changes in the water quality/ecology of the Bay during the construction, commissioning and operational phases of the replacement work.

- This monitoring will enable any changes in marine water quality to be identified and appropriate response or action to those changes taken. Furthermore, measuring the ecological state of the Bay and the discharge needs to be linked using appropriate monitoring and modelling tools to reduce ambiguity around cause and effect when deterioration of the water quality/ ecology of the Bay is detected.

[5] www.wfduk.org

2. Should the baseline water/ecological status of the bay mirror the current WFD status of St Aubin's Bay or aim to revert to 'pristine' status?

All UK case studies used current monitoring data within their modelling approach to identify the most appropriate action to take to reduce nutrient loads and seaweed biomass. None of the UK case studies examples looked to revert to pristine status. It is therefore recommended that Jersey should use the current data as their baseline and seek to achieve good status under the WFD.

Deliverable 3 (D3): Review current nutrient monitoring undertaken by the States of Jersey to assess DoE's ability to measure deterioration/improvement of the Bay's water quality/ecology; to assist in the regulation of the replacement STW using a cost-effective approach in accordance with the regulatory road map.

- DoE have adjusted their monitoring requirements over the past 10 years to reflect compliance against European water quality directives. Through this adjustment process, Jersey now has a water quality programme that is better adapted to answer the data requirements of the EU Directive eutrophication assessments.

- Initial monitoring in St Aubin's Bay began in 2012 using the Water Framework Directive - UKTAG guidance[6] and implemented sampling for most of the WFD criteria. These results informed longer term (3 year) chemical/ phys-chem monitoring programme. The final status assessment was carried out in 2015 resulting in a moderate status due to the low ratings for the phys-chem (nutrients) and elements of the opportunistic algal (*Ulva*) assessments.

- The water quality assessment programme of St Aubin's Bay is considered fit for purpose. However, there are a number of issues that need to be addressed, including:
    - Clarification on the normalisation of the winter dissolved inorganic nutrient values.
    - Confirmation that the reference conditions set for chlorophyll biomass growing seas are fit for purpose.
    - Further phytoplankton monitoring to help provide a clearer assessment.

- Despite this, the monitoring programme has adequate monitoring sites and sampling frequency. Compliance data has been collected for over 3 years and it provides the data required for a confident assessment of the chemical and ecological status of the bay. Ongoing support for continued monitoring at the same sites for a 6-year reporting cycle is recommended so that it is in line with the WFD protocol.

- The assessment programme can be used to detect possible change occurring as a result of the current WMP programme of measures and/or any improvement/deterioration in the effluent quality discharged from the STW.

- It will not, however, provide a confident assessment of the source of the nutrients, or the scale or priority of response to the nutrient sources needed to reach the appropriate standards. A modelling approach is required to achieve this and is a key recommendation throughout this review (see D4). For successful nutrient modelling, additional monitoring is required and should be undertaken prior to starting the modelling process. The recommendations for this monitoring are detailed in D4.

[6] www.ukwfd.org

Deliverable 4 (D4): Assess whether the current nutrient monitoring of St Aubin's Bay can be used to measure the effectiveness of catchment management measures implemented under the WMP for Jersey and RRM.

- As stated in the D3 summary, the water quality assessment programme of St Aubin's Bay is considered fit for purpose to assess the effectiveness of measures implemented under the WMP and will assist in the regulation of the replacement STW in accordance with the RRM.

- That said, there are knowledge/monitoring gaps that need to be addressed if DoE are to confidently assess the source of nutrient inputs into St Aubin's Bay. This enables the application of the most appropriate management and regulatory response in an effective and timely manner. D4 focuses on providing a suite of recommendations to be considered by DoE that could benefit future monitoring and assessment plans within their regulatory and management roles.

Modelling recommendations

- After careful consideration of the scientific studies and data collected on the nutrient pressures impacting St Aubin's Bay, it is strongly recommended that a modelling approach is required to achieve the best possible outcome for the effective management of nutrient pressures and subsequently *Ulva* growth in St Aubin's Bay.

- Many of the commissioned water quality reports identify the cause and the effect of nutrient pollution, but few offer a clear path to management prioritisation and targeted remediation. Modelling coupled with a weight of evidence approach will provide information on:
    - The scale of the issue,
    - The apportionment of source loading,
    - The most effective policy actions to respond to the issue; and
    - It will also enable predictions to be made on the amount of nutrient reduction required to reduce *Ulva* growth and the length of time this may take; which is key to managing public and political expectations.

- The modelling approach has been successfully used in UK estuaries (see section 4.4 for details). It is important to note that there is no quick fix and any improvements in measures can take several years to see a positive result. This is due to time lags associated with nutrient retention and multiple sources of inputs requiring an integrated approach using a programme of measures.

- The advantages of using the modelling approach for St Aubin's Bay are that the drivers, sources, impacts and ecological systems and interactions can be better understood. Model outputs will provide estimates for nutrient reduction and an understanding of the time lag between control measures being applied and improvements being seen. This is useful both for regulators and operational managers who are mitigating the issue as well as stakeholders who often expect quick recovery.

Monitoring recommendations

- To ensure that the modelling process provides the best possible outputs, it is recommended that DoE consider undertaking additional supportive monitoring, including:

- **Nutrient loading monitoring** - Two key monitoring elements currently missing are flow (water discharging into the Bay) and loading (amount of nutrient held within the water entering into the Bay). Both are critical to the modelling process.

- **Additional off-shore nutrient monitoring** - Previous studies undertaken in Jersey have indicated that the wider marine environment may influence nutrient levels in the Bay, contributing as a source of nutrients in its own right, driving the elevated biomass of *Ulva*. Further work into offshore nutrient influences is highly recommended.

- **Nutrient tipping points** - There should be more investigation of possible nutrient tipping points. These types of calculations can be investigated using a modelling approach. Scenarios of nutrient apportionment can be tested by the model to identify the nutrient load that can drive the macro-algal biomass into a moderate ecological state.

- **Phosphorous monitoring** - DoE have collected and analysed dissolved nitrogen data but have a limited amount of information on the dissolved phosphorus concentrations. It is therefore not possible to fully explore the role of nutrient limitation in controlling growth of the marine plants. It is recommended that DoE conduct phosphorus monitoring at all WFD marine sites.

- **Ulva monitoring** – The research into the *Ulva* biomass issues is comprehensive and has provided in depth knowledge of the issue. However, further research is recommended on:
    - Nutrients in sediment and the potential for overwintering of high nutrient sources (see sediment monitoring below).
    - The photobiotic layer and the ability of *Ulva* to settle on sand.

- **Sediment monitoring** - Sediment data is required for a greater understanding of nutrient storage and release including the role and fate of overwintering nitrogen. In the present monitoring design, there is limited information on sediments, both as a source of continuing nutrient supply and as a direct impact on the benthic diversity. Nutrients stored within sediments can also prolong the occurrence of nuisance algal growth even after effective nutrient reduction is implemented and is an important component of the modelling process.

- **STW monitoring data** - The treated effluent data collected from the STW discharges need to be included in any modelling approach, with a full costing of nutrient reduction scenarios. This is in line with the RRM and a phased approach to the replacement of the existing works. If the reduction in nitrogen is then applied to the qualifying discharges then an estimation of the corresponding reduction in weed growth can be made using the most appropriate model. As reported in Deliverable 2, using this principle, a maximum reduction of 10.1% in weed growth could theoretically be achieved in an impacted system (for example - Newtown Harbour) by applying nutrient stripping to all qualifying discharges.

- For further details on the monitoring/data required for a successful modelling approach can be found in Table 4-1.

- **Statistical review** - Whilst this review did explore the many different aspects of the data holdings and reviewed how the many reports have led to an increased understanding of the main drivers and impacts in Jersey marine waters, it did not perform any detailed statistical analysis on the integrated data. It is highly recommended that a more detailed statistical analysis of the changes over time[7] and the significance of this change and should be carried out using the long-term monitoring data.

[7] Statistical significance can be measures (p) and is the probability that the change you're seeing is only due to chance, and thus meaningless or is a real change related to some external factor. Typically, a p-level must be below 5% to be considered significant. In other words, if your p-value is 5% or less, you can confidently say that the change in your data is real, definite, and due to something other than statistical noise.

1 Deliverable 1 (D1): Provide an 'overview' of historic and current knowledge relating to nutrient pressures affecting St Aubin's Bay and the occurrence of *Ulva.*

D1:- The purpose of this deliverable is to provide a concise 'overview' of all the historical and current work undertaken around the nutrient pressures affecting St Aubin's Bay – which will set the context for the rest of the report and its outcomes / recommendations.

1.1 Background to historical and current issues

Nutrient pollution of all Jersey's water bodies is a longstanding issue; the effects of which are prevalent in Jersey's groundwater, streams and coastal waters. For an overview of historic water quality issues refer to Appendix D1. 1.1. To provide some context, Jersey's untreated water resources have some of the highest concentrations of nitrate in Europe. Approximately half of all samples taken from either surface or groundwater exceed the threshold of 50 mg/l nitrate. This compares to about 3% of surface water and 15% of groundwater samples exceeding the threshold in EU countries[8]. Consequently, Jersey Water (the Island's drinking water provider) cannot guarantee to meet drinking water standards for nitrate[7] and elevated nutrients entering STW make it harder for the operator to meet the required effluent discharge standard.

Jersey's inland waters are integrally linked to coastal waters, with a large proportion of the additional nutrients found in St Aubin's Bay being derived from catchment run-off and treated waste water from the Bellozanne sewage treatment works (STW). Nutrient pressures are particularly visible in St Aubin's Bay were the excessive growth of *Ulva* is evidenced since the 1980's[9], but now occurs annually; inciting both public and political attention. Research has shown that the growth of *Ulva* in St Aubin's bay occurs through a complex mix of environmental (topography of the bay, light penetration, water temperature etc.) and anthropogenic influences (alterations to the shape of the bay, drainage and additional nutrient loads). A more detailed summary of the issues around macroalgal blooms can be found in Appendix D1. 1.2

The States of Jersey departments directly responsible for the work relating to St Aubin's Bay are the Department for Infrastructure (DfI) and the Department of the Environment (DoE).

DoE has a responsibility to investigate, monitor, manage and regulate nutrient pressures affecting all the Island's water (including coastal waters up to the Islands territorial limits) under local legislation, the Water Pollution (Jersey) Law, 2000 and its international obligations under the OSPAR Convention.

Over the past two decades, DoE has met these responsibilities by managing and regulating water pollution issues (including nutrients), through targeted research, the development of legislation and water management policy and the implementation of bespoke water monitoring programmes. Examples of which include:

- Water Pollution (Code of Good Agricultural Practice) (Jersey) Order 2009.

[8] Water Management Plan for Jersey 2017 - 2021

[9] Investigations of the growth of sea lettuce (*Ulva lactuca*) at St Aubin's bay Jersey, States of Jersey, 1982

- Cross compliance - a mechanism that links direct payments to compliance by farmers with basic standards concerning the environment[10].
- STW- discharge consent and breaches.
- Diffuse Pollution project.
- Action for Cleaner Water Group – multi-agency that works toward protecting the Island water resources.
- Bespoke water quality and ecology monitoring programmes for marine and fresh waters using the WFD monitoring approach.
- Introduction of the WMP (2017-2021).

All of which provide a greater understanding of the issues and effective protection of the Island's water bodies, including St Aubin's Bay.

DfI is responsible for the operation of the Islands sewage infrastructure and the STW, which discharges treated effluent into St Aubin's Bay. DfI have a legal obligation under discharge permit DP(B)2000/07/01 to ensure its activities do not cause pollution to controlled waters[11]. DfI are also responsible for coastal infrastructure and cleaning the Islands beaches, including the removal and disposal of nuisance quantities of seaweed (notably *Ulva*).

The two departments work closely together and combine the outputs of the monitoring and assessment to implement the programme of measures required to help combat the high algal biomass issues.

When assessing the Island water quality Jersey utilises standards set by EU Directives, specifically the Urban Waste Water Treatment Directive (UWWTD)[12] and Water Framework Directive [13] assessment tools. EU counties must also comply with the Nitrates Directive, however Jersey has not historically adopted this approach. EU water directives provide Jersey with a mechanism to assess compliance related to direct discharges from STWs (UWWTD) and catchment sources (WFD) (Appendix D1. 1.3).

1. Urban Waste Water Treatment Directive – STW treated effluent discharges

In the past, Jersey has used the provisions of the UWWTD to define and regulate limits detailed within the discharge permit for the STW. Guidance under UWWTD provides indicative limits for nitrogen components within discharges (dependent on the population size and the sensitivity of the receiving waters), which can be used to inform consents to manage these point source sewage discharges. However, whilst the application of discharge consents can work well against the point sources like STW discharges they do not, understandably negate further pollution issues from groundwater, overflow, agricultural and urban loads.

As stated, the treated effluent discharge from the STW is regulated according to a discharge permit (issued under the Water Pollution (Jersey) Law 2000). The limit for total nitrogen has historically

[10] https://ec.europa.eu/agriculture/envir/cross-compliance_en

[11] Controlled waters under the Water Pollution (Jersey) Law 2000, include the territorial sea adjacent to Jersey, coastal waters, inland waters; lakes, marshland, ponds, reservoirs, streams, surface water sewers and groundwaters.

[12] The Urban Waste Water Treatment Directive (UWWTD) (91/271/EEC) is designed to reduce the pollution of freshwater, estuarine and coastal waters by domestic sewage and industrial wastewater collectively known as urban waste water.

[13] http://www.euwfd.com/html/what-is-the-wfd-.html - The Water Framework Directive is the most substantial piece of water legislation ever produced by the European Commission, and requires that all inland and coastal waters within defined river basin districts must reach at least good status by 2015 and defines how this should be achieved through the establishment of environmental objectives and ecological targets for surface waters.

been set against the UWWTD limit of 10 mg/l, based on the precautionary principle and the sensitivity of the receiving waters. St Aubin's Bay was designated in 1997 and 2009 as potentially sensitive under the UWWTD. The STW is currently being replaced because it has reached the end of its working life and engineering solutions have failed to lower total nitrogen discharge below the permit limit.

As part of the early design stages of the new works and in response to previous discharge permit non-compliance, a regulatory road map (2015) was developed to provide clarification of relevant aspects of the build and commissioning of the replacement STW and the monitoring and protection of the receiving environment (St Aubin's Bay) moving forward. The road map outlines a regulatory policy shift away from strict application of UWWTD limits for nutrients and more toward the use of the WFD to ensure that there is 'no environmental deterioration[14]' of the water quality in St Aubin's Bay. Specifically, this means that there should be no deterioration to the:

- Quality of the end of pipe discharge of treated effluent arising from the replacement works compared to the existing works.
- Receiving environment as a result of the replacement works.

2. Water Framework Directive – Water Management Plan

The EU Water Framework Directive monitors and assesses water quality issues from across catchments to the coast and provides a broader scope for regulating potentially polluting discharges. The WFD River Plan process can further deliver compliance monitoring through a "tool box" of assessment methods to provide an ecological assessment of the estuarine and coastal environment.

A Water Management Plan (WMP) (2017-2021)[15], that follows the principles of the WFD has been developed and agreed by the States Assembly in 2016. The five-year plan provides for a more holistic approach setting out measures to tackle key risk areas including elevated nutrients in Jersey's coastal water bodies and sets out a framework for the protection and restoration of Jersey's water resource. Thus, there has been a move from a nutrient and contaminant focus in the groundwater and streams to a comprehensive programme incorporating chemical and biological measurements for a full ecological assessment of all Jersey's water resources.

The plan identified key water management challenges in Jersey and assigned a status classification to all water bodies on the Island. Coastal water status assessment focused on St Aubin's Bay as it is considered to be the coastal water body most 'at risk' from anthropogenic pressures. The outcome of all these assessments are informing policy and regulation. The WMP recognises that only focusing on STW loads is not appropriate when dealing with the cumulative pressure of nutrient loads from different sources. It therefore looks to regulate these sources through a wide-ranging management approach that tackles both catchment and STW nutrient sources.

The main issues identified under the WMP affecting the health of the waters were the elevated levels of nutrients (particularly nitrate in fresh waters), the risk of elevated levels of the nutrient phosphorus and the risk of pesticide contamination[13]. Ongoing monitoring shows that the quality of the Island's inland (fresh) waters are improving but there is a lot still to be done. All measures

14 The WFD also contains an overarching aspiration to achieve good status for all water bodies. Deterioration of the receiving environment is considered to occur as soon as the status of at least one of the quality elements falls by one class, even if that fall does not result in a fall in classification of St Aubin's Bay as a whole.

15 Water Management Plan for Jersey 2017 - 2021

implemented to reduce nutrients at a catchment level will assist in combating the annual proliferation of *Ulva* blooms in St Aubin's Bay.

1.2 Review

1.2.1 Background

For the purposes of this review, Cefas was provided with over 30 reports spanning a 25-year period on the nutrient issues the Island faces (Appendix D1. 1.1 contains a list of the reports). These detail a significant history and legacy of nutrient pollution in Jersey's ground and surface waters, which extends to the coastal waters of St Aubin's Bay. Most of the reports and studies provide good content and quality and have advanced the state of knowledge concerning the Island's water quality issues.

It is important to acknowledge that all nutrient pressures affecting the Island's water bodies will impact St Aubin's Bay, given that 60% of the stream base flow derives from the Island's groundwater and the majority of Islands streams discharge into the Bay.

A lot of work on nutrient pressures affecting all the Island's water bodies has been carried out over a number of decades and whilst information is related to the nutrient pressure the Island faces; reviewing all the information is considered outside the scope of this review. Focus will be given to those reports that are directly related to St Aubin's Bay and the WMP (however, some fresh water reports are referenced within the review).

1.2.2 Site information: St Aubin's Bay

St Aubin's Bay is located on Jersey's south coast (Figure 1.1). The boundaries of the bay are made from the cliff of Noirmont point to the west of the bay and St Helier Harbour and the Island's La Collette reclamation site to the east. St Aubin's Bay is relatively sheltered, protected from the energy from the Atlantic; it has a macro-tidal environment with semi-diurnal tides[16] with a maximum tidal range of 12.5m (spring).

[16] Holmes, E.R. Estimated inorganic nutrient loading to intertidal regions from catchment and waste water sources and the observed effects on marine benthic macro-algae in Jersey, Channel Islands. University of East Anglia

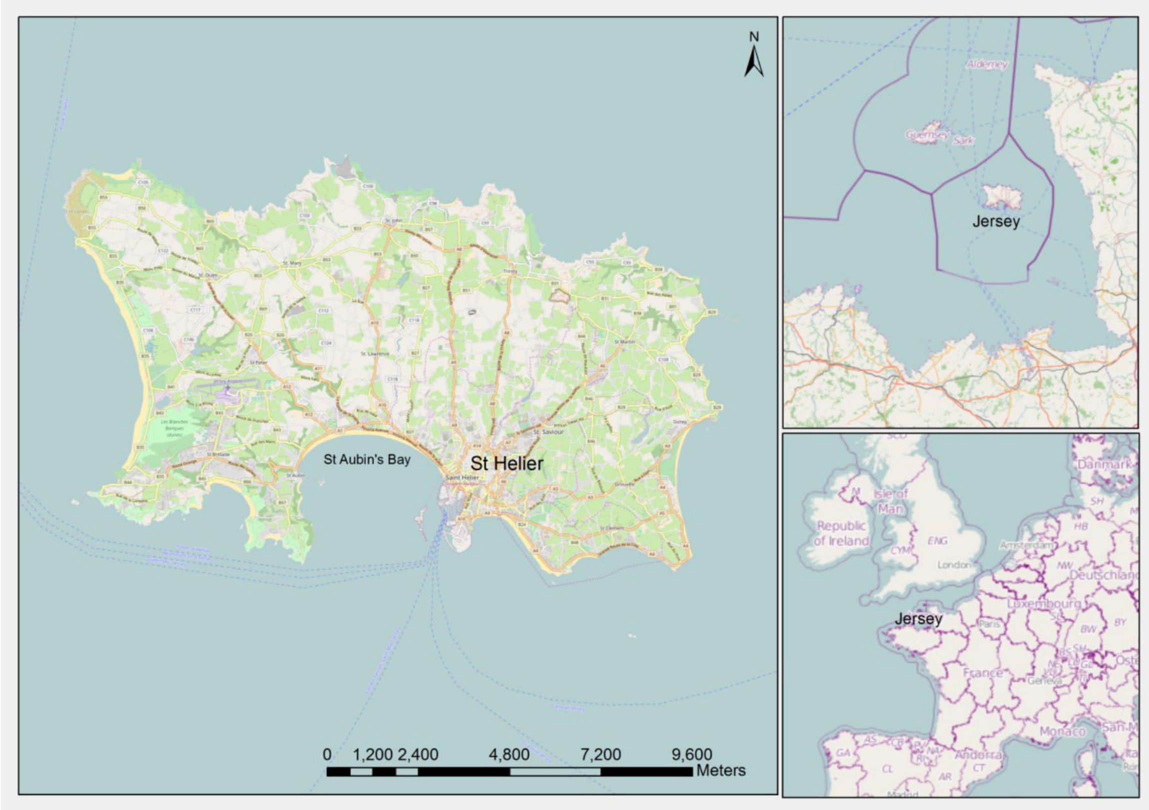

Figure 1-1: The location of Jersey and the problem areas in St Aubin's Bay.

