Cyfoeth Naturiol Cymru
Natural Resources Wales

# Surveillance of *Grateloupia turuturu* in Wales – Milford Haven July 2013

Chloe Jennings & Ben Wray

NRW Evidence Report No. 17

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We work to support Wales' economy by enabling the sustainable use of natural resources to support jobs and enterprise. We help businesses and developers to understand and consider environmental limits when they make important decisions.

We work to maintain and improve the quality of the environment for everyone and we work towards making the environment and our natural resources more resilient to climate change and other pressures.

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- Securing our data and information;
- Having a well resourced proactive programme of evidence work;
- Continuing to review and add to our evidence to ensure it is fit for the challenges facing us; and
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# CRYNODEB GWEITHREDOL

Y mae'r rhywogaeth estron *Grateloupia turuturu* (Gwymon Tafod y Diafol) wedi sefydlu yn y DU. Gall rhywogaethau estron effeithio'n ddifrifol ar fflora a ffawna brodorol. Cofnodwyd bresenoldeb cyntaf *G.turuturu* yn 1984 (Maggs *et al.* 1999) yn agos at fferm Wystrys Pacific *Crossostrea gigas* yn Aberdaugleddyf.

Cynhaliwyd arolwg i chwilio am bresenoldeb *G. turuturu*, ac i gofnodi unrhyw bresenoldeb yn Marina Neyland a'r ardal o amgylch Aberdaugleddyf. Archwiliwyd pontynau a strwythurau arnofiol eraill am bresenoldeb y rhywogaeth. Cynhaliwyd y gwaith gan ddefnyddio cyfarpar snorcelu o amgylch y strwythurau gan gofnodi'r presenoldeb. Gwnaed yr arolwg er mwyn cofnodi sefydliad y rhywogaeth yn Marina Neyland ac o amglylch Aberdaugleddyf er mwyn penderfynu a oedd difodi *G.turuturu* yn ymateb ymarferol.

Dangoswyd y canlyniadau bod *G. turuturu* yn tyfu ar 38% o'r pontynau a strwythurau arnofiol eraill a arolygwyd yn Marina Neyland ac o amglylch Aberdaugleddyf. Maen'n debygol bod Marina Neyland yn cynnig amgylchedd addas i *G.turuturu* atgynhyrchu. Mae'n debygol bod *G.turuturu* wedi ei chyflwyno i'r ardal drwy dŵr balast cychod, yn ogystal a mewnforio pysgod cregyn byw fel rhan o'r diwydiant dyframaeth lleol.

Yn ol canlyniadau'r arolwg, mae'n amlwg bod *G. turuturu* wedi lledaenu yn Aberdaugleddyf ac felly nid yw ymarferoldeb difa'r rhywogaeth yn debygol ar yr amser yma.

# EXECUTIVE SUMMARY

*Grateloupia turuturu* Devil's tongue weed is a marine non-native species in the UK. Non-native species have the ability to cause severe impacts to native flora and fauna. The first record of *G. turuturu* in Milford Haven was recorded in 1984 (Maggs *et al.* 1999) close to a Pacific oyster *Crassostrea gigas* farm.

A survey was undertaken to search for and record the presence of *G. turuturu* within Neyland marina and the surrounding Milford Haven area. Pontoons and other floating structures were surveyed using snorkelling apparatus, where presence of *G. turuturu* was recorded. The survey was undertaken to determine the extent to which *G. turuturu* had become established in Neyland marina and the wider Milford Haven waterway and assess the feasibility of eradication of this species in the area.

The results showed that 38% of the pontoons and other floating structures surveyed in Neyland marine and wider Milford Haven waterway had a presence of *G. turuturu*. It is postulated that Neyland marina provides a suitable environment for reproduction of *G. turuturu* and introduction may have occurred through ship ballast water and/or the import of live shellfish associated with local aquaculture.

Based on the findings of this study and the fact that *G. turuturu* is widespread across the Milford Haven waterway, the feasibility of eradicating this species in Milford Haven is unlikely at this time.

# 1. Introduction

## 1.1. Background

*Grateloupia turuturu* Devil's tongue weed, is a large red seaweed native to Japan, China and Korea (Sweet 2011; Pang *et al.* 2006; Gaoge *et al.* 2012; Balcom 2009). The alga consists of between 1 and 6 blades which can grow up to 15cm in length (Sweet 2011). This species was previously known as *Grateloupia doryphora* (Pang *et al.* 2006) and is found in the intertidal zone but can also occur subtidally down to a depth of 7 m (Patten 2006; Sweet 2011). The genus *Grateloupia* comprises 51 currently recognised species making it the largest family of *Halymeniacea* (Gavio and Frederico 2002). According to Simon *et al.* (2001) *G. turuturu* is considered to be the largest existing red alga in the world.

### 1.1.1. Impacts of non-native species

Non-native species have the ability to cause severe impacts, sometimes completely altering the habitat in which they inhabit (Wallentinus and Nyberg 2007; Jones *et al.* 2011). To date, there are ca. 40 marine non-native species in Welsh waters, 7 of which are classified as invasive (Jones *et al.* 2011). The impact of non-native species varies considerably, where the effects can be direct, indirect or both (Wallentinus and Nyberg 2007). Over recent years *Grateloupia turuturu* has been identified as rapidly spreading over many parts of the world (Mathieson *et al.* 2007; Patten 2006). The Atlantic coasts of Europe and North America as well as the Mediterranean Sea, parts of Australia and New Zealand have experienced a rapid spread of the species (Lafontaine *et al.* 2011; Mathieson *et al.* 2007; Balcom 2009). *G. turuturu* has the potential to impinge on native species, and a number of authors have realised these potential impacts of this species as it has large, broad blades, potentially depriving neighbouring species of light (Sweet 2011; Balcom 2009) and competing for space (Sweet 2011). *Chondrus crispus* is one such species that may be affected through resource competition, and is an important food source for snails and other invertebrates (Gough 2014). However, according to Sweet (2011), no negative impacts associated to *G. turuturu* have been reported to date. It is therefore important to monitor distribution and extent of this species as potential impacts on native biodiversity may become more apparent over time.