St Aubin's Bay receives most of the Islands catchment run-off and the principal treated effluent discharges (Figure 1-2)[17], whilst providing a facility for the Island's main port and opportunities for fishing and recreational activities[18]. It is also the focus point of the town, associated with tourism and highly visible to townspeople and visitors.

[17] Cascade (2016) St Aubin's Bay – Ulva studies 2015-2015

[18] WCA environment (2015) The Environmental Status of St. Aubin's Bay, Jersey According to the Requirements of the Water Framework Directive - Data Management and Assessment of Monitoring Programmes: Monitoring Programme Results and Status Assessments (2012-2015). For the States of Jersey Department for the Environment.

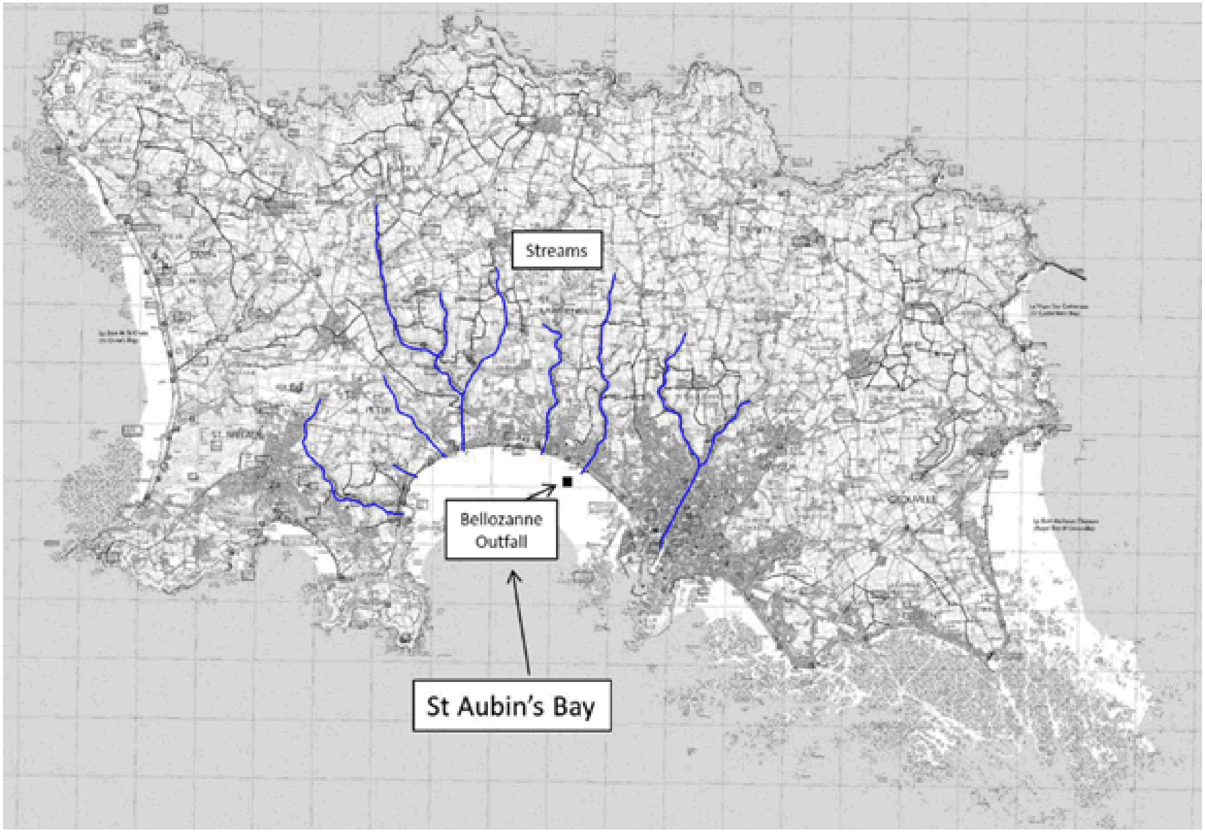

Figure 1-2: Map of Jersey showing stream inputs into St Aubin's Bay

1.2.3 Source of nutrients into St Aubin's Bay

St Aubin's Bay receives nutrients from the following known sources:

- Freshwater streams draining into the Bay, transporting nutrients from urban and agricultural land.
- Road drains and urban run-off, particularly from St Helier area.
- Bellozanne STW - treated effluent discharges.
- Occasional overflow from the Fort Regent Cavern and other Combined Sewer Overflows (CSO's).
- Mineralisation from sediments (largely un-reported or monitored).
- Marine sources include the wider marine environment, including regional inputs into the Bay of St Malo.

1.2.4 Overview of macroalgae blooms in St Aubin's Bay

As noted previously, the effects of nutrient pressures are very visible on St Aubin's Bay with algal blooms of *Ulva* now occurring annually; provoking public, political and media attention. This is of concern given its prominent location at the south of the Island next to Jersey's main town of St Helier and the effect these blooms have on local businesses, recreational users and tourism. Concern arising from *Ulva* growth was highlighted during a government run 'St Aubin's Bay' stakeholder workshop in 2013. Participants were asked about their vision for St Aubin's Bay in 2025, and a large proportion of participants responded that they would like the beach to be 'free of *Ulva*'[19]. In 2017, DfI in association with Ricardo (Environmental consultancy) hosted an International conference on *Ulva*. The speakers and delegates in attendance were wide ranging and included representatives

[19] Dialogue Matters – St Aubin's Water Quality Workshop 2013. For the Department of the Environment.

from New Zealand, Ireland, France and the UK. Areas discussed included the biological and ecological background to *Ulva*, the use of WFD to assess and manage its growth and the commercial use of the seaweed.

The excessive growth of opportunistic species such as *Ulva* is not restricted to Jersey. Blooms are a world-wide phenomenon reported to occur globally in places such as China, New Zealand[20] and along the Brittany coast (Appendix D1. 1.2). Over the last century, the global average for nitrogen loading is reported to have doubled in coastal areas which have subsequently become one of the most chemically altered ecosystems in the world[21], resulting in the occurrence of algal blooms. Macroalgae are natural components of shallow-water marine and transitional soft-sediment communities. However, excessive growth of opportunistic species may occur under certain conditions. Altering the natural balance not only of the algal community, but also of associated faunal communities. Opportunists such as *Ulva*, can out-compete other marine plants (phytoplankton, seagrasses and other seaweeds), taking advantage of nutrient inputs[22]. Such opportunist species are characterised by high rates of mineral nutrient uptake, nutrient saturation and growth and may have enhanced reproductive capability[23]. A full description of the drivers and impacts of opportunistic macroalgae can be found in Appendix D1. 1.2.

1.2.5 Overview of work carried out to assess nutrient pressure effecting St Aubin's Bay

Over the last two decades significant investigatory work has been undertaken to understand the nutrient pressures acting on St Aubin's Bay (Appendix D1. 1.3). These were to primarily fulfil operational and regulatory requirements and to assess the water quality status against the EU UWWTD and WFD. A succinct overview of the history of this work is detailed below; followed by a critique by Cefas on the work carried out and potential future direction.

In 1997, research into the nitrogen and phosphorous budgets entering the Bay was carried out[24] as part of the States of Jersey's drive to reduce pollutant input, improve water quality and to limit the excessive growth of *Ulva* and any potential ecological repercussions. To achieve this, it was essential to understand the relative contributions from STW and catchment sources of nutrients. The outcome of this research showed that there was a 50:50 split in to the Bay from the STW and catchment sources, with nitrate being the most dominant source of nitrogen entering St Aubin's Bay[19]. At this time, treatment options for the STW were also being considered to help in this process and ensure compliance with the requirements of EU UWWTD.

Simultaneously a trophic status assessment was carried out to determine whether St Aubin's Bay was eutrophic (sensitive) because the UWWTD requires treatment measures to be put in place on STWs that discharge into sensitive areas (including those suffering from hypernutrification (excess nutrients)). The outcome of this research showed that the Bay was 'potentially sensitive' because hypernutrification occurred during the winter months. Nutrient reduction measures were subsequently installed on the STW.

[20] Cascade (2016) St Aubin's Bay Ulva Studies 2014-2015. For the States of Jersey – Department for Infrastructure

[21] Agardy, T. and Alder, J. (2005) *Ecosystems and Human Well-being: Current State and Trends, Coastal systems, chapter 19* http://www.millenniumassessment.org/documents/document.288.aspx.pdf

[22] Scanlan, C.M., Foden, J., Wells, E. and Best, M.A., 2007. The monitoring of opportunistic macroalgal blooms for the water framework directive. Marine Pollution Bulletin, 55(1-6), pp.162-171.

[23] Hoffmann, A.J. and Ugarte, R., 1985. The arrival of propagules of marine macroalgae in the intertidal zone. Journal of Experimental Marine Biology and Ecology, 92(1), pp.83-95.

[24] CREH (1997) Estimation of nitrogen and phosphorus budgets entering St Aubin's Bay, Jersey

In 2009, the trophic status assessment was repeated in response to the nitrogen removal processes not meeting the design criteria and failing the total nitrogen limit detailed in the discharge permit. The result of this work showed that the overall nitrogen flux into the bay had not altered from 1997 and there was still winter hypernutrification as defined under the UWWTD. At this time CREH suggested considering assessing the nutrient concentrations in the nearshore (surf zone) because of the unique situation in St Aubin's Bay were the STW discharges at approximately mid tide and the outfalls discharge onto the beach for a proportion of the time therefore reducing mixing during these times. Monitoring nutrients within the surf zone (nearshore) has since begun (2014) and forms part of current monitoring programme undertaken by DoE.

The diffuse pollution project was initiated in 2010 to engage the farming industry in tackling the Island's nitrate issues. A bespoke monitoring programme was also instigated to measure nutrient pressures in three main problematic areas.

In 2012, water quality and ecology monitoring of St Aubin's Bay began, using criteria set by the WFD. Drivers for continuing this work include:

- The long-term non-compliance of the STW (between 2000– 2016 STW consistently breached its discharge permit limit for total nitrogen).
- The recommendations of an Environmental Security Panel Review of Marine Waters in Jersey (2011) (the report suggested that more monitoring of Jersey's coastal waters should be undertaken using the principles of the WFD).
- Coastal waters are a key element within the then future Water Management Plan, focus was given to St Aubin's Bay because it was considered the most 'at risk' coastal waters from pollution.
- To provide a base line water quality status with which to measure any changes in water quality or ecology of the bay following the development of the STW.
- To assist with detailed investigations into the occurrence of *Ulva*, by DoE and DfI as part of the planning process for the replacement STW (Appendix D1. 1.1)
- This work now forms an integral part of the WMP (2017).

This resulted in a detailed three-year assessment of the Bay's water quality (chemical) and ecological (seaweed/biota). This assessment has since been rationalised to focus on nutrients. Data collected since 2015 includes chlorophyll-a, phytoplankton, macroalgae, opportunistic macroalgae, seagrass and benthic invertebrates at a series of sites in St Aubin's Bay (Figure 1-3).

The status assessments under a recent application of the WFD indicates that St. Aubin's Bay should be initially classified as being at 'Good' chemical status and 'Moderate' ecological status. The overall status classification of St. Aubin's Bay, according to WFD assessment criteria report from WCA 2014/2015 is therefore 'Moderate' (due to the 'one-out-all-out' rule - designating status on the lowest classification)

The ecological quality elements driving the 'Moderate' status is the macroalgae assessments (opportunistic macroalgae) which fail the WFD thresholds for cover (%) and biomass and the physico-chemical assessment (dissolved inorganic nitrogen concentrations) which indicates that the bay is currently moderately impacted by nutrient enrichment.

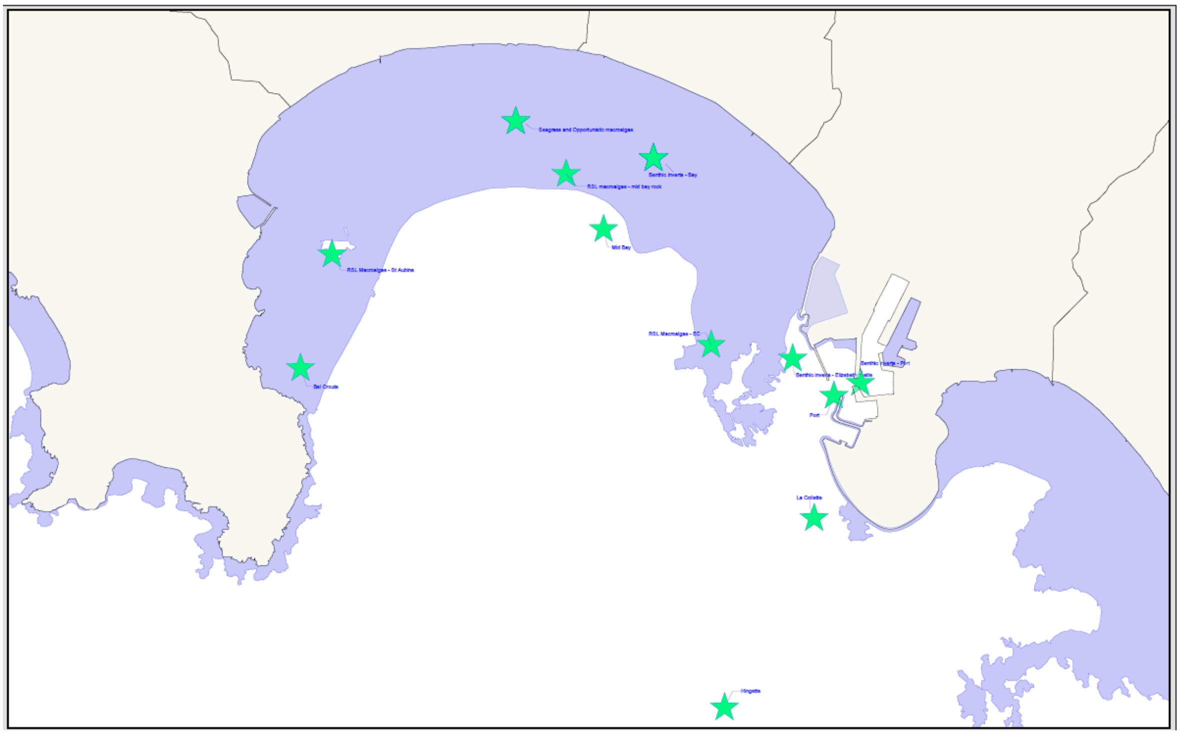

Figure 1-3: Map of St Aubin's Bay, showing the WFD sampling locations

Other monitoring that is carried out in St Aubin's Bay that does not form part of the WFD assessment can be found in section 3.2, and includes:

- Outfall discharge monitoring – measures nutrient input from catchment stream sources.
- St Aubin's nearshore zone monitoring - to measure nutrient concentrations in the surf zone.
- Time-lapse camera monitoring – to document the occurrence/distribution of *Ulva*.
- WFD Freshwater monitoring – which includes nutrient concentrations.
- STW regulatory and operational data on the quality of the treated effluent entering the Bay.
- Historic photographic assessment of *Ulva* occurrence.
- Offshore transect from St Aubin's Bay to Les Minquiers off shore reef - to measure nutrient concentrations.

In 2013, work began by DfI (the former Transport and Technical Services Department) to carry out assessments on St Aubin's Bay to assist them with the planning application /approval by the States of Jersey to commission the replacement of the existing STW (the current works has reached the end of it working life and is no longer fit for purpose).

Four key areas of work DfI carried out include:

- Nutrient data review of St Aubin's Bay - A detailed review of data held on the nutrients entering the bay[25].
- Hydrodynamic modelling for the proposed STW renewal feasibility studies[26]
- Literature review on *Ulva*[27].
- *Ulva* studies report 2014-2015[28] – looking at the occurrence of *Ulva* in St Aubin's Bay.

[25] Cascade (2013) Review of available historic freshwater and marine data from St Aubin's Bay and surrounding area. For the States of Jersey, Transport and Technical Services Department.

[26] Marcon (2013) Hydrodynamic model development and calibrations for the proposed STW renewal feasibility studies – Stage 1. For the States of Jersey, Transport and Technical Services Department.

[27] Cascade (2013) Ulva literature review. For the States of Jersey, Transport and Technical Services Department.

[28] Cascade (2016) Ulva Studies 2014-2015, For the States of Jersey, Department of Infrastructure

In 2013, a 'St Aubin's Bay' workshop was run by DoE and DfI so that the relevant stakeholders could develop their vision and objectives for the Bay. The workshop highlighted the concern about the growth of *Ulva* and many of the participants wished to see St Aubin's Bay free from *Ulva*[29].

As previously mentioned in section 1.1, work in 2013 also began to develop an integrated water management plan (WMP), to enable better planning and management of the quality of the Island water resources. A comprehensive review of the Island's water quality monitoring was undertaken that set out the status of the water bodies and the key pressures acting on it. This resulted in a refined monitoring programme following the principles of the WFD assessment requirements to measure the Island's water quality. The main issues identified under the WMP as affecting the health of the waters were:

- Elevated levels of nutrients (particularly nitrate in fresh waters).
- The risk of elevated levels of the nutrient phosphorus; and
- The risk of pesticide contamination[30].

The WMP for Jersey (2017-2021) was approved by the States Assembly in 2016. Ongoing monitoring shows that the quality of the Island's inland (fresh) waters is improving, but there remains a lot to be done to fully mitigate the water quality issues. All measures implemented to reduce nutrients at the catchment level will assist to combat the annual proliferation of *Ulva* blooms in St Aubin's Bay. The work undertaken in St Aubin's Bay forms an important part of the WMP.

In 2014, a Nitrate Working Group was established to bring together key stakeholders to examine and make recommendations on how to tackle the nitrate issue in Jersey's water resources[31]. In 2017 this group evolved into the Action for Cleaner Water Group. This had a broadened remit to include reducing pesticides in water.

In 2015, during the design process of the STW, a regulatory road map was produced by DoE establish a clear pathway for the regulation of the replacement STW[32]. Two key aspects detailed within the road map are:

- The principles of the 'phased approach'[10] in relation to the inclusion of nutrient removal within the waste water treatment process; and
- The definition of the 'no deterioration principle[10]' with regards to the quality of the STW discharge (end of pipe) and the receiving waters (using the WFD assessment criteria) in relation to future discharge from the STW.

The information gathered from all the above-mentioned monitoring is currently informing three major pieces of work that have a significant bearing on the management and regulation of nutrient pressures on St Aubin's Bay: -

- The design requirements for a replacement STW,
- The phased approach for the replacement STW, along with the revision and variation of the future discharge permit to regulate the works; and
- The implementation of measures under the first WMP for Jersey.

[29] Dialogue Matters – St Aubin's Water Quality Workshop 2013. For the Department of the Environment.

[30] Water Management Plan for Jersey 2017 – 2021

[31] States of Jersey (2014/2015) Nitrate Working Group 2014/2015 report and recommendations

[32] Please see Appendix D3 3.3 (see section 1.2)

1.2.6 Cefas critique on the work carried out on nutrient pressures in St Aubin's Bay

Whist many of the water quality projects were short lived and were developed to answer a single issue; the shared consensus from the majority of the reports is that nutrient and other contaminant inputs are high and can cause issues. These high concentrations need to be reduced through measures, such as improving catchment management and/or upgrading and increased efficiency of the STW.

The outcomes of these projects have been successful at building up an understanding of several water quality issues and identifying the cause and effect, but few offer a direct path to reduction and mitigation of the issues. Furthermore, the data has been collected for multiple purposes, resulting in a lack of continuous data collection. Making it difficult to adapt many of the data sets to the monitoring and assessment requirements. That said, with the introduction of the WMP there is now be a more holistic and joined up approach to identifying and managing water quality issues/data that involves all appropriate stakeholders, reducing the need for 'ad hoc' work in the future.

To further assist with the resolution of the nutrient issues in St Aubin's Bay and reduce the macroalgal blooms, the use of an effective model is strongly recommended. This will enable a series of long-term scenarios to be tested with outputs offering the best solution; weighing up the environmental outcomes and cost efficiency. The modelling approach would use a combination of data gathering, assessments, scenario testing and prioritisation of activities based on the most appropriate scenario. There are several international examples on how a modelling approach coupled with strong environmental directives has helped with other areas facing similar issues and impacts as seen in Aubin's Bay.

The outcomes from the modelling process could then be used to identify the most achievable solutions with best environmental outcomes through the support of measures already implemented under the WMP and the replacement STW. The modelling process could also help define further measures if required. It is worth noting that the examples presented in section 4.4 recognise that, even with the most appropriate and targeted management action (for example, reducing STW loads), it will take several years to see a corresponding ecological response. Time lags must be considered when adopting any of the various management actions to reduce nutrient loads into St Aubin's Bay.

2 Deliverable 2 (D2): Review of UK case studies with opportunistic macroalgal issues

Deliverable 2 (D2) - The purpose of this deliverable is to assess the robustness of using the WFD water quality status assessment as part of a regulatory tool for discharge permits

This section will summarise the WFD approach in the UK through a series of case studies. Examining how the UK uses the WFD criteria and assessment tools to help develop water management plans. It will provide examples of the application of the WFD, within a regulatory capacity and how concerns around eutrophication were addressed. Focus will be given on where the UK have used the WFD information to help define or refine regulatory discharge limits. Where possible, the report will also identify the programme of measures that were put in place to mitigate the impact and to improve the ecological classification.

The case studies, where appropriate, provide information on the following:

- The use of the WFD for regulatory purposes. Identifying whether organisations have used the WFD water quality assessment process to form part of policy and/or regulatory decisions relating to discharge permits or their equivalent.
- If, yes, identifying how it was incorporated into the permit.
- Make recommendations for what the baseline water/ecological status of the bay should be – should it mirror the current WFD status of St Aubin's Bay or aim to revert to 'pristine' status?

2.1 WFD Water Quality Status assessment

The current status of St Aubin's Bay, based on a recent assessment provided by WCA environment is Moderate with chemical status as good, and ecological status as moderate. The outcomes of each of the WFD elements is shown in Table 2.1. Issues around the high concentration of dissolved nutrients and *Ulva* blooms are shown in the moderate status for physio-chemical parameters and opportunistic macroalgae assessments. The one-out-all-out assessment for WFD is driven by the lowest classification outcomes and thus St Aubin's Bay will continue to be reported as moderate status while issues around high nutrient concentrations and macroalgal blooms continue. For a full summary of the WFD assessment for St Aubin's Bay, please refer to Appendix D2. 2.1.

Table 2-1: Summary of the chemical and ecological status for each pressure indicator based on the results obtained from the St Aubin's Bay monitoring programme.

Element	Metric	Status	Overall Status
Chemical Status	Priority Substances	Good	**Moderate**
Ecological Status	Physico-chemical Conditions	Moderate	
	Specific Pollutants	Good	
	Phytoplankton	High	
	Rocky Shore Macroalgae	Good	
	Opportunistic Macroalgae	Moderate	
	Seagrass	High	
	Benthic Invertebrates	Good	
	Imposex	Good	

2.2 UK's application of WFD and River basin planning for eutrophication reduction

In the UK, water quality status assessments have been produced through national processing of WFD classification data for nutrients and plant/algal indicators of eutrophication. These assessments are presented alongside local quality assurance and consideration of any wider local evidence from investigations and other sources. Providing a comprehensive assessment which can be linked directly to appropriate management actions.

A weight of evidence approach to assess the risks and impacts of eutrophication was used for both freshwaters and saline waters. The evidence for individual water bodies was assessed against a national suite of criteria for eutrophication in the different categories/ types of water for review. The criteria are both quantitative and qualitative and reflect scientific understanding of the process and effects of eutrophication. They are broken down in the same way for each water category; nutrients, plants/algae and secondary and other effects.

The UK take ongoing actions to reduce nutrient levels through an initial cycle (Cycle 1) of river basin planning. These assessments are used in WFD second planning cycle (Cycle 2). Particularly to inform the targeting of expensive regulatory measures to reduce nutrients, in line with Defra and UKTAG nutrient standards and EU WFD eutrophication guidance. Such measures include nutrient removal at STWs and further designations under the UWWTD or Nitrates Directives (Appendix D1.1.3). Actions in Cycle 2 will take time to take effect in terms of reducing the level of impact from eutrophication. However, positive ecological benefits in terms of reducing the worst symptoms of eutrophication would be expected.

Any improvements in biology following a reduction in nutrient levels will take time and will depend on the degree of nutrient reduction. The assessment of eutrophication for any waterbody is based on indicators of status. However, this will be indicative of eutrophication risks for future assessments and possibly beyond, due to the varying potential and lengthy timescales for ecological recovery.

The Cycle 2 outputs are based on latest WFD nutrient standards and WFD biological tools, which means the assessment is carried out on more recent and comprehensive dataset than that used for Cycle 1. The focus is more on the impacts of eutrophication, as the ecological issue of concern, rather than on concentrations of phosphorus and nitrogen or the risks from point or diffuse sources of nutrients.

For all the water categories, the likelihood of eutrophication in a water body is assessed using a weight-of-evidence approach. This considers information about compliance, with the relevant WFD nutrient standard for good ecological status as a measure of exposure to pressure; together with information on eutrophication related impacts based primarily on the WFD tools for plants and algae and their good/moderate status boundaries. These are the biological elements sensitive to nutrient pressure. The weight-of-evidence approach was used in the UK for assessing and presenting certainty of eutrophication and provides a more useful indication of the ecological implications of nutrient pressure than the maps of nutrient or biological status alone.

2.3 UK case studies

Many of the estuaries and harbours across southern England suffer from excessive growths of green seaweeds, such as *Ulva*, caused (primarily) by nutrient enrichment. The Hamble and Medina estuaries and Newtown, Portsmouth, Langstone and Chichester Harbours are badly affected with parts smothered in dense mats of green seaweed. The dense seaweed causes impacts such as deoxygenation of the underlying mudflats resulting in adverse impacts on their benthic invertebrate communities and on the feeding behavior of some birds.

Sewage effluents are one source of the nitrogen inputs that contribute to nutrient enrichment in the Solent and have been identified in the Habitats Direct RoCs for:

- Newtown Harbour (Appendix D2. 2.2)
- Portsmouth Harbour SPA (Appendix D2. 2.3)
- Langstone SPA (Appendix D2. 2.4)
- Chichester (Appendix D2. 2.5, Appendix D2. 2.6)

In response to this, the Environment Agency has developed 5 to 10-year action plans for the control of nutrient enrichment caused by effluent discharges. These action plans will be bespoke plans for each catchment based on the issues by the modelling and monitoring outcomes. These plans require controls to reduce nutrient inputs on many of these discharges. However, the nutrient limits will be proportional to the overall contribution from sewage discharges to this problem. It is usual for the effluent treatment requirements to be based on model predictions from a nutrient transport and a seaweed growth model (EcoS or CPM33 model). The resulting measures include:

- Relocating effluent discharges away from the most sensitive areas.
- Treating discharges to reduce nitrogen (N) concentrations: The target set is based on what is reasonable for the resident population. At this point, most of the STW's have the best available technique not entailing excessive costs (BATNEEC) set at 10 mg/l N[34].

The model generally used for the UK is the CPM (Combined Phytoplankton Macroalgal) model. The specific model used in these case studies is the dynamic Combined Phytoplankton and Macroalgae (dCPM) model as developed by CEFAS[35]. The dCPM model is a simple box model which takes annual or seasonal input loads and determines daily phytoplankton and macroalgal production. The model has been updated in recent years to include multiple boxes linked together in a flexible configuration. Each box represents a different portion of the water body and can have its own characteristics such as (i) depth, (ii) area available for macroalgal growth and (iii) light attenuation. Nutrients and phytoplankton are exchanged between the boxes and the coastal zone. Most recently, the model has been updated to include a freshwater source of chlorophyll.

The main outputs from the model include:

- Average summer and winter nutrient concentrations;
- Average summer and winter chlorophyll concentrations and macroalgal biomass; and
- An indication of factors limiting primary production (light, N, P or available area). Space only applies to macroalgae due to its requirements of availability of suitable growth habitat within the estuary.

The model requires data inputs of:

- Estuary area (km^2) and mean water depth (m) of the estuary. The model can also take advantage of the depth-binned Sea Zone data.

[33] CPM: Combined Phytoplankton and Macroalgae Model

[34] Some older STPs may have an extended period of time to achieve a target of 10mg/L for BATNEEC.

[35] Aldridge, J. A., S. J. Painting, D. K. Mills, P. Tett, J. Foden, and K. Winpenny. "The Combined Phytoplankton and Macroalgae (CPM) Model: predicting the biological response to nutrient inputs in different types of estuaries in England and Wales." *Report to the Environment Agency. CEFAS Contract C* 1882 (2008).

- Estimates of annual nutrient load (N and P, Mmol or kg y-1) and chlorophyll from freshwater (kg y-1) if significant.
- The relative loading in summer vs. winter (as a ratio). The summer/winter load ratio must be between 0 and 2, where zero means that all nutrient loading occurs in winter, 1 means summer loads and winter loads are the same, and 2 means that all nutrient loading occurs in summer. The model checks that the ratio is between these limits.
- Estimates of extent of the available intertidal area suitable for macro-algal growth, given as a percentage of the total area of the estuary.
- Water exchange rate (d^{-1}) – can be calibrated using salinity from adjacent seawater.
- Micro plankton loss rate (d^{-1}).
- Nitrogen losses due, for example, to denitrification (% of load).
- The light attenuation coefficient (Kd, m^{-1}).
- Latitude and longitude.
- Nutrient (µM) and chlorophyll concentrations (µg l-1 (mg m-3)) in adjacent seawater in summer and winter.
- Estimate of the spring tidal range. Available from Admiralty charts, tide tables, internet sites or from tidal software.
- Estimate of M2 tidal phase.
- River flow rates (m3 s-1) – both annual average and seasonal.

For very complex systems the Environment Agency have used 2 separate models (dCPM), one for the freshwater and groundwater inputs and an external marine nutrient component. An example of this complex system can be seen in the process developed for waterbodies in the Solent (Figure 2-1).

The Freshwater Model is called SAGIS (Source Apportionment GIS). This was developed by the Environment Agency for UKWIR, with support from SEPA and Natural England to analyse sources of chemicals (and nutrients) at the river basin scale; and identify measures to improve river, lake and estuary water quality. National data on the source of chemicals from a range of point and diffuse sectors are processed to create inputs to other water quality models.

The external marine nutrient component is the TELEMAC-2D and is used in many fields of application. In the maritime field, particular mention may be made of harbour structure design, studies of the effect of building submersible breakwaters or dredging works. The impact of discharges from a sea outfall, study of thermal plumes and, with regard to rivers, the impact of various types of construction (bridges, sills, groynes), dam breaks, flood studies, transport of dissipating or non-dissipating tracers. The 3D module is also used where stratification may be an issue.

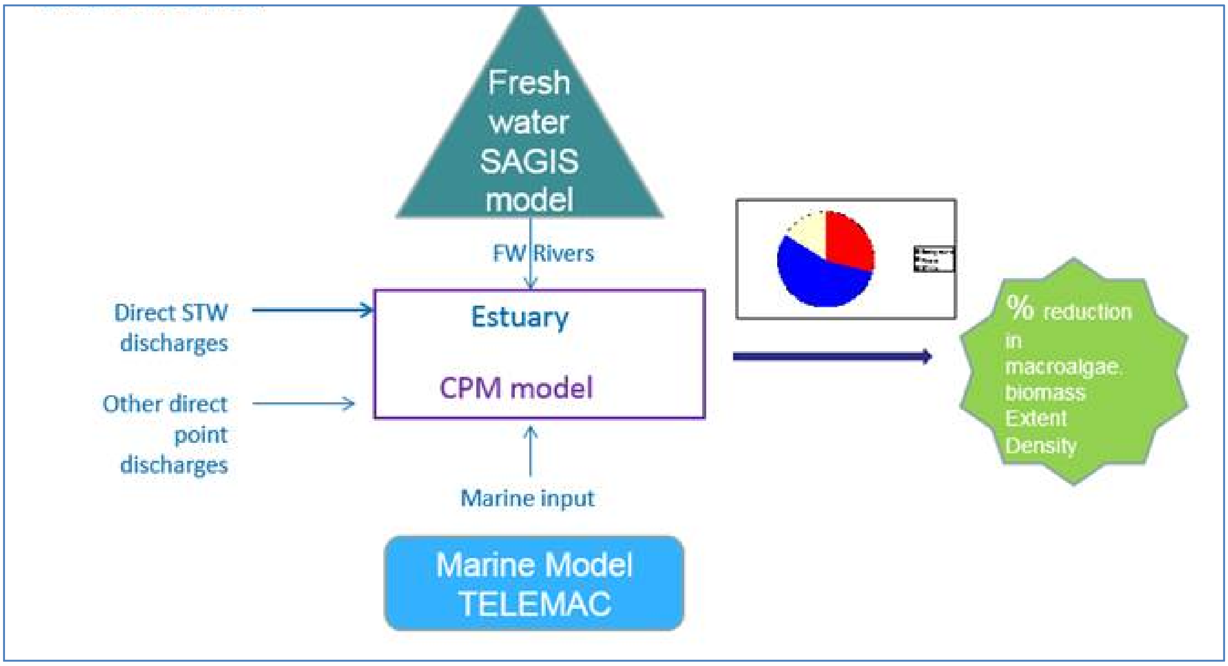

Figure 2-1: Diagrammatic representation of the linkages between the three different models used in the Solent management plans.

There is no single fix, and each modelling or combined modelling approach answers questions around a different set of conditions that may require different management actions. Mechanisms that have been identified for an improved programme of measure (SWT discharge permits or diffuse source management) will depend on the outputs of the model or models and need to be developed within bespoke programmes. There are a range of measures that can be adopted, ranging from educational, voluntary and non- statutory to statutory actions. The outcomes of each bespoke analysis will require different degrees of regulatory measures, voluntary measures and legal measures.

It is important to note that controls can either be to:

- Improve the treated effluent quality from STWs through the application of the relevant aspects of the UWWTD or;
- Improve diffuse sources, through the application of measures under the WFD. Diffuse sources are more problematic to deal with in a direct manner and require an assessment to determine whether they are a nitrate vulnerable zone under the Nitrates Directive.

The next section summarises four case studies where nutrient enrichment and excessive *Ulva* growth has occurred. Please see Appendix D2 for a full review of the UK case studies that have demonstrated programme of measures to remediate the green seaweed issues.

2.3.1 Newtown Harbour, Isle of Wight

Newtown Harbour is situated on the north side of the Isle of Wight, UK and empties into the Solent (Figure 2-2). It is a multi-armed estuary that receives inputs from several small freshwater streams. It receives run-off from a large catchment dominated by agricultural land and small urban sources. Issues in Newtown Harbour are dominated by the occurrence of thick mats of seaweed, with high biomass during the growing season. The case for designating Newtown Harbour (Isle of Wight) as a Sensitive and Polluted water was successful due to these ongoing weed issues and now has nitrogen vulnerable zone (NVZ) and STW improvements.

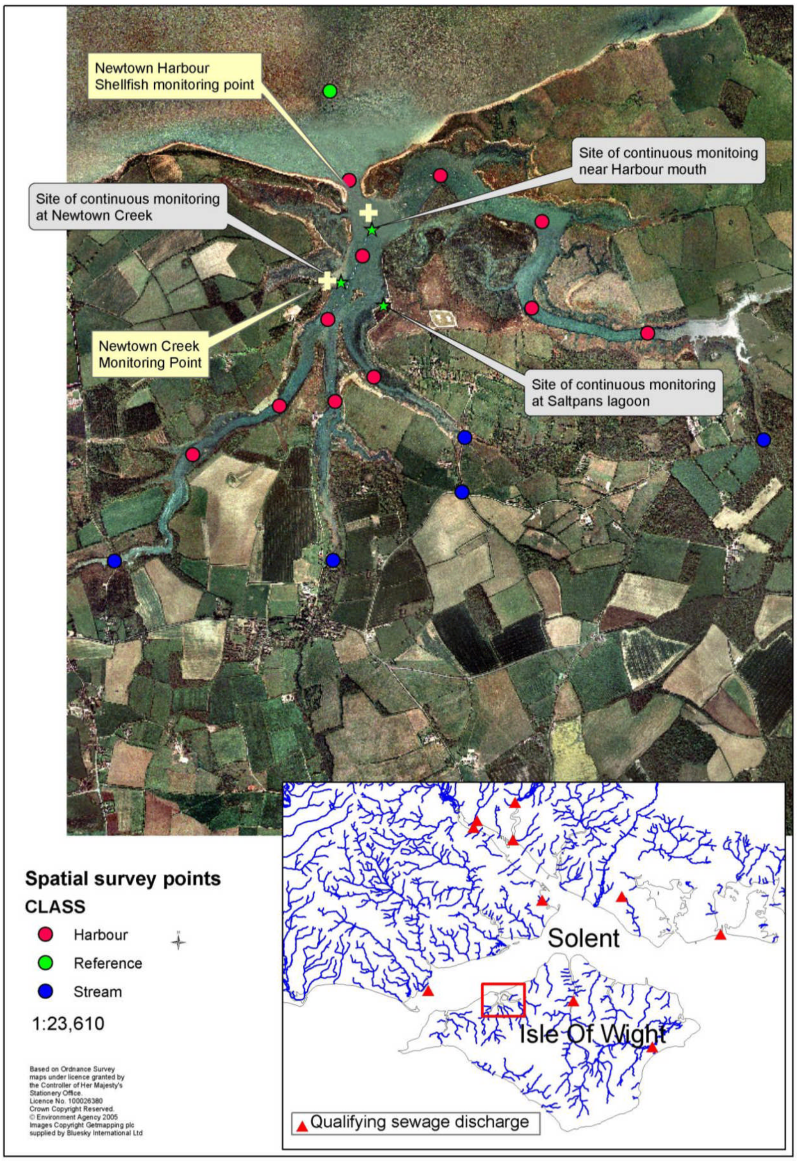

Figure 2-2: Location of Newtown Harbour and monitoring sites.