### 1.1.2. Dispersion of *G. turuturu*

*G. turuturu* originated from Callao, Peru (Simon *et al.* 2001; Gavio and Frederiq 2002) and the species was first recorded in Britain in 1969 from Southsea beach, Solent (Sweet 2011). The species can tolerate nutrient rich water at low salinities (Sweet 2011) and is able to survive temperatures varying between 4 - 28ºC (Mathieson *et al.* 2007). It can be found growing in sheltered areas such as harbours and embayment's, as well as attached to artificial structures such as pontoons and harbour walls (Sweet 2011). Dispersion of *G. turuturu* is thought to be via fertile blades drifting or by attachment on small stones (Sweet 2011). Currents and wave action probably play a large part (Sweet 2011). The spores of the *G. turuturu* may be carried in the ballast waters of ships and specimens have also been found attached to the hulls of vessels (Sweet 2011). Entry of the species into Europe was most likely caused by the transport of Pacific oysters *Crassostrea gigas* for aquaculture (Sweet 2011). The species is fast growing and can exist as a resistant crustose form (Sweet 2011). *G. turuturu* reproduces through the production and release of spores which settle onto hard surfaces, these form crusts and eventually sprout fronds which become long and red (Gough, 2014).

According to Streftaris *et al.* (2005) non-native species are one of four greatest threats to the world's oceans, not only on a local but also on a regional and national scale. The eradication of non-native species however involves the reduction of their population density below sustainable levels (Myers *et al.* 2000). There is very little known about the rates and mechanisms of spread of marine alga (Lyons and Scheibling 2009). *G. turuturu* has invaded multiple regions of the world, with the pattern of its spread tending to show the mode of introduction (Lyons and Scheibling 2009). The current distribution of *G. turuturu* in Britain is limited to the Southeast coast of England and Pembrokeshire, Wales (Sweet 2011).

### 1.1.3. Identification

*Grateloupia turuturu* is a red alga with thin, pink or maroon coloured blades with small bladelets known as pinnae usually found at the base of the frond. The alga is slippery with a very gelatinous texture (Gough 2014; Patten 2006). *G. turuturu* has a distinctive appearance and is therefore relatively straightforward to identify (Figure 1) and separate from other native flora in Neyland marina that are limited in number and variety.

### 1.1.4. Purpose of the study

The purpose of this survey was to assess the extent of dispersion of *G. turuturu* in Neyland marina and the wider Milford Haven waterway with the purpose of establishing whether eradication of this species was feasible. Information on the extent, density and dispersion of *G. turuturu* in the Milford Haven waterway may also influence future management responses to this and other marine non-native species.

The survey was undertaken by 13 surveyors from Natural Resources Wales over a 2 day period in July, 2013. Habitats Directive diving surveys elsewhere were originally planned for this period but due to adverse weather conditions, diving activity was postponed allowing for the *G. turuturu* survey to take place.

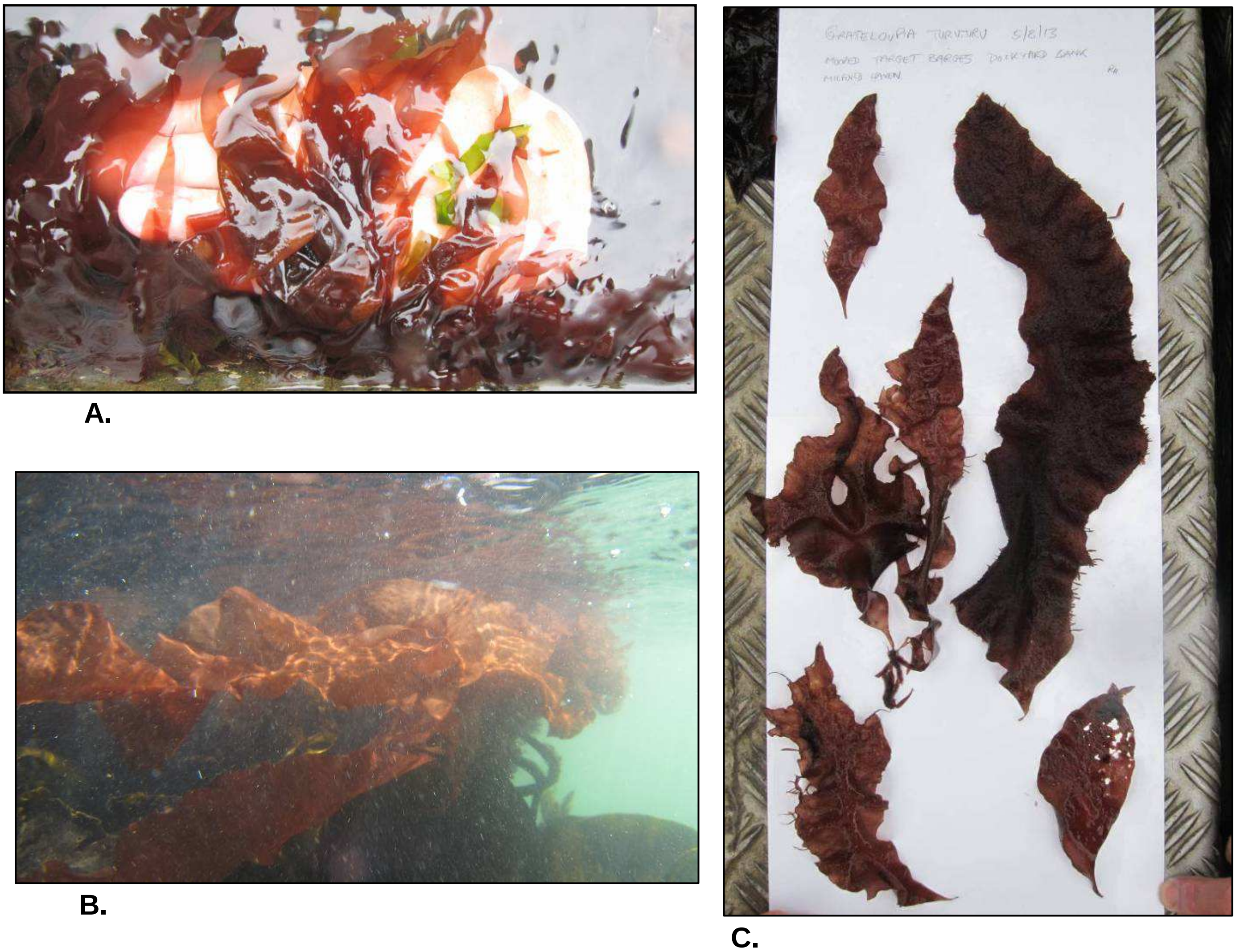


Figure 1. (A) *G. turuturu* being held at the surface of the water. (B) *G. turuturu* completely submerged. (C) *G.turuturu* samples to be pressed (Photos taken 05/08/2013, Photo (A) shows *G.turuturu* taken from moored target barges, Dockyard bank, Milford Haven

# 2. Methods

## 2.1. Pontoons

To ensure accuracy and consistency of identification, each surveyor was provided with a training card with information about *G. turuturu* including a description of its habitat, ecology and distribution prior to the survey.

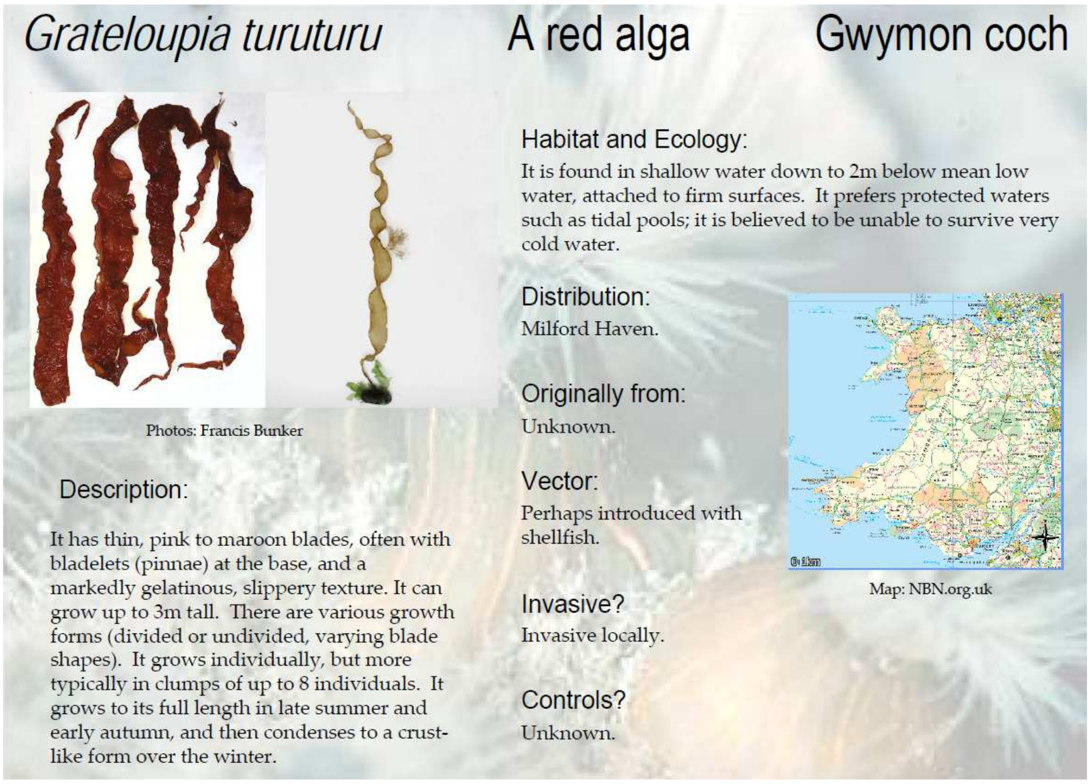


Figure 2. Laminated training sheet for each surveyor.

The 22 platforms at Neyland marina including all of the 184 finger pontoons were surveyed on July 31st, 2013. Teams of two people surveyed each pontoon (one person either side) for the presence of *G. turuturu.* Roughly 8 surveyors conducted the pontoon survey at Neyland marina. The survey took place during daylight hours starting at 09:30 am for a duration of approximately 3 hours.

Diversity of red seaweeds in Neyland marina is limited, making identification of *G. turuturu* straightforward. The pontoons were surveyed by walking along each edge scrutinising the epifauna for presence of *G. turuturu*. Where *G. turuturu* was present, samples were taken for identification purposes or where surveyors wanted confirmation of identification. Specimens were later discarded in the appropriate manner after identification.