The main factors affecting nutrient enrichment and excessive *Ulva* growth are the indirect discharges into the Solent such as diffuse agricultural sources and the offshore waters. Estimates of the macroalgal growth attributed to direct sewage discharges is only 18%. Coastal, background and indirect river and effluent sources dominate the summer nutrient budget and subsequent *Ulva* growth. However, despite low proportional input, reductions in indirect sewage discharges can have a significant impact on macroalgae growth. The UWWT Directive requires nutrient stripping at qualifying discharges only if the benefits of remedial nutrient removal can be demonstrated, thus the modelling option was to determine whether reducing dissolved available inorganic nitrogen (DAIN) inputs to Newtown Harbour would affect the levels of macroalgal growth there. Modelling of the weed issues in Newtown Harbour showed that most of the inputs into the system were from marine sources. However, a small decrease in nutrient load related to the STW in the smaller feeder estuaries, provided corresponding reductions in loads and did result in a small but significant decrease in weed biomass.

Widespread nutrient removal from indirect STW's and reductions in agricultural inputs of nitrogen may subsequently modify macroalgal growth in the harbour.

Predictions of green seaweed growth suggest that half of the *Ulva* growth in Newtown Harbour is supported by background offshore nutrients. It is a high salinity estuary, directly influenced by the tidal flow from the offshore areas of the Solent. In this case, the coastal waters of the Solent are directly influencing the nutrient budget of the Harbour in comparison to the freshwater load, with only a third supported by riverine nutrients, predominantly from Southampton Water.

The outcomes of the modeling in Newtown Harbour could be relevant to St Aubin's as the offshore (>34ppt) environment may also be influencing the green weed issues. As noted in other recommendations, this can be further clarified with offshore monitoring and combined modelling approach.

2.3.2 Langstone Harbour

Langstone Harbour is an inlet of the English Channel in Hampshire, sandwiched between Portsea Island to the south and west, Hayling Island to the south and east, and Langstone to the north. Together with Chichester Harbour, which is at the other (eastern) side of Hayling Island it is designated as a Special Protection Area for wildlife. West of Portsmouth is Portsmouth Harbour and the three linked harbours are important recreational and conservation areas as well as supporting commercial fishing and shipping (Figure 2-3).

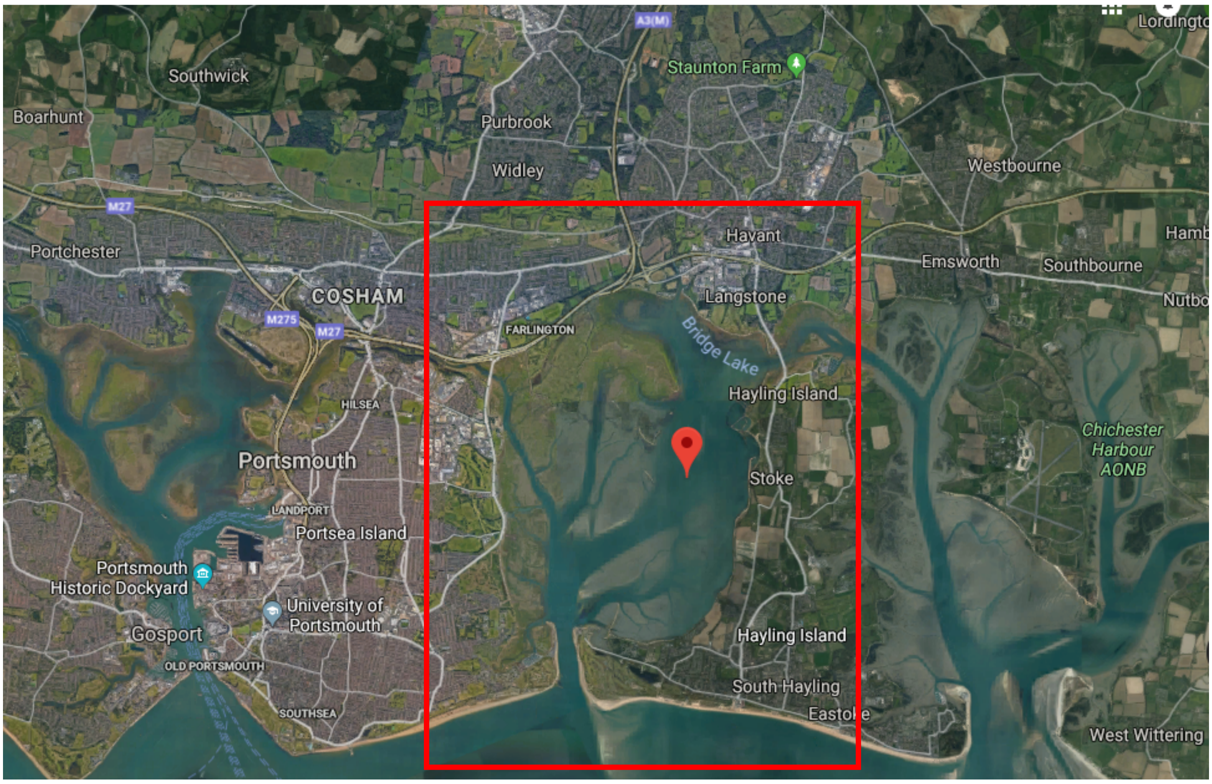

Figure 2-3: Location of Langstone Harbour at southern end of England.

For nitrogen (N), the river and other diffuse sources account for about half of the N load in the harbour; while the majority of DAIP is predicted to come from offshore input (> 90%). There are no direct STW discharges within the harbour. The existing STW in Langstone, Budds Farm now discharges via the Eastney long sea outfall located 5km off the coast.

The Langstone Estuary CPM model is part of suite of CPM modelling works carried out nationally in 2012/ 2013 by the National Marine Monitoring Service, Environment Agency. The objective of this study is to quantify the nutrient contributions from river inputs and to assess the effect of these nutrients and any limiting nutrients on the trophic status of the estuarine system.

The calibrated CPM model was used to predict the effect of a range of reductions of direct and indirect nutrient loadings. A scenario looking at the effect of a 25% reduction in the offshore nutrient loadings was run. The scenario tests showed that chlorophyll is very difficult to change with nutrient reduction scenarios. This will be due to the fact that the phytoplankton are generally light limited all year round.

For the macroalgae, the data shows a different picture, when summer standing stock is predicted to decrease >10% there is a 10% decrease in nutrient loadings. Whereas when the summer standing stock is predicted to decreased to 40% there is a 50% reduction in nutrient loadings. Additionally, microalgae already suffers from nitrogen limitation at the baseline concentrations (reference conditions for nutrient concentrations). The reduction in offshore nutrients would influence the microalgae standing stock of a similar magnitude to the reduction of river nutrient loadings. Reductions in offshore nutrients are difficult to manage and implement, but when included in the modeling process allow accounting of the microalgae growth to that source. Nutrient levels can be expected to stay static unless indirect management actions (improved agricultural practices) contributed to a reduction in offshore nutrients.

For nutrient apportionment, the model indicates that most of the P within the box is provided by coastal inputs (approximately 95% in baseline) while the modelled N is more evenly balanced between offshore and freshwater inputs approximately 60% in baseline but increasing to 78% in the 50% reduction scenario). The results, therefore, show that the model P is only changed in winter through the change in offshore nutrients while model N is easier to change through reductions in freshwater input particularly during the summer. With the general N limitation in the microalgae, reductions in N only increase the N limitation during the summer growing season and, therefore, have the effect of reducing the macroalgal growth but also of slightly increasing the available P in the system.

Thus, for management, whilst Langstone Harbour modelling showed the influences of multiple sources, it was possible to still implement reduction scenarios from the freshwater source through STW management. The current STW consents are sufficient to meet these required deceases in nutrient loadings.

One of the additional goals in this study was to evaluate the effect of the nutrient reduction scenarios against the WFD standards for Chlorophyll and microalgae (< 500 g (wet weight)/m2 affected area). For chlorophyll, the tests are applied to the observations from 2006 through 2012 for salinities >1ppt and chlorophyll values < 200ug/l. Both the years of observations and all the model scenarios have biomass less than the required WFD threshold and therefore pass the test. The modelling showed that both the chlorophyll observations and model observations also pass the WFD thresholds thus showing that the nutrient reduction scenarios were able to meet WFD requirements for chlorophyll and microalgae.

2.3.3 Portsmouth Harbour

Portsmouth Harbour is a large natural harbour in Hampshire, England. Geographically it is a ria, but it was formerly the valley of a stream flowing from Portsdown into the Solent (Figure 2.4). The city of Portsmouth lies to the east on Portsea Island, and Gosport to the west on the mainland. At its north end is Portchester Castle, of Roman origin and the first fortress built to protect the harbour. The mouth of the harbour provides access to the Solent and is a major commercial ferry port.

Portsmouth Harbour has dual designation as both a Sensitive Area (Eutrophic) and Polluted Water (Eutrophic). It was designated a Sensitive Area (Eutrophic) under the UWWTD in 2002. There are no direct STW discharges into Portsmouth Harbour but because of its designation, nutrient stripping was undertaken at two indirect qualifying sewage discharges to the Solent outside Portsmouth Harbour (Peel Common and Eastney/Budds Farm STWs).

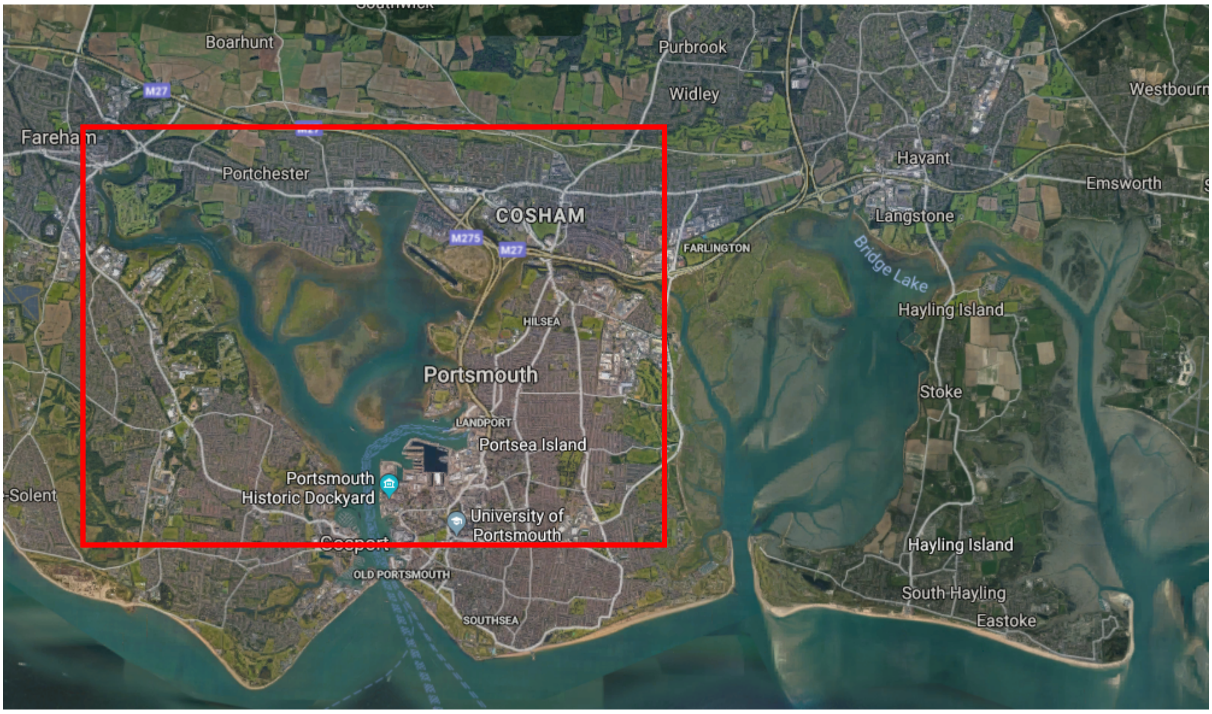

Figure 2-4: Location of Portsmouth Harbour at southern end of England.

A weight-of-evidence based approach to assessing the risks and impacts of eutrophication was employed. The eutrophication issues focus on nutrients and microalgae because other potential indicators such as dissolved oxygen sags and phytoplankton blooms have not occurred. The coastal background source is the biggest nutrient source to Portsmouth Harbour and this is anticipated to reduce very slowly over time. To reflect improvements in agricultural diffuse and sewage sources throughout the Solent area. Sewage discharges are a relatively small nutrient source and many of the larger sewage discharges have already been tackled via nutrient stripping and STW diversion schemes. Agricultural diffuse sources are significant and further reductions from this sector are anticipated as the uptake of statutory and regulatory measures continues.

Current measures to reduce nitrogen into Portsmouth Harbour from agricultural and sewage sources include a mixture of statutory and voluntary measures. Statutory measures include nutrient stripping at offshore qualifying sewage works and mandatory agricultural practice rules in the NVZ known as the Action Programme Measures. Voluntary measures include advice and incentives to farmers and landowners, catchment sensitive farming projects, environmental stewardship schemes and other measures detailed in the Solent Diffuse Water Pollution Plan.

Any changes are likely to take a long time because of the variety of nutrient sources, and nutrients will take a long time to decrease in groundwater. Changes in nutrient loadings are relatively small with STW improvements only recently delivered and the full uptake of some agricultural measures still ongoing. In addition, there is a natural biological time lag and inter-annual variation in natural factors like the weather. The final decision implemented by the Environment Agency was that nutrient control measures should continue; with the expectation that measurable reductions in the weed biomass will take a long time for a variety of reasons. These include the influence of groundwater (in which nitrogen will decline very slowly), the relatively recent and/or ongoing implementation of measures, the variety of sources, natural biological time lag and natural inter-annual variation.

2.3.4 Chichester Harbour

Chichester Harbour is a large natural harbour to the south west of the city of Chichester on the Solent. It straddles the boundary of West Sussex and Hampshire (Figure 2.5). It is one of four natural harbours in that area of the coastline, the others being Portsmouth Harbour, Langstone Harbour and Pagham Harbour. The harbour and surrounding land is managed by Chichester Harbour Conservancy. Chichester Harbour is an Area of Outstanding Natural Beauty. The harbour is of national and international importance for nature conservation. It is a Site of Special Scientific Interest, a wetland of international importance, a Special Protection Area for wild birds and a Special Area of Conservation. The harbour is of importance for wintering wildfowl and waders of which five species reach numbers which are internationally important. There are a number of habitats including a large area of salt marsh habitat and mudflats which are exposed at low tide. These areas are particularly important for wintering birds.

Figure 2-5: Location of Portsmouth Harbour at southern end of England.

Chichester is currently discharging above current flow consents with concerns that increasing population will lead to increases in these elevated STW flows. In most other cases presented in this report, the increase in flow may be expected to be within the current consent limits. However, for some STWs such as Chichester, this will require new consents. Increases in flows are calculated by taking account of population growth in the catchment as well as changes in per capita water consumption (typically 160 – 170 l/h). The predicted flows for each STW catchment by 2015 is required so the impact of population growth on green weed growth can be modelled and the impact of STW consent can be determined. The water management bodies have provided a position statement of what they believe the flow consents need to be for 2015 which was used as 'position statement' for future flow conditions.

Modelling of the weed biomass for Chichester Harbour was used to test the consent limits of the STW. It was found that reducing STW loads does significantly reduce the seasonal biomass and the modelling outputs provided an outcome with sufficient confidence to the water managers on the consent thresholds. Modelling outcomes provided different permutations of consent flows and allowed the best decisions to ensure reductions at the most appropriate cost. Permutations include representing the seasonal growth of weed cover through the days with the STW consent at 17.45mg/L and a DWF (dry weather flow) of around 10,534 m^3/d.

The other permutations include the estimate of the amount of weed with a tightened consent of 10mg/L but with the allowance of a greater flow. This tightened consent showed a reduction of an average of 200g of weed per m^2 and even better results when the flow was kept low. These permutations are compared against the amount of weed formed if the STW was not there and clearly shows that the inputs from the STW make a significant contribution to the biomass of the weed. Consent modification applications have now been submitted by Southern Water Services (SWS) to amend these consents.

2.4 Management of eutrophication issues in the UK

The first application of the Water Framework Directive in the UK highlighted that eutrophication issues in transitional and coastal waters is a fairly localised issue, with 18 of 145 transitional and coastal waters identified as "moderate" or "poor"[36]. These are mostly shallow harbours/estuaries affected by elevated nitrogen and macroalgal growth, similar to the current issues facing St Aubin's Bay.

For the UK, there are measures already in place under UWWTD and/or Nitrates Directives (Appendix D1. 1.3). These UWWTD and Nitrates Directive assessments outcomes are used to inform WFD planning, particularly the targeting of expensive regulatory measures to reduce nutrients in water bodies and catchments. In the UK low cost, low risk measures will be considered in all other problem areas. Over time it is expected that the number of water bodies in the UK within this category will reduce as the understanding of the biological responses to nutrients and review standards and classification tools improves. It is acknowledged that some uncertainty will remain as the links between nutrients and their impacts are complex and affected by many factors. The WFD planning cycles are now also aligned with the water board planning cycles to ensure that new build associated with a rising coastal population can be incorporated into the financial planning for the water companies.

The EA are often asked to advise on whether development activities will impact on WFD status. They infer this from WFD classifications, interpreted data and models. In both data collecting and developer's guidance[37], there is a sharing of methods and information with 3rd parties, partly to show transparency and partly to share methodology, providing the UK with a consistent evidence base. The data is also fed into other programmes (e.g. MSFD, OSPAR comprehensive reporting). There is a natural flow of information between the monitoring, the regulation, the assessment and programme of measures represented by Figure 2-6.

[36] Weight of evidence approach – see Appendix 4.3
[37] https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit

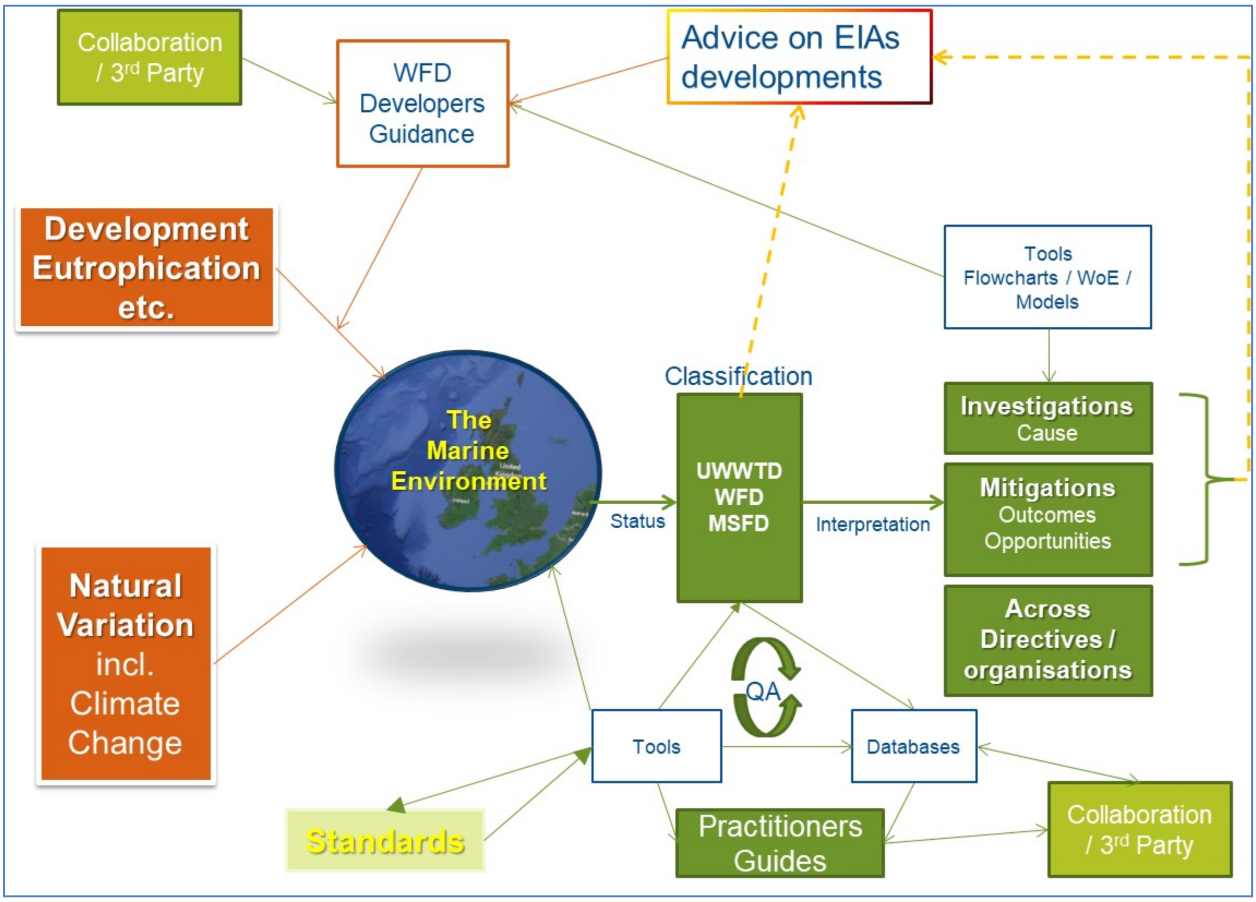

Figure 2-6: Data flow, guidance and assessment for UK estuaries and coastal waters.