Figure 3 Neyland marina showing the pontoons and finger pontoons

Figure 4 Aerial photograph of part of Neyland marina

## 2.2. Buoys and other floating structures

A total of 64 structures were surveyed as part of the current study. Surveying the buoys and floating structures involved snorkelling under and around each one, noting the presence or absence of *G. turuturu*. The upper Haven above Neyland was surveyed on Friday 2nd August and the Haven below Neyland (closer towards the entrance of Milford Haven) was surveyed on Monday August 5th. Surveying on these days was done using the *MV Pedryn* where surveyors were dropped near each structure to check for presence of *G. turuturu.*

Figure 5. Locations of buoys and other floating structures in Milford Haven that were surveyed for the presence/absence of *G. turuturu*

Figure 6. Example of a floating structure that was surveyed for *G. turuturu* – military shooting target

# 3. Results

## 3.1. Pontoons – Neyland marina

*Grateloupia turuturu* was found in 29 locations within Neyland marina (Figures 7 & 8). It is evident from the results that a greater amount of *G. turuturu* was found towards the marina entrance around the holding berth and across the lower basin (24 samples) compared to in the upper basin where only 4 samples were found.

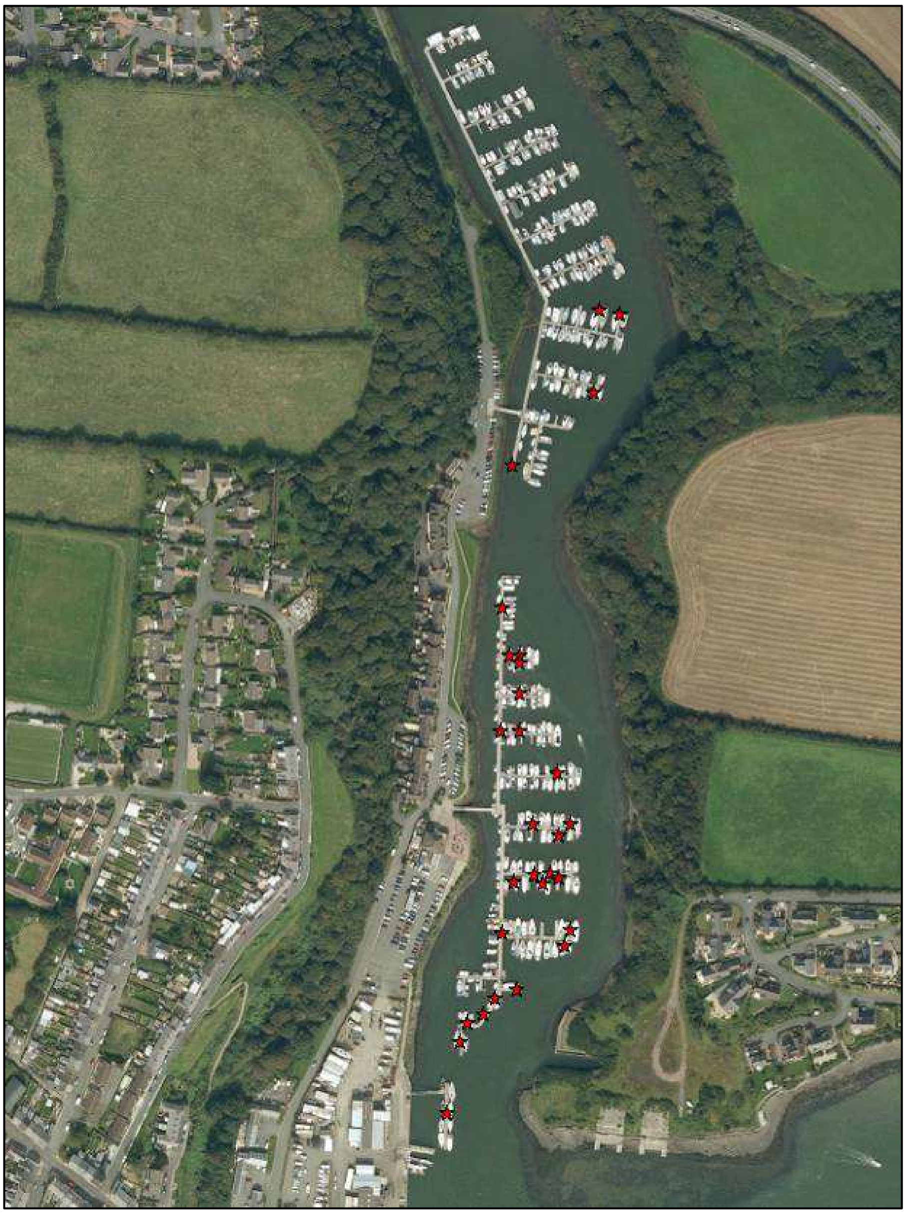

Figure 7. Location of *Grateloupia turuturu* samples in Neyland marina, 31st August 2013