2.5 Relating UK case studies to St Aubin's Bay

For Jersey, the assessment outcomes for St Aubin's Bay have been designated as moderate status. The moderate status is based on high nutrients and high weed biomass with failures of both the nutrient and marine plants tools. The measures that will be implemented under the WMP will assist in the reduction of nutrient inputs into St Aubin's Bay. However, there is ambiguity about the direction of action and what actions to implement and prioritise to obtain the best results for the Bay. Further monitoring and investigations will improve certainty around the prioritisation of actions where expensive measures may be required; but may not provide the detailed targeted actions that will give the best short and long-term reductions in weed biomass. However, following a modelling approach, similar to the Environment Agency in the UK, would help provide the clarity needed to decide on the most appropriate measures for *Ulva* reduction in St Aubin's Bay. The outcomes of modelling work in the UK show that the best results were obtained when a combination of measures were implemented for both direct STW inputs and diffuse agricultural inputs.

The aim of Deliverable 2 was to assess the robustness of using the WFD water quality status assessment as part of a regulatory tool for discharge permit compliance. This was partly achieved by providing examples of other waterbodies that have faced similar water quality issues as identified in St Aubin's Bay. Providing examples of management activity that have been implemented to resolve issues and to develop greater understanding of the factors that drive the opportunistic microalgae blooms. These examples help show how organisations have used the WFD water quality assessment process to form part of policy and/or regulatory decisions relating to discharge permits or their equivalent and how they were incorporated into the permit.

The case studies presented show how each of the waterbodies has a similar issue but with subtle differences in how the eutrophication issues are addressed. These subtle but important differences, in monitoring design or nutrient reduction targets and the prioritisation of measures implemented are bespoke solutions to achieving the best outcomes based on the monitoring and modelling applied in each situation. The findings from the case studies will be used to identify some of the bespoke activity that could be applied to resolve the issues faced in St Aubin's Bay.

To answer the questions below:

1. Identifying whether any organisation has used the WFD water quality assessment process to form part of policy and/or regulatory decisions relating to discharge permits or their equivalent?
   If, yes, identifying how it was incorporated into the permit?

The numbers from the CPM model or any aspect of a coupled modelled approach do not give you consent limits directly nor does it provide direct quantitative input into the water quality assessment process. For the UK, and with all the case studies identified above, the approach uses a combined set of management tools to reduce loads and the effects of the weed biomass. This is done through aligning the regulatory values that are attached to individual discharge permits with a bespoke approach that applies a weight of evidence approach. This approach will use all available information in the development of a programme of measures to reduce the pollutant loads to achieve the most cost effective desirable outcomes, in partnership with water agencies and other stakeholders.

The modelling outcomes, coupled with the in-situ monitoring and the application of assessment tools, (such as the WFD marine plant toolbox[38]) provide answers to different management questions. This identifies which single or multiple management activities will provide the most appropriate reduction of weed biomass with respect to costs and timing. More specifically, the WFD is not directly used with consent limits of discharge permits, however, EU Directives such as the WFD are used to identify problem areas and provide information to reach the required target.

Assessment of state (as based on the processes available under UWWTD, Nitrates Directive and WFD assessments) are aligned with the modelling outcomes to provide guidance on how the reduction in nutrient load can be aligned with the consents required of the STW or multiple STWs. It can also guide decisions on what is required for the reduction in the diffuse load, in the absence of strict consent guidelines and where the reduction required depends on close interactions with land owners and stakeholders. This can be done by identifying best agricultural management practices, working closely with farmers and through cumulative approaches to pollutant load reductions.

The outputs of the models and the expertise of the local and regional bodies who manage that system, will then combine the information from a weight of evidence approach into the appropriate implementation activity. This will result in a bespoke management plan to tackle single or multiple sources of pollutant load.

The shape of the implementation and the programme of measures will depend on the level of nutrient reduction required to achieve an appropriate state assessment result; as per the EU directives in place. As part of this overall approach, you may (for example) look at the modelled source apportionment for the water body to determine the appropriate measures. If the STW contributed the greatest significant percentage of nutrients to the water body, then you could

[38] www.wfduk.org

tighten its consent in accordance with the model outputs. However, in many cases the STW may not be a main (or significant source) and even if you reduced the discharge to zero you will still get growth. Thus, with all the case studies presented here, you will have worked on the premise that you understand your nutrient budget and tune the sources appropriately – targeting direct and diffuse sources where appropriate.

The UK consent decisions are implemented via a regional officer and through a bespoke process[39]. The individual regional officer makes the decision on consent (licenses) once they have all the information in front of them (monitoring, modelling, regional knowledge and information collected via UWWTD and WFD assessment processes.

2. Should the baseline water/ecological status of the bay mirror the current WFD status of St Aubin's Bay or aim to revert to 'pristine' status?

No options for the four case study examples provided choose the option of reverting to pristine status. All examples have used a current data held within a modelling approach to identify the most appropriate action to take to reduce nutrient loads leading to a reduction in seaweed biomass. It is recommended that Jersey do the same for St Aubin's Bay, whilst looking to achieve good status under the WFD.

St Aubin's Bay may require the application of coupled models that identifies the main catchment activity against the nutrient input. Following this the CPM model should be used to estimate how much an input must be altered to give a reduction in the weed biomass. It may also be useful to run the coupled models to understand the effect of the offshore environment in terms of input. The modeling outputs will identify the level of nutrients reduction required to minimise *Ulva* growth to an acceptable level, using the most appropriate measures. Following this a cost benefit analysis should be applied to enable the biggest improvements to be made for the lowest costs.

The WFD status is part of the evidence that needs to be considered in the overall approach, but to provide guidance on how best to achieve an appropriate ecological outcome. The WFD status should mirror the concerns that may have already been identified under previous directives (such as the UWWTD) or through previous monitoring programmes.

2.6 UK approaches to managing eutrophication issues

The UK approach to combating eutrophication issues, which Jersey could consider, is a holistic approach to understand the interconnected system. To provide the most appropriate pathways to remediation or mitigation of the pressures that are driving the impact.

A weight of evidence approach (Figure 2-7, Appendix D2. 2.7) developed by the UK Environment Agency considers a range of multiple factors in the assessment of eutrophication and provides a process by which prioritisation of measures can be developed. Jersey could apply such an approach in their ongoing WFD assessment and the outcomes can be used in public consultations with the various agencies and stakeholder groups.

[39] https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit

I : Pressure. Please read the guide to this workbook for more information on the meaning of each column							
DIN is moderate status or worse under WFD? (Y/N)				Ospar data on DIN loads from freshwaters and discharges (2000-2011)			
2014	2013	2012	2011	Average DIN loading kg/yr	Average DIN loading divided by WB area (kg/yr/ha)	% of Ospar loads	Charts showing Ospar annual loadings, and the annual average rainfall across the region

Ecological element expected to be most responsive to elevated nutrients, as defined by available information, or best judgement	WFD Phytoplankton & Opportunistic Macroalgae Classification Results									
	Phytoplankton is moderate or worse status under WFD (Y/N)					Opportunistic Macroalgae is moderate status or worse under WFD (Y/N)				
	2014	2013	2012	2011	Confidence of Phytoplankton data in 2014	2014	2013	2012	2011	Confidence of Opp Mac data in 2014

Supporting information									
Dissolved Oxygen problem linked to eutrophication	Opportunistic macroalgae persists through winter months (measured with biomass sampling evidence)	Intertidal seagrass or intertidal benthic invertebrates problem linked to eutrophication (monitoring evidence)	Anoxia in surface sediment layer (top 2cm)	Weed smothers seagrass or saltmarsh?	Aesthetic effects, e.g. odour nuisance, algal scum or foam	Other evidence of impacts to invertebrates or fish	Other, e.g. complaints from water users.	Details of designations under the UWWTD, Nitrates Directive and Habitats Directive.

Figure 2-7: Weight of Evidence approach is constructed as no single piece of evidence provides enough confidence that eutrophication is a problem, and there is a need to combine evidence on nutrient pressure, primary production, & secondary adverse effects.

Within the OSPAR requirements, Jersey DoE will be required to deliver timely and reliable eutrophication assessments. In the UK and Europe this has been traditionally done through in-situ measurements, but in recent years there has been a move toward automated sampling platforms. Implementation of SmartBuoys[40] can provide an invaluable source of high frequency data, particularly for measurements into the assessment of eutrophication. High frequency data can provide greater certainty in the assessment and provide greater detail in areas that are moving away or towards good environmental status. Innovation has continued to move forward in eutrophication assessments, with the ability to confidently model hydrodynamic and biogeochemical processes across the European marine seas as well as model the input of pollutant loads into the coastal zones. Modelling of loads can provide direct links of activity back to the programme of measures around urban and agricultural activity.

[40] SmartBuoy description and data – www.cefas.co.uk

In addition, the use of Earth Observation data, from remote satellites has now provided the scope to integrate a source of data across large temporal and spatial scales. The high variability of water quality parameters in time and space demands a high number of measurements (high frequency, dense spatial coverage) to attain the required accuracy and confidence in trend and threshold analysis. Consequently, the required monitoring effort for in situ sampling would be very high and appropriate eutrophication assessments required innovative monitoring and cross-integration of all available data.

Satellite remote sensing provides synoptic data on the distribution of water quality parameters for large cross-border areas with similar or disparate monitoring methods. The utility of satellite remote sensing may provide a more cost-effective alternative data source and common ground for consistent basin-wide maps of water quality information across Jersey national and international seas (specifically that of the Bay of St Malo and the English Channel).

2.7 Conclusion

European Directives (e.g. WFD) and international agreements (e.g. OSPAR) contain a variety of requirements, some of which can be delivered through a permitting and compliance system and some of which are delivered in other ways. The majority of environmental quality and specific permitting standards and other related requirements for environmental and human health protection come from directives. European regulations ensure that the directives, along with national policy requirements and outcomes, can be delivered through a permitting and compliance system that are aligned to the individual country.

The frameworks around permitting and the application of environmental directives are closely linked and require a bespoke approach which looks to align regional information, thresholds and data into the application of environmental assessments, such as the Water Framework Directive. Ultimately, the decisions around discharge permits will be developed based on regional knowledge, and input from the operators and water companies. However, the identification of the downstream issues, which can be assessed through directives such as the WFD, can be used as supporting information to derive discharge permits that are advantageous to the receiving environment. They should be set to ensure no further deterioration, and, where possible, look to improve and remediate problems or issues identified by the WFD assessment.

Examples in this report presented as case studies are all taken from the UK, which have similar issues as measured in Jersey with areas of high algal biomass, leading to deterioration of amenities and in the UK have an impact on the underlying benthic health.

It is recommended that DoE continue to apply the full ecological assessments provided by the WFD tool kit to monitor for changes in the water quality/ecology of the Bay during the construction, commissioning and operational phases of the replacement works. This will identify any issue with water quality to be detected and allow for further regulatory controls to be implemented if required. The linkages between the ecological state and the regulatory discharge permits need to be linked via appropriate monitoring and modelling tools to reduce ambiguity around cause and effect.

3 Deliverable 3 (D3): Assessment of current monitoring

D3: Review current nutrient monitoring undertaken by the States of Jersey to assess DoE's ability to measure deterioration or improvement of the Bay's water quality and or ecology; to assist in the regulation of the replacement STW using a cost-effective approach in accordance with the regulatory road map.

3.1 Background

Over 30 studies on water quality around Jersey and St Aubin's Bay have been produced over the last two decades. These studies are explained in section 1.2, which provides the context for the review of the data collected as part of these ongoing water quality studies. Most of the reports and studies have provided good content and quality and have advanced the state of knowledge around St Aubin's Bay and the water quality issues. This knowledge and understanding of the Island's water resources is now being used to inform and implement water management and regulatory measures, primarily through the WMP and regulatory road map:

1. The WMP is an integrated, multi- staged approach to monitor and remediate the different sources of nutrient loads into all Jersey water bodies, including the coastal and marine environment (see Section 2.1 for further details).

2. The RRM has been developed to provide clarification of relevant aspects of the build and commissioning of the replacement sewage treatment works and the monitoring and protection of the receiving environment (St Aubin's Bay) (see Appendix D3. 3.3 for further details).

This section (D3) provides an overview of the current monitoring of St Aubin's Bay and assesses whether it is sufficient to measure any deterioration or improvement in the Bays water quality/ ecology where it can be reliability linked to the source of nutrients (e.g. catchment or STW). The RRM provides clarification of relevant aspects of the build and commissioning of the new sewage treatment works and the monitoring and protection of the receiving environment (St Aubin's Bay). To achieve the steps required under the WMP and the RRM requires a good understanding of the current state (as per the WFD assessments) as well as an understanding of the historical data that provides the baseline to assess state and temporal change.

3.2 Overview of the data and monitoring

The main components of the current marine monitoring programme of St Aubin's Bay focus on the monitoring requirements needed to assess the water quality status of the Bay under the WFD. However, other monitoring does take place to assist in further understanding of nutrient pressures and *Ulva* growth in the Bay.

Monitoring of St Aubin's Bay using the Water Framework Directive transitional and coastal water tools (see UKTAG guidance[41]) began in 2012. It included an initial chemical screening of the Bellozanne STW and 4 sampling locations in the bay itself. The result of this first assessment informed a longer term (3 year) chemical/ phys-chem monitoring programme[42.] The final status

[41] www.wfduk.gov.uk

[42] WCA environment (2013) The Environmental Status of St. Aubin's Bay, Jersey According to the Requirements of the Water Framework Directive - Data Management and Assessment of Monitoring Programmes: Monitoring Programme Results and Status Assessments (2012-2013). For the States of Jersey Department for the Environment.

assessment was carried out in 2015 resulting in a Moderate status due to the low ratings for the physico-chemical (nutrients) and elements of the opportunistic algal (*Ulva*) assessments[43].

Following the status assessment in 2015, the WFD monitoring programme was rationalised to focus on the nutrient pressure effecting the Bay, whist keeping an eye on other parameters. Monitoring now includes:

- Chemical measurements being assessed every five years, with monthly measurements of dissolved nutrients, temp, pH, DO, salinity.
- Ecological measurements include sampling for; phytoplankton, chlorophyll-a (monthly), benthic invertebrates (bi-annually), opportunistic algae (annually), RSL seaweed (abundance of seaweed on the rocky shore) and seagrass (1/year).

Other monitoring that is carried out in St Aubin's Bay that does not form part of the WFD assessment includes:

- **Outfall monitoring:** Monthly monitoring of St Aubin's Bay outfall for nutrients, DO and other parameters.

- **St Aubin's nearshore zone:** Bi-monthly monitoring of St Aubin's for nutrients (including nitrates) at five locations along the bay, with a control site at St Brelade. The aim is to understand better the nutrient pressures on the bay from catchment and STW sources.

- **Offshore transect**: Nutrient monitoring along a transect from St Aubin's Bay to Les Minquiers off-shore reef (approximately nine miles south of Jersey) has been under taken twice by DfI (and DoE).

- **Time-lapse camera:** Cameras are situated at 2 sites around the bay taking photos to assess the occurrence, distribution and biomass of the seaweed.

- **Historic photographic assessment:** Photographs of St Aubin's bay were obtained from various sources and assessed for the occurrence of *Ulva*.

- **WFD Freshwater monitoring:** Nutrients (including nitrates) are measured in streams across the Island including some which discharge into St Aubin's Bay.

- **STW regulatory and operational data:** Nutrients (including total nitrogen) are measured in samples taken from the treated sewage effluent discharge.

- **DfI monitoring:** DfI carry out independent monitoring of St Aubin's Bay. Please note that routine monitoring under the UWWTD (as carried out in 1997 and 2009)[44] for source apportionment of nutrients and trophic status assessment of the Bay are not routinely carried out.

3.3 State of Jersey data

DoE have a combined database (WQMIS) that has several sources of monitoring data, which provided access to many of the water quality datasets (Figure 3-1). However, several important

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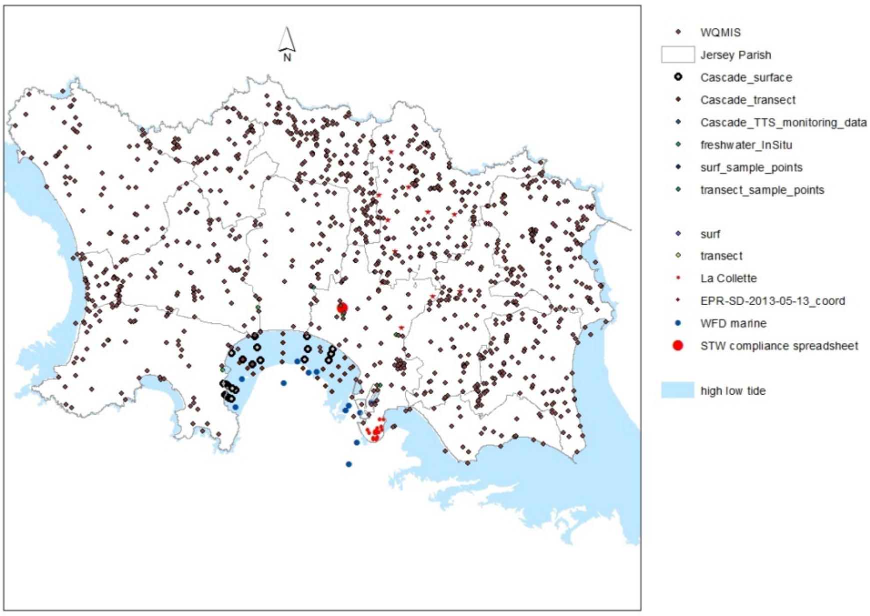
[43] WCA environment (2015) The Environmental Status of St. Aubin's Bay, Jersey According to the Requirements of the Water Framework Directive - Data Management and Assessment of Monitoring Programmes: Monitoring Programme Results and Status Assessments (2012-2015). For the States of Jersey Department for the Environment.