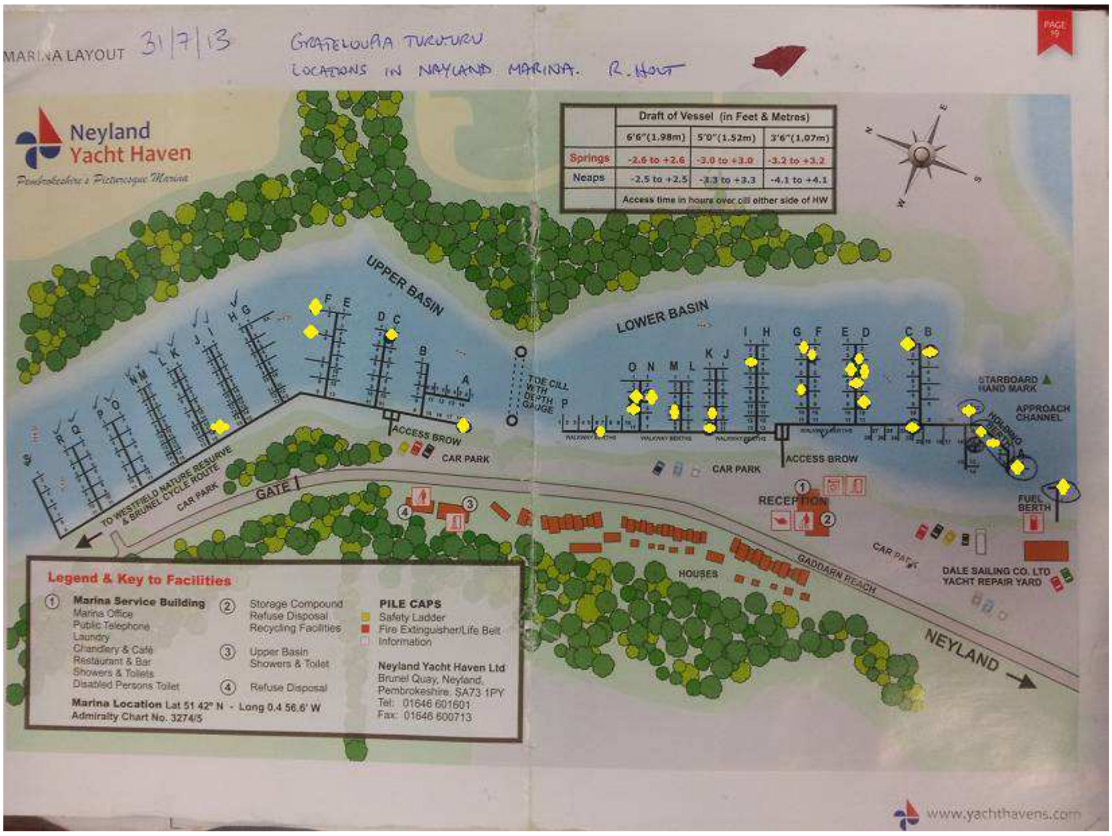


Figure 8. A scanned map of Neyland marina showing the locations where *Grateloupia turuturu* was found. ✦ A yellow star indicates the presence of *G. turuturu*.

### 3.2. Buoys and other floating structures – wider Milford Haven waterway

Of the 64 buoys and other floating structures surveyed, *G. turuturu* was present on 24 out of the 64, roughly 38%. Figure 9 shows the distribution of the structures surveyed and proportion of positive records.

Figure 9. Stars show the locations of where the presence/absence of *G. turuturu* was surveyed in the Milford Haven area. Red stars represent where the *G. turuturu* was present and black stars indicate where the species was absent. *G. turuturu* was found at a total of 24 out of 64 buoys and other floating structures

Table 1. Summary of the locations where *Grateloupia turuturu* was present in order from the highest location up-river

| General location | Location of *Grateloupia* within the general area | Amount of *Grateloupia* present |
|---|---|---|
| Just south of the junction between Cleddau and Carew rivers | On hull of part built yacht with no mast | Small plants |
| Mid channel Cosheston Pill | On floating pontoon | Common-large plants |
| Entrance to Neyland marina | On small port and starboard channel markers and on Neyland spit buoy | Common-large plants |
| Dockyard Bank | On channel navigation buoys | Variable quantities |
| Dockyard Bank | On military target barges | Some large plants – some very ‘roughened’ appearance |
| Hazel Beach | On navigation buoys | Small amounts |
| Milford | On navigation buoys and fisherman’s pontoon | Some large plants |
| Angle Bay area | On buoys | Variable |
| LNG Jetties area | On navigation buoys | Variable quantities some with large plants |
| Dale Bay | On the visitors mooring pontoon at the SE end of the moorings | Patches of dense plants plus lots of Asterocarpa (non-native ascidian) |
| Millbay, St Ann’s Head and Chapel Rocks | Navigation buoys in the East and West Channel entrances into Milford Haven | Many buoys with small plants |

Table 1 above provides an overview of where *G. turuturu* was found within the Milford Haven area. Most of the large plants were found toward the entrance of Neyland marina and throughout the mid channel.

# 4. Discussion

## 4.1. Pontoons

*Grateloupia turuturu* is native to the Asia Pacific region and the relatively warm temperate shores of Japan where it tends to thrive in shallow, protected environments but is intolerant of very cold waters (Gough 2014). It is possible that warmer summer temperatures found in Milford Haven and more localised increased temperatures, particularly in the lower Haven in Neyland marina, are providing environmental conditions closer to the optimal growth environment for *G. turuturu*.

Based on the survey in July 2013, the lower basin of Neyland marina exhibited a greater occurrence of *G. turuturu* compared to the upper basin despite the upper basin being more sheltered and shallower than the lower basin. One explanation could be extreme winter temperatures and a strong freshwater influence in the upper basin which is acting to limit spread its spread. As *G. turuturu* is often found in upper surface waters, it may be being influenced by the formation of ice in Neyland marina in the winter, further helping to inhibit expansion into the upper reaches of Neyland marina. Future surveys of this area may indicate whether this species is being inhibited by environmental factors in the marina, or whether it simply hasn't had sufficient time to take hold in this area.