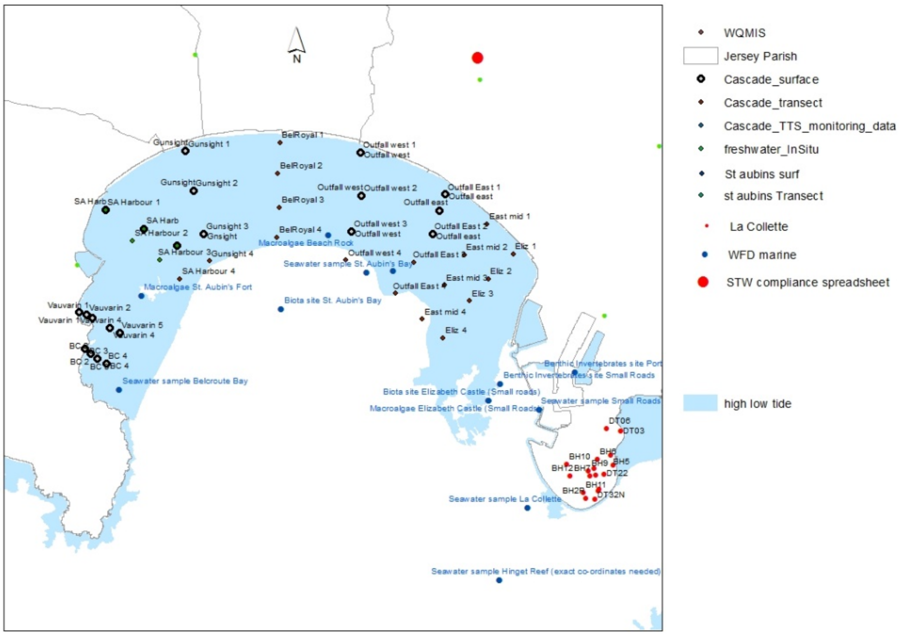
[44] CREH (1997) Trophic status of St Aubin's Bay and CREH (2009) Reassessment of the trophic status of St Aubin's Bay

datasets are still outside of this database (Appendix D3. 3.4) and, where appropriate, this data has now been combined into a single file (Appendix D3. 3.5, Appendix D3. 3.6).

This analysis showed that there is a substantial amount of data collected in Jersey (Figure 3-1), with data on sewage discharges, chronic and diffuse pollution and the ecological impacts of a modified freshwater, estuarine and coastal system.

Figure 3-1: Sites in Jersey which have water quality data collected over the previous 2 decades across (a) all of Jersey and (b) within St Aubin's Bay.





A full summary of the datasets available are listed in Appendices D3. 3.5, with full details of each data set described and visualised in Appendix D3. 3.6.

3.4 Critique of the current data and monitoring

Jersey DoE have been adjusting their monitoring requirements over the past 10 years to reflect a move towards compliance against European water quality directives (Table 3-1). The development of classification systems and ecological assessment tools is an important and technically challenging aspect of assessing the consequences of nutrient enrichment. Jersey, through the adjustment of data frequency and specific water quality parameters, now has a water quality programme that is better adapted to answering the data requirements of the EU Directive eutrophication assessments. The current monitoring programme complies well with most of the current data requirements for the European water quality assessments (Table 3-1). Subsequently the water quality data provides a robust baseline from which to assess the changing environment of St Aubin's Bay.

The water quality assessment programme of St Aubin's Bay (developed and aligned against the WFD requirements) is considered fit for purpose. It provides the data required for a confident assessment of the chemical and ecological state of the bay, with adequate monitoring sites and frequency of monitoring per annum. It has effectively measured compliance data for over 3 years. However ongoing support for continued monitoring at the same sites for a 6-year reporting cycle is recommended to be in line with WFD protocol.

Recommendation 1: Ensure resource is provided for continued monitoring at the WFD sites for a full 6 years to run a full assessment cycle.

Whilst this programme is in the first 6-year cycle, it is on track to provide a confident ongoing summary of the issues of eutrophication and pollution in Jersey coastal and marine waters. This is particularly relevant because there is now an emphasis on integrated monitoring to provide the many strands of data required for ecological assessments. This approach, coupled with a greater awareness of the pressures (increasing population, inadequate infrastructure) drivers (nutrients), impacts (what has changed in the ecology) and states (the use of indicators to assess current status of the ecology) provides a good basis for a successful monitoring programme. The integrated approach will continue to require DfI and DoE to work together on future monitoring of the Bay to ensure that continuity in the monitoring is achieved.

The WFD has a unique approach to the overall ecological assessment with a ''one-out–all-out'' approach. This approach of the WFD is at odds with that of the other directives and OSPAR, which use a ''weight of evidence'' approach to assess eutrophication and the status of bodies of water and for targeting control measures. Potentially WFD could class a water body as Moderate based on a moderate nutrient assessment without evidence of undesirable disturbance as is required elsewhere[45]. The Water Framework Directives classification system uses biological, chemical, and hydro-morphological "quality elements" to describe ecosystem health. The ''one-out–all-out'' rule embodies the precautionary principle in the face of uncertainty about how the complex web of interactions and inter-dependencies operate.

However, the issues of annual macroalgal blooms above designated thresholds of biomass and area are well documented. Using tools from either UWWTD, WFD and OSPAR methods is sufficient to assess waterbodies as moderate without evidence of other primary impacts (phytoplankton) or secondary impacts such as reduced dissolved oxygen. Thus, the interim moderate status for St

45 https://www.wfduk.org/sites/default/files/Media/Environmental%20standards/Annex%2014%20Coastal%20waters%20phytoplankton.pdf

Aubin's Bay is considered reasonable and suggests a eutrophication issue that needs to be resolved through appropriate measures. However, full guidance for a programme of measures should include the application of the full set of assessment tools under the WFD to identify the full suite of pressures, drivers and impacts that are specific to Jersey's coastal and marine environment.

Recommendation 2: Continue to apply the full suite of assessment tools available under the WFD methodology and guidance.

Table 3-1: Summary of the monitoring and how it complies with the current data requirements of the European water quality assessments.

Assessment strategy	Type of monitoring	Frequency
Source (WFD, NITRATES, UWWTD)	Outfall monitoring	Monthly monitoring of St Aubin's Bay outfall for nutrients, DO and other parameters.
Source (WFD, NITRATES, UWWTD)	Regulatory and operational data	Nutrients (including total nitrogen) from the treated waste water discharge.
Source (WFD, NITRATES, UWWTD)	Stage discharge monitoring	DoE in process of setting up a monitoring programme to measure the amount of water entering St Aubin's from catchment sources.
WFD – F/W tool	WFD Freshwater monitoring	Nutrients (including nitrates) measured in streams which discharge into St Aubin's Bay.
WFD – Estuarine and coastal tools	St Aubin's nearshore zone	Weekly monitoring of St Aubin's for nutrients (including nitrates) at five locations along the bay, with a control site at St Brelade. The aim is to better understand the nutrient pressures acting on the bay from both catchment and STW sources.
WFD – Estuarine and coastal tools	Current monitoring WFD standards -WQ	Water: chemical (reduced to 5 yearly), nutrients (monthly), temperature (monthly), pH (monthly), DO (monthly), salinity (monthly)
WFD – Estuarine and coastal tools	Current monitoring WFD standards - Ecology	Ecological: phytoplankton, chlorophyll-a (monthly), benthic invertebrates (1/year), opportunistic algae (1/year), RSL seaweed (abundance of seaweed on the rocky shore) and seagrass (1/year).
Supporting data (Weight of Evidence)	Time-lapse camera	Cameras are situated in two location around the bay taking photos to assess the occurrence and distribution of the seaweed.
Supporting data (Weight of Evidence)	Historic photographic assessment	Photographs of St Aubin's bay were obtained from various sources and assessed for the occurrence of *Ulva*.
OSPAR	Offshore transect	Nutrient monitoring along a transect from St Aubin's Bay to Les Minquiers off-shore reef (approximately 9 miles south of Jersey) (monitored twice)

4 Deliverable 4 (D4): Effectiveness of current management measures

D4: To assess whether the current nutrient monitoring of St Aubin's Bay can be used to measure the effectiveness of catchment management measures implemented under the WMP and inform the RRM

4.1 Introduction

Many aspects of the monitoring and data collection have been explored (Appendix D4. 4.1 and Appendix D4. 4.2), and two presentations have been provided to the Jersey DoE – Water Resources Section (WRS) on a suite of recommendations to take the monitoring and assessment forward. The main aims of the recommendations are to promote, where applicable, the activities that should continue and identify additional work that could benefit DoE with their future monitoring and assessment plans within their regulatory and management roles. The conclusion and recommendations for each deliverable are detailed in this section.

Several reports commissioned by DoE and DfI have also provided useful recommendations. The key recommendations are listed in Appendix D4. 4.3 with additional comments from the reviewers on the appropriateness of the recommendation.

4.2 Monitoring success in relation to the WMP and the RRM

A key objective of this project was to assess whether the current nutrient monitoring of St Aubin's Bay can be used to assess deterioration of the Bay water quality linking it to:

- The effectiveness of catchment management measures implemented under the WMP.
- Whether the data can be used to inform any future phases of the STW under the principles of the RRM.

WMP - The decades of data collection, analysis and reporting has provided Jersey with a monitoring and assessment programme that can access a large volume of data for the establishment and understanding of the ecological baseline. It can also confidently identify the issues around anthropogenic inputs and assess the effectiveness of catchment management measures implemented under the WMP. The outputs of the data cannot, at this stage, be used to make confident recommendations of targeted management actions planned to reduce the nutrient loads in a cost efficient and timely manner.

High nutrient loads are a major driver in many of the pollution issues. There seems to be little impact from industrial processes, but diffuse loads from agriculture have been identified as a major source of nutrients and other pollutants.

STW - RRM (Appendix D3. 3.3) - Whilst the phased approach in the RRM provides a set of activities that will enable a reduction in sewage nutrient loads, it is a phased approach over 6 years for phase 1, with a longer time for implementation of phase 2. Thus, reductions in loading will only be measured over (at least) this period of time. However nutrient reductions may still occur due to the "no environmental deterioration", and with targeted management at other potential nutrient sources (agriculture).

The outcomes of the case studies presented in Deliverable 2 show that intervention actions that only dealt with agricultural sources had limited success and significant reductions in nutrient loads from sewage treatment was also required. Note also that all these studies suggest that the programme of measures for direct or diffuse loads, would have a time lag before biological responses would change. This would mean that all measures outlined in the WMP and regulatory road map would ultimately be successful in reducing loads, however the corresponding response in the biology would take a much longer period of time.

Recommendation 3: Address both catchment and STW sources of nutrient loading together through the WMP and the RRM.

4.3 Main outcomes for assessing against effectiveness of catchment managements

4.3.1 Assessing effectiveness of regulatory road map

The States of Jersey have monitored and assessed the status of the Island's water quality and ecology to help understand and tackle key environmental issues, including nutrient pollution over many years. Past reports and data provide a robust baseline that fulfills the requirements for ecological assessments, particularly those related to European Union (EU) Environmental Directives, such as the WFD. Many of the historical water quality reports identify the cause of nutrient pollution and its effect, but few offer a clear path to the management of the issue and how to best target remediation. Recent work under the WMP and the steps detailed in the RRM for the replacement STW go a long way towards a more integrated approach.

Recommendation 4: DoE should continue to work towards a holistic and integrated approach to the management of nutrient pressures to enable effective management and targeted remediation.

The review recognises that during the planning stages of the STW replacement and in response to previous discharge permit non-compliance a RRM was developed. This was to provide clarification of relevant aspects of the build and commissioning of the replacement STW and the monitoring and protection of the receiving environment (St Aubin's Bay). The RRM outlines a regulatory policy shift away from strict application of UWWTD limits for nutrients and more toward the use of the Water Framework Directive (WFD) to ensure that there is 'no environmental deterioration[46]' of the water quality in St Aubin's Bay.

In the UK, the WFD is not used specifically as conditions within discharge consents, but rather as a tool to assess the water quality of a particular water body, identify those areas at risk and assist with remedial measures and setting appropriate levels for any discharge consents. Regulated facilities will need to comply with other pieces of environmental legislation. However, the environmental permitting regime does not currently transpose all the European Directives relevant to regulated facilities. Some of this legislation can be addressed by the environmental permits (through permit conditions and/or the decisions of the regulator) and other legislation is in addition to the environmental permitting regime.

In the UK and Europe, there is a recognition that it is not feasible to manage and implement program of measures that looks to revert water bodies to 'pristine' status, it is therefore advisable for Jersey

46 The WFD also contains an overarching aspiration to achieve good status for all water bodies. Deterioration of the receiving environment is considered to occur as soon as the status of at least one of the quality elements falls by one class, even if that fall does not result in a fall in classification of St Aubin's Bay as a whole.

to continue working towards ‘good’ status for St Aubin’s Bay through the catchment measures implemented under the WMP and the replacement STW.

Recommendation 5: DoE should continue working towards ‘good’ status for St Aubin’s Bay through the implementation of catchment measures under the WMP and implementation of measures through replacement of the current STW.

4.3.2 Assessment of effectiveness of current WFD monitoring

Initial monitoring in St Aubin’s Bay began in 2012 using the Water Framework Directive - UKTAG guidance[47] and implemented sampling for most of the WFD criteria. These results informed longer term (3 year) chemical/ phys-chem monitoring programme. The final status assessment was carried out in 2015 resulting in a moderate status due to the low ratings for the phys-chem (nutrients) and elements of the opportunistic algal (*Ulva*) assessments.

Analysis of the implementation of the UK WFD assessment tools for St Aubin’s Bay shows that the data gathering, and the assessment of that data have been successfully carried out for Jersey and provide an initial robust water quality status assessment of the Bay. However, there are limitations to this assessment, mostly on the lack of information on the most appropriate regional thresholds and the short time period (should be based on a 6-year assessment not 3) which has constrained the confidence of the first assessment.

Recommendation 6: DoE should continue monitoring to complete the 6-year monitoring cycle required by the WFD to provide confidence in their initial status assessment.

It is recommended that DoE continue to apply the full ecological assessments provided by the WFD tool kit to monitor for changes in the water quality/ ecology of the Bay during the construction, commissioning and operational phases of the replacement STW. The WFD monitoring and assessment should continue after the work has been completed, until such time that ‘good’ ecological status is achieved or DoE are satisfied that the nutrient reduction measures implemented are successfully reducing the *Ulva* to acceptable level. Ecological time lags may mean that the improvements in the biology may take years after the improvement in water quality and requires a long-term commitment to monitoring and assessment. Long term monitoring and assessment will continue to identify failures or improvements in the water quality assessment and allow for further regulatory controls to be implemented if required.

Recommendation 7: DoE should continue to apply the full ecological assessments provided by the WFD tool kit to monitor for changes in the water quality/ ecology of the Bay during the construction, commissioning and operational phases of the replacement work. The WFD monitoring and assessment should continue after the work has been completed, until such time that ‘good’ ecological status is achieved or DoE are satisfied that the nutrient reduction measures implemented are successfully reducing the *Ulva* to acceptable level.

The review did however identify several issues that need to be addressed. The first of which is relating to the physio-chemical assessment and the normalisation of the Winter DIN[48] values. The physico- chemical assessment for nutrients has been developed correctly as per the methodology under the WFD guidelines and the frequency of data collection for nutrients is sufficient to be

[47] www.ukwfd.org
[48] Winter Dissolved Inorganic Nutrients

confident in the interim assessment outcomes (nutrient concentrations are in moderate state). However, it is not clear on the type of normalisation techniques that were used when normalizing the nutrient concentrations against salinity. St Aubin's Bay is a nearly fully saline site and the assessment should ensure that you are measuring against the appropriate standard. For example, the UK Winter DIN standards for coastal waters is a value that has been normalised against a salinity of 34ppt. Ecological assessors[49] were aware that the salinity exceeded the coastal water threshold but applied it anyway to enable the assessment to be carried out.

Recommendation 8: DoE should provide clarity on the type of normalization techniques used for salinity for the 3-year interim status assessment and to ensure that the salinity value used in the normalisation analysis is appropriate for the coastal waters of Jersey.

Note that the standard for winter DIN for coastal waters was set from a conservative mixing curve from a west coast non-impacted estuary and coastal waterbody. This dilution line may not be relevant to the Jersey coast continuum and requires investigation of the shape of the freshwater and saline gradient relevant to the Jersey waters.

Recommendation 9: DoE should investigate whether the winter DIN levels set for UK coastal water is appropriate for Jersey waters.

Recommendation 10: DoE should develop more appropriate regionally specific thresholds to assess the outcomes of the dissolved nutrient metric.

There is a similar issue for chlorophyll biomass where the reference condition for the growing season 90th percentile value of chlorophyll-a value of 3.33ug/L in Atlantic waters is lower than the UK reference value of 6.67 µg/L (Figure 4.1). This change in reference boundaries and subsequent shifts in the classification boundaries (Appendix D2. 2.1) would not change outcomes for the chlorophyll assessment (high to good) however, the reference values need to be more representative of the area of assessment[50].

Recommendation 11: DoE should confirm whether reference condition set for chlorophyll biomass growing season is appropriate for Jersey waters. If look to develop more appropriate regionally specific thresholds (such as those for French coastal waters) to assess the outcomes of the chlorophyll metric.

[49] WCA environment (2015) The Environmental Status of St. Aubin's Bay, Jersey According to the Requirements of the Water Framework Directive - Data Management and Assessment of Monitoring Programmes: Monitoring Programme Results and Status Assessments (2012-2015). For the States of Jersey Department for the Environment.

[50] https://circabc.europa.eu/webdav/CircaBC/env/wfd/Library/working_groups/ecological_status/1sworkingsgroup/x31th%20meeting%20-%2016-17%20March%202016/Documents/4.3%20-%20Intercalibration%20CoastalTransitional/Intercalibration_guidance_draft%20for%20MS_Coastal%20waters_Phytoplankton%20(2).pdf

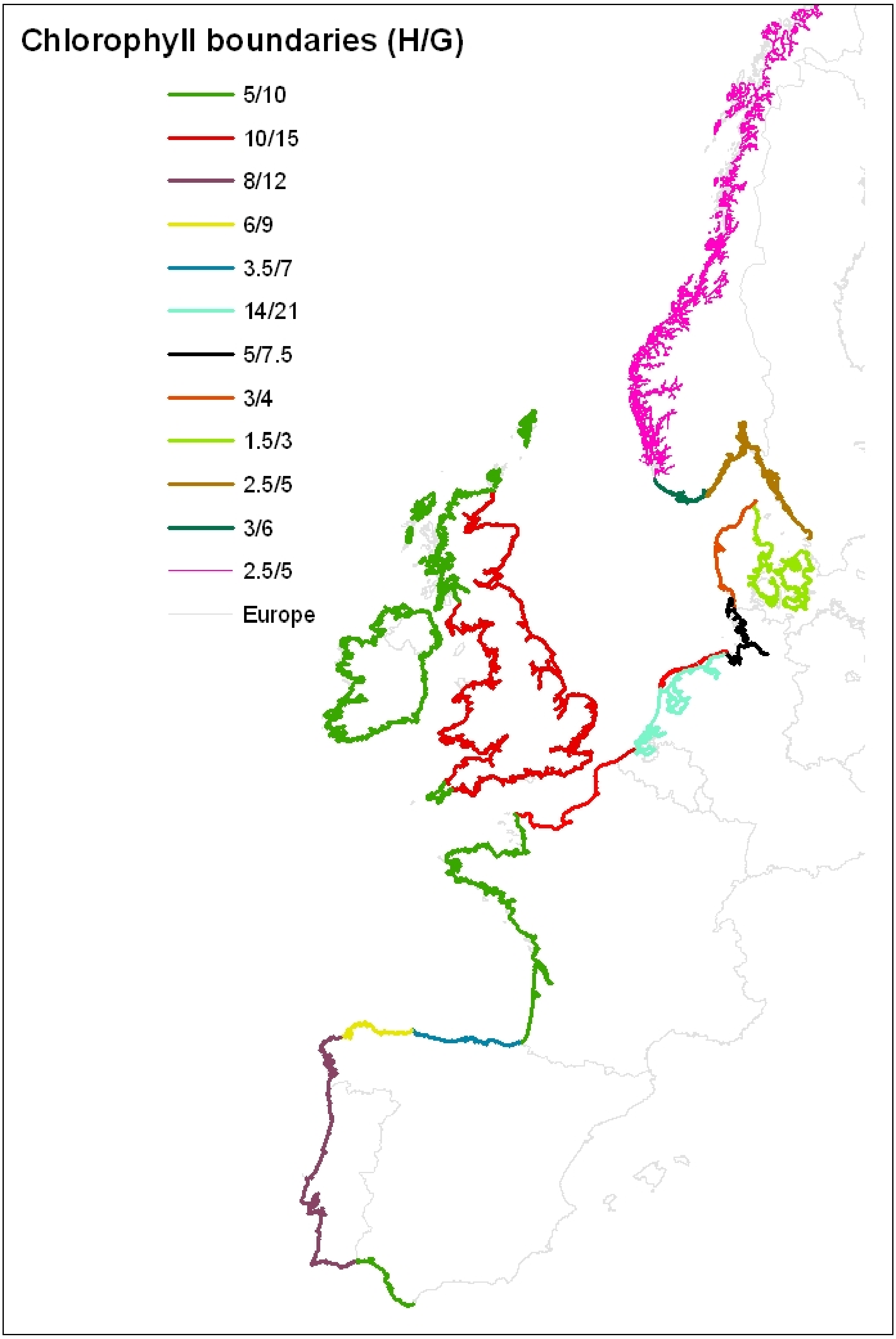


Figure 4-1: Different regional thresholds for European member states across the North East Atlantic, identified by boundary conditions for High/Good and Good/Moderate thresholds under the Water Framework Directive. The values are P90chl-a values for the growing season (March to October) measured as µg/L.

The review also identified that the initial outcome for the phytoplankton assessment show a difference in outcomes, with a variation between taxa frequency tools and seasonal succession.

Whilst this is most likely related to the short-term data collection, these differences need to be resolved as either an artifact of the short-term data collection or related to the thresholds set for taxa counts and seasonal growth envelopes or related to some other ecological shift.

Recommendation 12: DoE should continue monitoring phytoplankton for (at least) a full cycle to help resolve the differences in outcomes within the phytoplankton assessment.

The phytoplankton seasonal succession tool is based on the seasonal shifts of two phytoplankton functional groups (diatoms and dinoflagellates) from English coastal waterbodies. This may not be relevant as a growth envelope for Jersey coastal waters. It is important to build a baseline of seasonal variability for Jersey waters and implement standards related to Jersey/Atlantic coast.

Recommendation 13: DoE should build on a baseline data of phytoplankton seasonal variability for Jersey waters and implement standards related to Jersey/Atlantic coast.

4.3.3 Future monitoring under the WFD in Jersey

As mentioned, the scale of monitoring carried out by DoE is comprehensive and has provided an important baseline of understanding of the historical changes and the current assessment. Analysis of the data and the initial WFD assessment shows that there is sufficient monitoring at the right scales for a confident assessment of ecological state, although adaptations and improvements to the monitoring can be made as local knowledge, experience and understanding increases over the monitoring period. An example of a possible adaption to current monitoring is the *Ulva* surveys. DoE has been monitoring *Ulva* via time lapse cameras over a period of 3 years and has discovered that the *Ulva* is very transient. It is transported around the beach, affected by tidal movement, wind and in stormy conditions and can be removed from the beach completely. The *Ulva* appears to increase periodically with a 'dying off' period at the end of the bloom season. Currently *Ulva* is surveyed once per season, it is therefore recommended that a survey be carried out once per month over the growing season to ensure that the data is collected at the peak of the bloom. The results showing the 'worse case' should be used to reflect the extent of the issue.

Recommendation 14: DoE should increase the survey frequency of *Ulva* during the bloom period.

It is recommended that DoE continue to develop the current monitoring design for water and biology with the current frequency for WFD requirements continuing monthly for all nutrients (dissolved nutrients, including phosphorus) until first full assessment (6 years). After the first full assessment (6 yearly cycle), the monitoring and assessment should continue to collect data at an optimal frequency for high data confidence and continue to collect data over the appropriate spatial and temporal considerations.

Recommendation 1: DoE should continuously look to improve and adapt their monitoring programmes to ensure they provide the best possible status assessment after the initial 6-year period.

The detail and complexity of the water quality issues and the historical range and extensiveness of the monitoring reports has made it difficult to completely capture the wide breadth of information and studies that have occurred. Much of the previous work was fit for purpose for a single issue or issues outside the remit of the eutrophication issues that are the main concern for this review. Thus, whilst those reports have been reviewed, the expectation into the future is to continue to monitor regularly at fixed coastal and offshore sites for the various biological and physico-chemical parameters to build a confident ecological assessment guided by the current EU UWWTD, WFD, and OSPAR guidelines.

Recommendation 26: DoE should continue to regularly monitor the various biological and physico-chemical parameters at fixed coastal and offshore sites to build a confident ecological assessment guided by the current EU UWWTD, WFD, and OSPAR guidelines.

However, WFD and OSPAR use broad scale tools that are not always successful in determining how and why the eutrophication is occurring. DoE need to continue the combined monitoring approach but ensure that additional analyses, outside of the metrics applied under the WFD assessment, could be applied if required. DoE should use an additional holistic method to integrate the many layers of evidence to better inform decision making. An example of this is the Weight of Evidence Approach used by the UK Environment Agency (Annex D2. 2.7).

Recommendation 37: DoE should use an additional holistic method to integrate the evidence collected to better inform decision making – e.g. Weight of Evidence Approach used by the UK Environment Agency.

The missing detail in all the monitoring reports and assessment of anthropogenic pressures is a modelling approach where the variable data sources could be integrated across a hydrodynamic and biogeochemical model to provide a more holistic assessment of the ecosystem. There have been some exceptions, with Macron developing a DIVAST hydrodynamic model[51] that models different STW discharge designs with seasonality to be able to simulate the future characteristics and effects on the wider marine environment, however it does not include confident estimates of the three main sources (direct, diffuse and offshore) and does provide an estimate of the influence of offshore monitoring. Details of an appropriate modelling approach are explored in detail in Section 4.4.

4.3.4 Water quality monitoring outside the WFD assessment criteria

DoE have collected and analysed dissolved nitrogen data but have a limited amount of information on the dissolved phosphorus concentrations and thus, are not able to fully explore the role of nutrient limitation in controlling growth of the marine plants. It is recommended that DoE conduct phosphorus monitoring at all WFD marine sites.

Recommendation 48: DoE should include dissolved phosphorus in their marine monitoring programmes.

For more comprehensive WFD monitoring, there are other actions that can be included to add to a weight of evidence approach and/or provide a risk-based assessment. These can include independent monitoring, which can be valuable to answer questions or tackle specific issues outside the WFD assessment process. Along with the consideration of third party evidence, if scientifically robust and considered reliable. This would provide additional information in a weight of evidence approach.

Recommendation 59: DoE should look to adopt a risk-based approach for the full assessment of WFD criteria. This can include independent monitoring (not required for WFD assessment) and consideration of any further third party evidence when addressing issues.

[51] Proposed Sewage Treatment Works Renewal Feasibility Studies: Modelling – Stage I. Hydrodynamic Model Development and Calibration (Macron).

It is important to adapt monitoring to the local environment and use the most relevant assessment tools and data available. For example, seagrass community data is monitored during the *Ulva* survey, as standard practice, however, a more detailed seagrass assessment is being carried out by DoE Marine Resources Section for other purposes. This is a much more in-depth survey following the French interpretation of the WFD monitoring for this species. It is therefore recommended that the data from this monitoring be used to support the WFD status assessment of St Aubin's Bay.

Recommendation 20: DoE should adopt the weight of evidence approach, with consideration to the following: inclusion of independent monitoring, optimal monitoring frequency, monitoring at the appropriate spatial and temporal scales and adapting the monitoring standards to suit the local conditions.

4.3.5 Future *Ulva* monitoring

It is difficult to add anything to the information already known around the *Ulva* biomass issues. Several years of studies and bilateral meetings with the French have provided a large pool of knowledge, culminating in an extensive review by Cascade in 2013[52]. This review suggests that DoE and DfI may not be using latest modelling opportunities to estimate *Ulva* biomass. There is uncertainty around knowledge on the nutrients in sediment and the potential for overwintering of high nutrient sources. There should also be more work on the photobiotic layer and the ability of *Ulva* to settle on sand. The WFD assessment is currently applied, however the area under investigation is outside of the UK and French coastal zones, so technically an assessment could also be using available OSPAR and MSFD assessment tools as well.

Recommendation 21: DoE should investigate the use of the latest modelling opportunities to best inform them going forward.

Recommendation 6: DoE should improve their knowledge of the nutrient stores in sediments and the potential for overwintering of high nutrient sources as a priority topic under future R&D work.

Recommendation 7: DoE should carry out further work on the photobiotic layer and the ability of *Ulva* to settle on sand as a priority topic under future R&D work.

Recommendation 24: DoE should consider utilising and comparing the outcomes of the OSPAR assessment tools when carrying out nutrient assessments.

The macroalgal mat can be a habitat in its own right[53] and contain a diversity of *Ulva* species within the mat. There is a requirement for more research on this naturally occurring primary producer before it is physically removed. Management proposals currently involving the wholescale clearance of the macroalgal mat may not always be the best approach. However, this review is not focused on

[52] Cascade (2013) St Aubin's Bay Sea Lettuce Literature Review

[53] Thorton, A (2016). The impact of green macroalgal mats on benthic invertebrates and overwintering wading birds. Thesis submitted to Bournemouth University.

the issues around the function of the macroalgal mat and the connections with the benthic taxa and/or bird feeding and would recommend additional work in this area.

Recommendation 85: DoE should consider researching the ecological importance of *Ulva* in supporting species within the macroalgal mat. The results of which should be considered within management of the *Ulva*.

4.3.6 Future data use and statistical analysis

This review explores the many different aspects of the data holdings and reviewed how the many reports have led to an increased understanding of the main drivers and impacts in Jersey marine waters. It did not however, perform any detailed statistical analysis on the integrated data. It is highly recommended that a more detailed statistical analysis is carried out using the long-term monitoring data of St Aubin's Bay to assess changes over time[54] and the significance of this change.

Recommendation 96: DoE should carry out more detailed statistical analysis of temporal trend and significance of change on their integrated water quality data.

Many statistical tools provide quantitative evidence on the main influencing drivers (nutrients, turbidity, flushing, source loads) on the response variables (macroalgal growth, biomass) and provide information to managers on ways to modify the current sampling regime; (once a full reporting cycle has been carried out) offering the most cost effective and appropriate frequency of data collection.

4.4 Recommendations for an appropriate modelling approach.

After careful consideration of the scientific studies and data collected on the nutrient pressures impacting St Aubin's bay, the reviewers are strongly of the opinion that a modelling approach is required to achieve the best possible outcome for the effective management of nutrient pressures and subsequently *Ulva* growth in St Aubin's Bay.

Many of the commissioned water quality reports identify the cause and the effect of nutrient pollution, but few offer a clear path to management prioritisation and targeted remediation. Modelling coupled with a weight of evidence approach will provide information of the scale of the issue, the apportionment of source loading, and the best policy actions to respond to the issue and apply the most appropriate management actions. It will also enable predictions to be made on the amount of nutrient reduction required to reduce *Ulva* growth and the length of time this may take; which is key to managing public and political expectations.

There are several examples on how a modelling approach coupled with strong environmental directives has helped with other areas that have faced similar issues and impacts as St Aubin's Bay. Examples such as Portsmouth Harbour in the UK demonstrate the value of coupling modelling through the integration of information on tidal movement (offshore to inshore) and CPM (biomass) model (Table 4-1 and Appendix D2. 2.3). This type of approach has been successful (over time) in some UK estuaries but it is important to note that there is no quick fix. It can take years to see any positive effect from measures implemented, due to time lags associated with nutrient retention and

[54] Statistical significance can be measures (p) and is the probability that the change you're seeing is only due to chance, and thus meaningless or is a real change related to some external factor. Typically, a p-level must be below 5% to be considered significant. In other words, if your p-value is 5% or less, you can confidently say that the change in your data is real, definite, and due to something other than statistical noise.

multiple sources of inputs. This requires an integrated approach to the programme of measures (Appendix D2).

A coupled phytoplankton and microalgae model (CPM) treats a water body as a single well-mixed box with direct nutrient inputs from rivers and point source discharges along with exchanges of nutrients and chlorophyll with coastal waters. The estuarine model could be run to look at the contributions from the various sources of inputs. The model could also run scenarios where you reduced each contribution to zero.

The model can determine daily phytoplankton and macroalgal production within the box and has been updated in recent years to include multiple boxes linked together in a flexible configuration. Each box represents a different portion of the water body and can have its own characteristics such as depth, area available for macroalgal growth and light attenuation. Nutrients and phytoplankton are exchanged between the boxes with the outer-most box having the only direct exchange with the coastal zone. The development of an effective model is strongly recommended where a series of scenarios could be tested and outputs offering the best solution weighing up the environmental outcomes and cost efficiency. This report suggests some options for modelling but the final decision on the scope of monitoring will be based on the main nutrient inputs and the available policy implementation. For example, if you are reasonably sure that the main inputs are all from the catchment and not related to offshore water movement, then application of a freshwater - marine model will be sufficient. However, if the offshore concentrations are considered important, coupled freshwater – shelf and hydrodynamic models may be required.

Recommendation 107: DoE should develop an effective model to enable a series of scenarios to be tested. The outputs of which should offer the best solution weighing up the environmental outcomes and cost efficiency of tackling the nutrient issues in St Aubin's Bay.

To assist in the modeling, establishment of the coastal hydrodynamics are required. This could be supported by the establishment of long term mooring buoys with appropriate sensors (or several) to give a better idea of the hydrodynamics within and across the coastal to offshore zone.

Recommendation 118: DoE should consider carrying out coastal hydrodynamic modelling. This could be supported by the establishment of long term mooring buoys with appropriate sensors.

The most appropriate model where both catchment and offshore inputs are considered an issue would be the coupling of a hydrodynamic model (for example Telemac model) and an algal biomass model (for example dCPM model). A Telemac model can provide reasonably detailed bathymetry of the region and then, given input loadings, it can provide a picture of the winter nutrient distribution. It can also yield water exchange rates for the CPM model. The case studies show various permutations of the modelling approach, with bespoke monitoring and modelling based on the issues within each case study. For Jersey, the inputs into St Aubin's Bay has already been recognised as a mix of direct and diffuse catchment loads, but the offshore input is relatively unknown, and could be significant. Due to these conflicting issues and unknown loadings, it is recommended that Jersey applies a coupled modelling approach, using an algal biomass model (such as dCPM) and a shelf wide circulation model (such as the Telemac hydrodynamic model[55]).

[55] http://www.opentelemac.org/index.php/presentation?id=17

A way forward for Jersey may be an approach similar to Poole Harbour in the UK. A high-resolution depth-averaged hydrodynamic model was developed for Poole Harbour, UK, with the aim to test water quality scenarios for reducing nutrient levels. These scenarios were developed from a separate Combined Macroalgae and Phytoplankton (CPM) model, a simple linked box model that can be used to calculate nutrient concentrations and the biomass of phytoplankton and macroalgal communities.

For the CPM model to function, exchange rates between the different parts of the water body are required. The flushing rates of Poole Harbour are calculated from the hydrodynamic model. Furthermore, as there is uncertainty in what leads to the spatial distribution of microalgae growth, the hydrodynamic model was used to investigate any links between environmental conditions, nutrient concentrations and microalgae growth[56.]

Recommendation 129: DoE should consider the use of hydrodynamic and algal biomass modelling.

4.5 Modelling to improve the effectiveness of the current monitoring.

4.5.1 Monitoring information required for the implementation of a modelling approach

The information required for the implementation of a microalgae and phytoplankton box model are detailed in Table 4-1 and Figure 4-2 describes the pathways within the CPM model, once the required information has been inputted. Modelling will allow DoE to test a range of water quality scenarios to investigate how nutrient levels could be further reduced, particularly as there is a degree of uncertainty as to what leads to the full spatial distribution of microalgae growth.

A coupled modelling approach can also identify possible links between environmental conditions, nutrient concentrations and microalgae growth. Initial outcomes of this approach as applied in Poole Harbour are shown in Figure 4-3 and Figure 4-4. The modelling of the water quality scenarios is a two-stage process. The CPM model is used to provide the boundary conditions for nutrient levels which are then modelled using the separate Telemac model. The CPM model assesses the nutrient loads over an annual period to encompass the life cycle of the microalgae and phytoplankton.

To ensure that the modelling process provides the best possible outputs, it is recommended that DoE consider undertaking additional supportive monitoring, including:

- Nutrient assessment of the sediments in St Aubin's Bay.
- Nutrient loading monitoring, for example setting up a stage discharge monitoring programme.
- Additional off-shore nutrient monitoring.
- Assess the nutrient tipping points as part of the modelling process.

Recommendation 30: DoE should obtain and/or collect the information detailed in Table 4-1 if a modelling approach is implemented

Table 4-2: Details of the input information required for a successful modelling approach.

Information required for model	Details
Depth information	Either as average single average value (m) relative to Mean Sea Level (MSL) or by specifying data in depth 'bins'. Binned depths are specified by giving the proportion of the water body lying in certain depth ranges or bins. For example, 10% of water depth

56 Haverson, D; Aldridge, J; Edwards, K. Assessment of nutrients and macroalgae growth in Poole Harbour, UK https://henry.baw.de/bitstream/handle/20.500.11970/104508/32_Haverson_2017.pdf?sequence=1&isAllowed=y

	may be in the range between 1 to 2 m below Lowest Astronomical Tide (LAT). The user also needs to provide an offset that allows the model to convert from LAT to MSL.
Spring tidal range (m).	Available from Admiralty charts, tide tables, internet or tidal software.
Annual average river flow rates	($m^3 s^{-1}$) into a given compartment.
Ratio of summer to annual average river flow rate.	This value should be between 0 and 2 (see note on loadings ratio below and appendix 1 notes about the loadings ratio).
Annual nutrient loads	(N and P, kg y^{-1}) direct loads for each compartment representing combined stream and STW inputs.
Ratio summer to annual average loading ratio.	The summer/annual load ratios for N and P control the seasonal variation in nutrient loadings. They will have a value between 0 and 2 where, for example, a value of zero means all nutrient loading is in winter, a value of 1 means summer and winter loads are equal, and 2 causes all nutrient loading to be in summer. Other values represent intermediate situations
Offshore nutrient (µM) and chlorophyll concentrations	(µg l^{-1} or mg m^{-3}) are specified for outermost compartments that exchange with surrounding waters. Winter and summer values are required.
Water exchange rates	(d^{-1}) specified as the proportion of the box volume exchanged per day via tidal exchange between linked compartment or offshore waters
Light attenuation coefficient	(Kd, m^{-1}) in the compartment. Only a single annual average value can be specified. This may be problematic if there are large seasonal variations and in this case it is suggested the Kd be biased toward summer values.