## 4.2. Buoys and other floating structures

When considering Milford Haven as a whole, Neyland marina appears to be a localised hotspot for the presence of *G. turuturu* (See Figure 8). One explanation for this could be the increased survey intensity in Neyland marina (including all of the pontoons) compared to outside the marina where only floating structures such as boats and buoys were surveyed. On the other hand, the results show that the highest abundance of *G. turuturu* is within the marina, and this is consistent with a number of other studies describing marinas as hotspots for non-native species (Pearce *et al.* 2003; Ashton *et al.* 2012; Ruddock *et al.* 2008). Factors making marina's more susceptible to the introduction of marine INNS include: suitability of settlement surfaces (Tyrell & Byers, 2007), sheltered environment (Bax *et al.,* 2002) and effective introductory pathway through the high level of recreation and commercial boat traffic (Ashton, 2006).

The highest risk pathways associated with the introduction of non-native species are through commercial shipping, recreational boating and aquaculture such as farming oyster, clams, scallops and other molluscs (Naylor *et al.* 2001; Pearce *et al.* 2012). According to Pearce *et al.* (2012) 10 billion tonnes of ballast water, containing thousands of species are carried by ships every year. It is therefore known that commercial vessels are often the initial source of the introduction of a non native species into an area (Ashton *et* *al.* 2012). Recreational vessels tend to then spread the species within that area along the coast (Ashton *et al.* 2012). The attachment of organisms to the submerged surfaces of a marine vessel is called hull fouling (Ashton *et al.* 2012). It is likely that the initial vector for *G. turuturu* into the Milford Haven waterway came from either the import of shellfish or through ballast water, with translocation a result of natural dispersal and hull fouling.

It is estimated that invasive species cost Wales £4,928,000 per annum and mitigation and control is currently being carried out by a wide range of organisations in Wales (Jones *et al.* 2011). In order to understand and manage the introduction and translocation of marine non-native species, further research is needed to fully understand the biology and associated pathways (Jones *et al.* 2011). Forecasting the pathway of these potentially invasive species is important to prevent their spread when they do arrive (Eno 1996; Pearce *et al.* 2012).

Identifying high risk points of human-induced introduction is crucial (Eno 1996). Pathways such as vessel movements are high risk areas because vessels can be hotspots for marine non-native species (Pearce *et al.* 2012). The importance of early detection and action is evident as once a non-native becomes established, the prospects for eradication or even control can be poor (Ruddock *et al.* 2008; Pearce *et al.* 2003). Predicting where a particular species is most likely to arrive and how, as well as where it has the potential to establish, is crucial in preventing their spread (Pearce *et al.* 2012).

## *4.3.* Feasibility of eradication of *Grateloupia turuturu*

It is estimated that over 7000 species are transported in ballast waters everyday (Lyons and Scheibling 2009). The decision to eradicate a species depends on the overall costs, the potential negative impacts if nothing is done and the likelihood of success (Myers *et al.* 2000). Eradicating a species or even reducing its density is challenging (Myers *et al.* 2000). According to Pearce *et al.* (2012) in the marine environment, non-native species are almost impossible to eradicate once they have become established, however, if potential eradication attempts are to have any chance of success they must be accompanied by sufficient resources to fund the project to its conclusion (Myers *et al.* 2000). To date, no non-native marine species have been successfully eradicated from British waters (Eno *et al.* 1997; Genovesi 2005) highlighting the difficulties in successful eradication.

The control of the invasive carpet seasquirt *Didemnum vexillum* is currently under way in Holyhead marina in north Wales. *D. vexillum* is an invasive species as it out competes and smothers native flora and fauna. Eradication of this species has been attempted over a number of successive winters during the last few years, and although the population has been significantly reduced a full eradication has yet to be confirmed.

The most effective way to mitigate the effects of non-native species is to prevent their introduction (Pearce *et al.* 2012). Aquaculture – the farming of shellfish, fish and aquatic plants is one of the fastest growing sectors of the world food economy with global production more than doubling in value and volume in the last decade. Aquaculture now supplies more than one-third of seafood consumed worldwide. It is well documented that although the ecological impacts of mollusc related aquaculture (including the farming of oysters, mussels, clams and scallops) are small relative to other forms of aquaculture; mollusc farming is responsible for many invasions of non-native species (Naylor *et al.* 2001; Willis *et al.* 2004), and may have been the case with the introduction of *G. turuturu* into Milford Haven. However, through effective management and regulation of shellfish movements these risks could be mitigated.

In the studies of Eno (1996) marine plants spread more rapidly compared to invertebrate species. The removal of the invasive species *Sargassum muticum* has been attempted through removal by hand, by trawling, cutting as well as by using chemicals (Eno *et al.* 1996). These methods have failed either due to the lack of selectivity of the chemicals or the fact that these methods must be repeated multiple times and is therefore time consuming and costly (Eno *et al.* 1996).

# 5. Conclusion

Due to the lack of evidence around what effects, if any, *Grateloupia turuturu* has on local biodiversity and the surrounding environment, the species is not currently identified as invasive (Sweet 2011). More research is needed in order to confirm what the potential implications of this species are on native biodiversity. Specimens of *G. turuturu* were found throughout Neyland marina and the surrounding Milford Haven area with the greatest numbers being recorded in the lower basin of the Neyland marina. It is likely that optimal environmental conditions present in the lower basin of Neyland marina are preferable for this species allowing it to thrive and subsequently spread to other floating structures in the wider Milford Haven area. Of the buoys and floating structures surveyed in the wider Milford Haven area, 38% had *Grateloupia turuturu* growing on them, clearly demonstrating the relative ease of dispersion of this species.

*Grateloupia turuturu* has established more rapidly and to a greater extent than initially expected, therefore eradication of this species in Milford Haven is thought to be unfeasible at this time. However, the spread of *G. turuturu* to other areas of Wales and the UK could be slowed down by ensuring annual hull cleaning and an overall increased awareness of non-native species to include the appropriate guidance and biosecurity training to all relevant authorities.

The development of the upcoming EU IAS (Invasive Alien Species) Regulation and Marine Strategy Framework Directive 2010 (particularly Descriptor 2) acknowledge the clear need and importance of effective INNS management in Europe and the UK. However, these regulations and directives should be observed closely to ensure that they are ‘fit for purpose’ and provide the required statutory tools for effective marine INNS management in Europe and the UK. Key to the prevention of the introduction of non-natives is to forecast the pathways by which they are likely to be introduced (Pearce *et al.* 2012).

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# 7. Appendices

## Appendix 1. Details of each buoy and floating structure surveyed for *Grateloupia turturu.*

| Date | Lat_deg_min_sec | Long_deg_min_sec | Time | Notes | Photo number | Prescence (P/A) | Idenetifier(s) |
|---|---|---|---|---|---|---|---|
| 05/08/2013 | 051º42.132" | 004º56.355" | | Mooring buoy of S/Y 'Autonomy' near Hobbs point - small craft moornigs | | A | RB |
| 05/08/2013 | 051º42.068" | 004º56.368" | | Faded orange buoy HP4D. Small craft moornig near Hobbs point | | A | HL |
| 05/08/2013 | 051º41.996" | 004º56.553" | | Outside wall of Hobbs point slipway pontoon | | A | Rh, RB, HG |
| 05/08/2013 | 051º42.068" | 004º56.789" | | Neyland spit past marker buoy | | P | NO |
| 05/08/2013 | 051º41.924" | 004º56.818" | | North cardinal marker near Llanion | | P | RB |
| 05/08/2013 | 051º41.990" | 004º57.135" | | South cardinal marker near Traynor on Dockyard bank | | P | HL |
| 05/08/2013 | 051º42.054" | 004º57.075" | | Starboard marker buoy near DYB number 4 | | P | NO |
| 05/08/2013 | 051º42.188" | 004º56.917" | | Yellow marker buoy near Neyland point | | P | RB |
| 05/08/2013 | 051º42.247" | 004º56.994" | | Floating pontoon near Neyland point | | P | Rh, RB, HG |
| 05/08/2013 | 051º42.037" | 004º57.209" | | Mooring buoy DYB - Yello and black with large mooring ring | | Unsure | HL |
| 05/08/2013 | 051º42.061" | 004º57.265" | 10:42 | Targets on DYB-MBG 5-71 | 2848-2849 | P | HG, NO |
| 05/08/2013 | 051º42.042" | 004º57.334" | | Target TB11 on DYB | | A | RH |
| 05/08/2013 | 051º42.048" | 004º57.365" | | Unnumbered target | | P | HL |
| 05/08/2013 | 051º41.752" | 005º05.226" | | Red and white marker off Thorn point to Angle Bay | | A | HL, NO |
| 05/08/2013 | 051º41.633" | 005º05.475" | | Green marker buoy S3, between Thorn point and Angle Bay | | A | HG, RH |
| 05/08/2013 | 051º41.656" | 005º04.957" | 14:07 | North cardinal near Angle Bay. 'Al Khor' | 2875, 2877, 2878 | P | NO, HL |
| 05/08/2013 | 051º42.197" | 005º02.706" | | Red marker buoy Cunjic off Hakin point | 2879-2881 | P | HG |
| 05/08/2013 | 051º42.582" | 005º02.192" | | Pontoon at Milford dock near small craft moornigs - holding pontoon | | A | RH |
| 05/08/2013 | 051º42.564" | 005º02.239" | | Fishermans pontoon - Milford dock | | P | RH, NO, HL |
| 05/08/2013 | 051º42.206" | 005º01.687" | | Red marker buoy - Milford shelf | 2885 | P | RH, NO, HL, HG |
| 05/08/2013 | 051º42.103" | 004º57.657" | | Starboard marker buoy off Carr spit number 2 | | P | NO |
| 05/08/2013 | 051º42.212" | 004º57.863" | | Post marker buoy off Hazel beach | | P | RB |
| 05/08/2013 | 051º42.225" | 004º58.191" | | Pontoon - seasonal - Hazel beach | | A | RH,RB, NO, HL, HG |
| 05/08/2013 | 051º41.545" | 004º58.798" | | Red marker buoy near Pennar fkats | | P | NO |
| 05/08/2013 | 051º41.076" | 004º58.612" | | Red marker buoy - Crow pool, Pennar gut | | A | HL |
| 05/08/2013 | 051º41.104" | 004º58.548" | | Mooring buoy of Velonde at Crow pool, Pennar gut- PP1 | | A | NO |
| 05/08/2013 | 051º41.657" | 005º06.925" | | Starboard channel marker - Thorni chapel buoy | | A | RH |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 05/08/2013 | 051º42.441" | 005º09.086" | | Yellow buoys at entrance to Dale - dead slow marker | | A | RB |
| 05/08/2013 | 051º42.472" | 005º09.397 | | Floating pontoon M-Dale | | P | HL, RB |
| 05/08/2013 | 051º42.165" | 005º08.297" | | East cardinal near Dakotian | | A | RB |
| 05/08/2013 | 051º41.637" | 005º08.298" | | Angle, North C | | P | RH, NO |
| 05/08/2013 | 051º41.176" | 005º07.235" | 12:55 | Mill bay | | P | RH |
| 05/08/2013 | 051º40.275" | 005º10.535" | | Red marker buoy, St Anns | | A | RH, NO |
| 05/08/2013 | 051º40.190" | 005º10.122" | | West cardinal marker near St Anns mid channel | | A | HL, RB |
| 05/08/2013 | 051º40.233" | 005º08.979" | 13:27 | Red marker buoy - Rows rocks | 2870-2871 | P | RH, NO |
| 05/08/2013 | 051º40.062" | 005º08.277" | | Green marker buoy - 'Sheep' | | A | HL, RB |
| 05/08/2013 | 051º40.026" | 005º08.119" | 13:40 | Red marker buoy - E. Chapel | 2872-2874 | P | NO, RB |
| 05/08/2013 | 051º42.465" | 005º06.341" | | South cardinal - Montreal rock | | A | HG, HL |
| 02/08/2013 | 051º42.494" | 004º56.549" | 11:45 | Starboard marker (3 Knots) | | P | RH |
| 02/08/2013 | 051º42.445" | 004º56.544" | 11:49 | Port marker nearset Neyland (3 knots) | 2707-2710 | P | JL |
| 02/08/2013 | 051º42.422" | 004º56.504" | 11:56 | Starboard marker | 2711-2713 | A | ML, JV |
| 02/08/2013 | 051º42.412" | 004º56.512" | 11:58 | Port marker (3 knots) | 2714-2716 | P | JL |
| 02/08/2013 | 051º42.434" | 004º56.431" | 12:04 | Yellow hazard dredge pipe marker | | A | JV |
| 02/08/2013 | 051º42.233" | 004º56.272" | 12:11 | Mooring big orange block - HP091 | 2723-2724 | A | RH |
| 02/08/2013 | 051º42.291" | 004º56.200" | 12:14 | White/ pale pink mooring - HP12F | 2725-2727 | A | JV |
| 02/08/2013 | 051º42.312" | 004º56.076" | 12:17 | Large pink buoy near bridge HP19D | 2728 | A | JV |
| 02/08/2013 | 051º42.421" | 004º55.745" | 12:22 | Large orange mooring block, north side | 2719-2731 | A | RH |
| 02/08/2013 | 051º42.363" | 004º55.646" | 12:27 | Pink mooring B14 | 2732-2733 | A | JV |
| 02/08/2013 | 051º42.093" | 004º55.155" | 12:32 | Floating pontoon mid channel Cosheston pill | 2734-2736 | P | RH, JL |
| 02/08/2013 | 051º42.099" | 004º55.045" | 12:39 | Really big pink buoy WR12 | 2737 | A | JV |
| 02/08/2013 | 051º42.441" | 004º54.859" | 12:44 | Yellow weather station | 2738 | A | RH |
| 02/08/2013 | 051º42.477" | 004º54.756" | 12:47 | White mooring RB 15B | 2739-2740 | A | JV |
| 02/08/2013 | 051º42.523" | 004º54.585" | 12:52 | RB9A | 2741-2744 | A | RH |
| 02/08/2013 | 051º42.545" | 004º54.534" | 12:56 | RB8 | | A | JL |
| 02/08/2013 | 051º42.573" | 004º54.484" | 13:00 | Maisey star 93913 | 2745-2749 | A | RH, JV |
| 02/08/2013 | 051º42.616" | 004º54.396" | 13:05 | RB58 | 2750 | A | JL |
| 02/08/2013 | 051º42.628" | 004º54.221" | 13:08 | RB2B | 2752 | A | JV |
| 02/08/2013 | 051º42.662" | 004º53.349" | 13:17 | JP 13 | | A | RH |
| 02/08/2013 | 051º42.814" | 004º53.320" | 13:20 | Black hull without mast | | P | RH, JV |
| 02/08/2013 | 051º42.015" | 004º53.262" | 13:25 | Dead slow marker buoy east side of channel | | A | JL |
| 02/08/2013 | 051º43.029" | 004º52.407" | 14:50 | Dead slow marker buoy west side of channel | | A | JV |
| 02/08/2013 | 051º43.029" | 004º52.407" | 13:30 | Lawrenny Quay pontoon site | | A | LM, RB |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 02/08/2013 | 051º43.096" | 004º52.621" | 13:35 | Pontoon Lawrenny pub | | A | MC |
| 02/08/2013 | 051º45.087" | 004º52.476" | 13:40 | White buoy | 2773-2774 | A | JV |