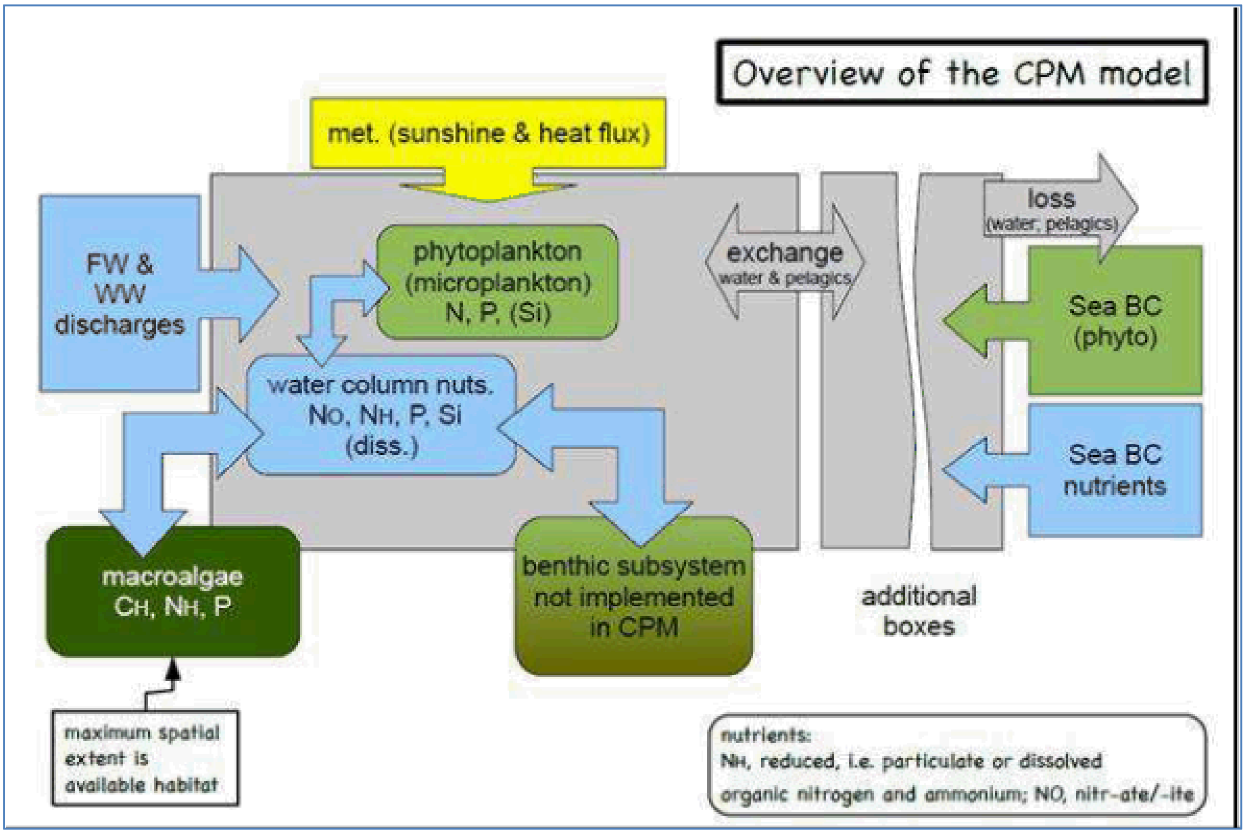


Figure 4-2: Overview of the Combined Phytoplankton & Macroalgae (CPM) model.

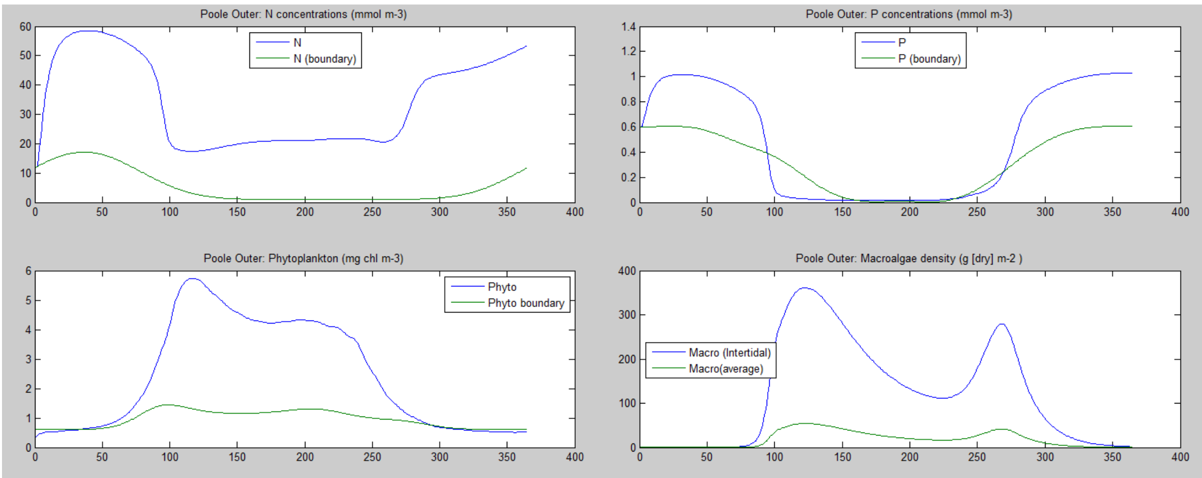


Figure 4-3: Outputs of the seasonality for N, P phytoplankton and macroalgal biomass calculated by the application of the CPM model in Poole Harbour in the UK.

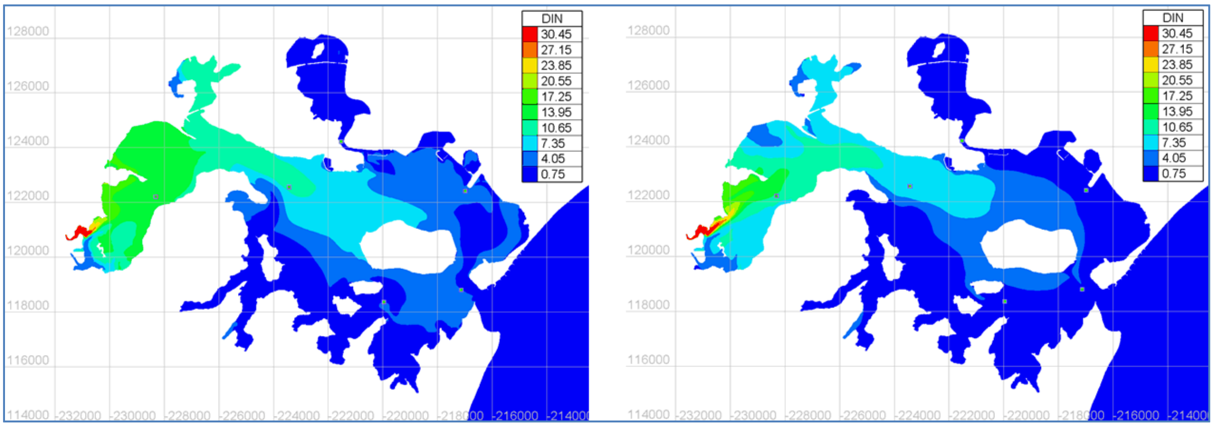


Figure 4-4: Outputs of the distribution of Winter DIN calculated by the application of the CPM model in Poole Harbour in the UK.

4.5.2 Sediment monitoring

Sediment data is required to be collected for a greater understanding of nutrient storage and release and the role and fate of overwintering N. In the present monitoring design, there is limited information on sediments, both as a source of continuing nutrient supply and as a direct impact on the benthic diversity. Nutrients stored within sediments can also prolong the occurrence of nuisance algal growth even after effective nutrient reduction is implemented and is an important component of the modelling process.

The development of green macroalgal mats can affect feeding relationships between invertebrate assemblages and overwintering migratory wading birds. As such, any decline in wading bird numbers because of nutrient enrichment affecting their food supply or altering feeding behavior, would result in sanctions under current EU legislation. A review recommendation would be for the initiation of sediment sampling, particularly in relation to the issues of overwintering and nutrient storage. A comprehensive methodology is presented in Appendix D4. 4.4 however further discussions on site selection and parameterisation of modeling is advisable.

Recommendation 31: DoE should undertake sediment sampling, particularly in relation to the issues of overwintering and nutrient storage.

4.5.3 Incorporation of STW monitoring data within modeling process

The treated effluent data collected from the STW discharges needs to be included in any modelling approach, with a full costing of nutrient reduction scenarios. If the reduction in nitrogen is then applied to the qualifying discharges, an estimation of the corresponding reduction in *Ulva* growth can be made using the most appropriate model. As reported in Deliverable 2, using this principle, a maximum reduction of 10.1% in weed growth could theoretically be achieved in an impacted system (for example - Newtown Harbour) by applying nutrient stripping to all of the qualifying discharges.

Recommendation 32: DoE should include all STW treated effluent results within any chosen modelling approach, with a full costing of nutrient reduction scenarios. Cost benefit analysis needs to be included as an additional set of analyses based on input from the relevant Jersey agencies.

4.5.4 Source apportionment and nutrient loading monitoring

Understanding the source apportionment and loading of nutrients into St Aubin's Bay is critical for effective management of the issue. Specific source apportionment investigation has been done historically by the CREH[57] source apportionment survey, which identified a 50/50 split between catchment and STW sources. Routine monitoring under the UWWTD for source apportionment of nutrients (1997) and trophic status assessment (1997 and 2009) [58] of the Bay was also carried out. It is recommended that this process is repeated every 10 years (unless more permanent monitoring is implemented), especially given that in the last trophic assessment in 2009 it was reported that no algal blooms occurred during the study period[59]. This is important given that since 2012 algal blooms have occurred annually, indicating that, under the current assessments, the frequency of the blooms has increased.

Recommendation 33: DoE/DfI should consider carrying out the source apportionment of nutrients and trophic status assessment of St Aubin's Bay every 10 years.

This work can then be used, amongst other data gathered, to measure effectiveness of measures implemented under the WMP to reduce loads from direct and diffuse catchment sources. It would also test and report on the effectiveness of the replacement STW. It would be relatively easy to calculate the load from the STW and, with appropriate monitoring and modelling data, be able to assess the changes over time.

Recommendation 34: DoE should assess the effectiveness of the programme of measures implemented in the St Aubin's Bay catchment by the calculation of loads from St Aubin's catchment. In particular loads calculated from the STW during and after the replacement of the STW.

DoE have considered the scale and timetable for land-based nutrient reductions and the quantitative direct (stream) and indirect (groundwater) reductions and improvements in nutrient supply to the STW and to the Bay through the WMP and RRM. More detailed work on relative loading from both sources is recommended, which will require amongst other things the implementation of a stream flow (stage discharge) monitoring programme. This will form part holistic nutrient reduction programme addressing all possible sources and needs to continue to address all sources of nutrient loads.

Recommendation 135: DoE should undertake the appropriate monitoring to assess nutrient loading into the bay – which would include setting up a stream flow (stage discharge) monitoring programme.

4.5.5 Off-shore monitoring

The reports provided do not explore in detail some other potential sources of contributory nutrients, such as offshore nutrients. Transboundary issues would require a holistic approach to both the local and offshore contributions. Previous studies undertaken in Jersey have indicated that the wider marine environment may influence nutrient levels in the Bay as well as possibly being partly responsible as one of the sources of nutrients driving the elevated biomass of *Ulva*. A bay located

[57] CREH (1997) Estimation of nitrogen and phosphorus budgets entering St Aubin's Bay, Jersey

[58] CREH (1997) Trophic status of St Aubin's Bay and CREH (2009) Reassessment of the trophic status of St Aubin's Bay

[59] CREH (2009) Reassessment of the trophic status of St Aubin's Bay

close to St Aubin's Bay is St Brelade's Bay. This bay, whilst experiencing similar offshore transboundary issues does not experience *Ulva* growth. Indicating that whilst the off-shore sources may be providing a background level it would appear that the additional land-based sources could be tipping the balance in St Aubin's Bay. This review recommends greater linkages with coastal and offshore monitoring.

Recommendation 146: DoE/DfI should consider undertaking more off-shore monitoring to enable greater linkages with coastal and offshore nutrient sources (i.e. French coast) and linking up the input of catchment and offshore inputs via the modelling approach.

Estuaries and beaches in northern France have experienced an increase in macroalgal mats over the last two decades[60] and common factors need to be explored. Discussions should be undertaken with French authorities on a combined approach to the assessment of the offshore waters. It would be useful to try to establish whether the French rivers and the Channel/Atlantic are a significant nutrient source to either eliminate the possibility or factor the additional source of N into a model. Offshore monitoring data should be used within the modelling approach, which will help provide further evidence of an integrated assessment. Cefas can provide additional offshore data (nutrients, fish and sediments (Figure 4-5) for modelling purposes, collected across several multidisciplinary trips.

Recommendation 157: DoE should use offshore monitoring data within the modelling approach. If required, further monitoring on the offshore sites should be instigated.

[60] Ménesguen, A. and Cugier, P., 2006. A new numerical technique for tracking chemical species in a multisource, coastal ecosystem applied to nitrogen causing *Ulva* blooms in the Bay of Brest (France). *Limnology and Oceanography*, 51 (1, 2), 591-601.

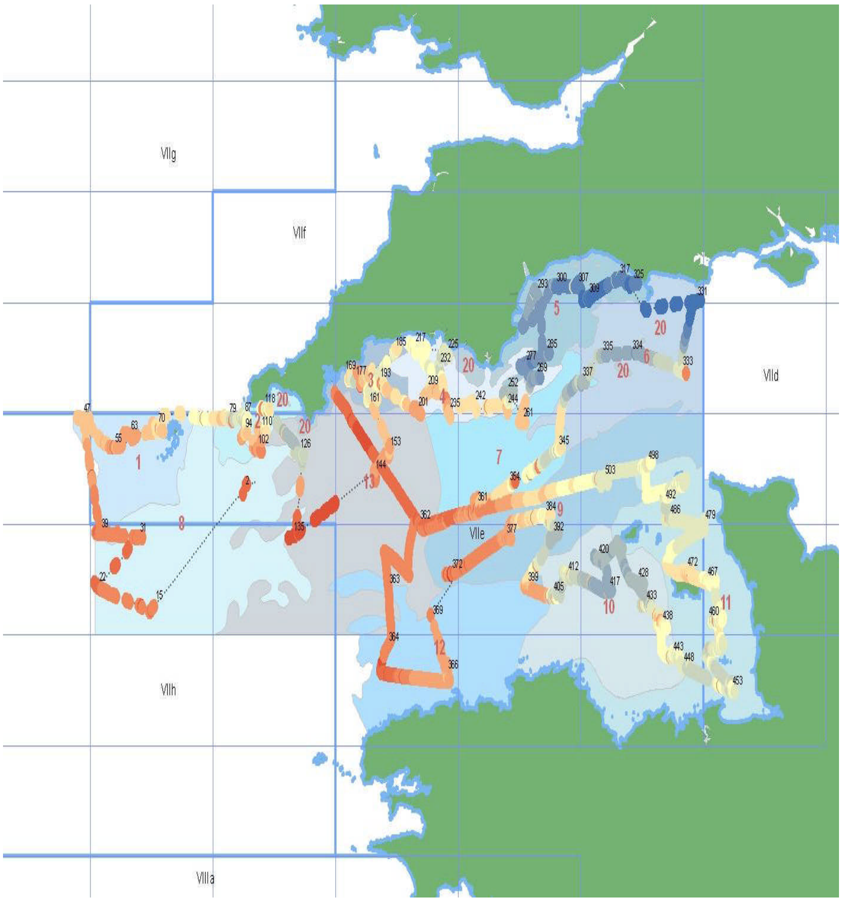


Figure 4-5: Additional offshore data that has been collected through Cefas integrated monitoring trips could be used in the assessment of offshore concentrations. The colored lines represent the track undertaken by Cefas research vessels, with the frequency of trips from low (1 – 5 sampling trips) to moderate (yellow to orange, 5 – 20 sampling trips) and high (red, > 20 sampling points)

4.5.6 Investigating nutrient tipping points

There should be more investigation of possible nutrient tipping points (Figure 4-6) to prepare for future monitoring and management options. This would be similar to the UK southern estuaries where the background marine concentrations are significant but have stayed relatively constant over time (however the tipping point of elevated biomass has come from the additional STW source in the UK Southern estuaries). These types of calculations can be investigated through a modelling approach where scenarios of nutrient apportionment can be tested though the model to identify the nutrient load that can drive biomass into moderate or poor ecological state.

Recommendation 168: DoE should investigate further the possible nutrient tipping points.

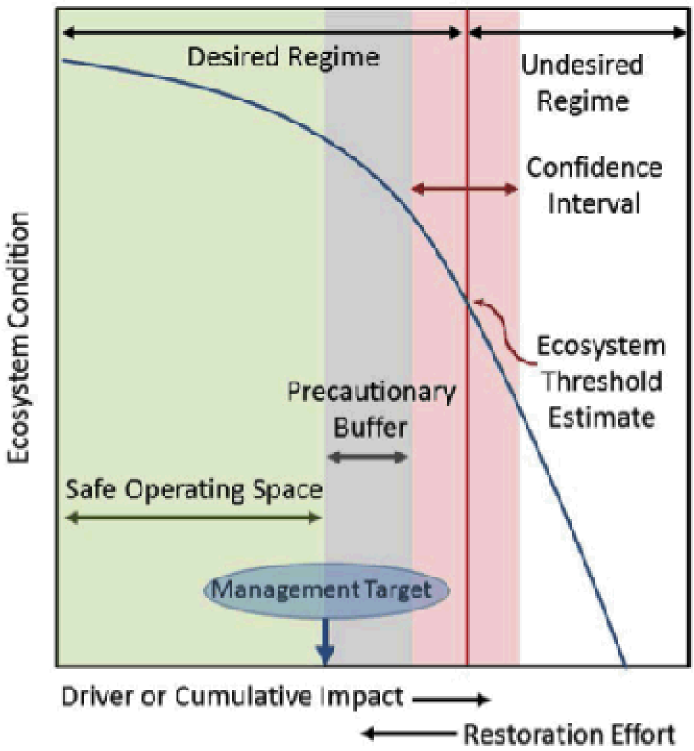


Figure 4-6: Conceptual picture of tipping point.

5 Conclusions

The review presents information on many aspects of the monitoring and assessment of environmental issues in Jersey, particularly the monitoring and assessment of the seasonally high blooms of opportunistic microalgae in St Aubin's Bay. Many recommendations have been made around many of the aspects reviewed under this report, including the use of the WFD outcomes to implement or support regulatory discharge permits, the different aspects of monitoring and assessment currently undertaken by DoE and the applicability and effectiveness of current monitoring and assessment in making informed management and policy decisions on catchment management activities. A short list of the main recommendations is presented in Table 5-3 with the assessment of achievability against these main recommendations.

Table 5-3: A prioritised list of the main recommendations for Jersey DoE to consider.

Priority	Applicability	Achievability
1	Apply a biomass/weed modelling approach to identify the main sources of nutrient loads that are driving the high summer *Ulva* biomass issues and can predict the amount of microalgae that will grow. Applying a coupled modelling approach (hydrodynamic model with weed growth) can be used to investigate any links between environmental conditions, nutrient concentrations and microalgae growth. The outcomes of this approach can then be the basis of applying a cost benefit analysis on different programme of measures.	High – single and coupled models have already been developed for the UK coastal areas with similar issues of weed biomass. Fine tuning of model input parameters for Jersey is possible.
2	Hydrodynamic modelling to model the movement and influence of offshore waters in nutrient loading.	High/medium – development of model requires climatic and environmental conditions – which are accessible.
3	Two key monitoring elements currently missing are for flow (water discharging into the Bay) and loading (amount of nutrient held within the water entering into the Bay). Both are critical to the modelling process.	High – this type of monitoring programme has already been undertaken in Jersey and is common place in the UK.
4	Long term calculations of the main sources of nutrients driving the *Ulva* biomass (coupled recommendation 1, 2 above).	High – given positive outcomes for recommendation 1 and 2 above.
5	Integrated assessments using qualitative tools. Examples provided have included the Weight of Evidence approach for UK WFD assessment, but Jersey DoE could use any type of integrated assessments.	Medium – requires additional work within DoE.
6	Additional sampling for phosphorus (P) in water samples.	High - Whilst nitrogen is the main cause of the accelerated growth, the role of P is not well understood, particularly for nutrient ratios and nutrient limiting conditions.
7	Additional collection of sediment samples in impacted area may provide further information for model parameterisation and overwintering of nutrients.	High – though discussion on site selection, timing and parameterisation is required
8	Improving the WFD ecological and chemical assessments through continued monitoring of the catchment and coastal areas.	Medium – work is required to test reference and boundary conditions to ensure they are fit for purpose for Jersey Marine waters. Boundaries set for Atlantic waters (French) may be more appropriate for the Jersey coast.
9	Further assessments using indicators from the	Medium – many of the OSPAR assessment

	OSPAR common procedure could be applied for Jersey[61].	metrics are similar to WFD tools but with boundary conditions relative to offshore waters. As with WFD, some discussion and analysis of historical datasets may be required to set the reference boundary condition.
10	Further work on offshore monitoring.	Medium. Sampling (not part of the WFD programme) has been carried out from coastal to offshore sites. However, the monitoring of the offshore waters requires a combined effort with French monitoring programmes, analysis of other offshore data and the possibility of using additional sources of data – such as the Earth Observation data.

[61] Jersey data will be submitted to OSPAR via Marine Resources