Appendix 2. Additional marine species (including non-native species) recorded on various floating structures during the survey

| Floating structure | Grateloupia turuturu Present/ Absent | Additional species | Comments |
|---|---|---|---|
| Mooring buoy DYB | Unsure | Botrylloides violaceus | |
| | | Styella clava | abundant |
| Starboard marker buoy | Present | Botrylloides violaceus | abundant |
| | | Styella clava | abundant |
| Red marker buoy | Present | Sargassum muticum | Small amount |
| Starboard channel marker | Absent | Asterocarpa humilis | 1 |
| Floating pontoon | Present | Asterocarpa humilis | |
| | | Sargassum muticum | |
| Cardinal marker | Absent | Botrylloides violaceus | |
| | | Asterocarpa humilis | |
| Target | Present | Palmaria | abundant |
| | | Sargassum muticum | abundant |
| Target | Absent | Botrylloides violaceus | abundant |
| | | Palmaria | abundant |
| Boatyard rudders | Absent | Heterosiphonia japonica | |
| | | Sargassum muticum | |

# Data Archive Appendix

Data outputs associated with this project are archived as project 445, media 1486 on server–based storage at Natural Resources Wales.

The data archive contains:

[A] The final report in Microsoft Word and pdf format

[B] Species data in Microsoft excel

[C] A series of GIS layers on which the maps in the report are based

[D] A full set of images produced in jpg format

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue http://194.83.155.90/olibcgi by searching 'Dataset Titles'. The metadata is held as record no 115636.

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