Marine Institute
Project Ref: ITT17-020

To identify spawning, nurseries and essential habitat of endangered skates off the west coast of Ireland.

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Marine Dimensions

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We are also indebted to all those wonderfully dedicated volunteer observers who went to the trouble of reporting their sightings of mermaids' purses. Thanks also to the Shark Trust for sharing Great Eggcase Hunt citizen science sightings of eggcases reported on beaches in Ireland. We are also most grateful to the community in Tralee Bay who have embraced the project and shared their invaluable knowledge of the local marine environment.

Cover photo: White Skate eggcase. Credit: Sarah Varian/Marine Dimensions.

Summary

To identify spawning, nurseries and essential habitat of endangered skates off the west coast of Ireland is a conservation research project that aims to collect, collate and report the essential habitat, spawning and nursery sites for several species of endangered skate, ray and flat shark. Review of available scientific information has highlighted the importance of citizen science programmes and local community based observations for these species, with nursery areas for the endangered Undulate Ray *Raja undulata*, critically endangered White Skate *Rostroraja alba* and Flapper Skate *Dipturus intermedia* (Common Skate Complex *Dipturus batis*) identified through the Purse Search Shark and Ray Eggcase Sightings Scheme. Movement ecology for Undulate Ray, Common Skate and Angel Shark has also been reviewed through the Inland Fisheries Ireland Sportfish Tagging Programme. The effectiveness and reliability of citizen science sightings reported through Purse Search were subsequently investigated through a semi quantitative exploratory survey programme, carried out by biologists at key sites along the west coast. A simple index, the Nursery Hotspot Indicator (NHI) Index, was then developed for use as a tool for prioritising sites for further investigation and conservation management, including an ongoing monitoring programme that would monitor health and recovery of endangered species. Further investigation is recommended for high priority sites, including an eggcase tagging experiment that could be used to estimate egg deposition rates and movement relative to eggcase discard numbers recorded on beaches. Non-invasive techniques for monitoring movement ecology, eg. photo identification techniques and BRUV (baited remote underwater video), are also proposed.

Project background

The key importance of Irish coastal waters for endangered skates (and the skate-like angel shark) has now been established with the recent Red List of Irish Elasmobranchs, published by the National Parks and Wildlife Service, and recent advice from the International Council for the Exploration of the Seas. These species are subject to extreme threats due to by-catch in fishing gear and in two cases, Irish waters represent the last remaining refuge in the north Atlantic. The species in question are the White Skate, Common Skates, Undulate Ray, Common Stingray and the Angel Shark. In the context of Ireland's approach to meeting Good Environmental Status (GES) in the EU's Marine Strategy Framework Directive, it is necessary to conduct more research into these species, which can underpin future management initiatives.

A recital of the Council of the European Union, December 2016, stated that *"the current system of management of skates and rays under generic TACs could be improved to fully address the need to sustainably manage vulnerable species and data limited stocks and allow for the sustainable exploitation of commercially important species.*" Furthermore Ireland has an obligation to achieve good environmental status under the meaning of the Marine Strategy Framework Directive. In recognition of these objectives, the Marine Institute has initiated a project to improve the knowledge base for sustainable management and conservation of these endangered species.

The main Actions are as follows:

1. Strengthen the scientific basis on essential skate/shark habitat especially spawning and nursery areas.
2. Develop programmes to track recovery of the stocks, especially in essential habitats.
3. Propose measures to mitigate by-catch mortality.
4. Engage in public outreach to the above aims.

As part of the above described project, there is a requirement to identify spawning, nurseries and essential habitat of endangered skates off the west coast of Ireland. Marine Dimensions is the service provider being contracted (as of 15th June, 2017) to provide services relating to the outputs listed in the Tender Specification.

Objective

The objective of the project is to collect, collate and report the essential habitat, spawning and nursery sites for endangered skates off the west coast of Ireland.

Scientific team

Marine Institute	Dr Maurice Clarke	Project Director
Marine Dimensions	Dr Sarah Varian	Project Coordinator
	Eleanor Turner	Research Assistant
	William Mulville	Research Assistant
	Paula Farrell	Education and Research Assistant
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Paul Cuddihy	GIS, web development.

Project Strategy Outline

There is a paucity of published scientific information on endangered species of skate, ray and flat shark in Ireland in general, especially in relation to reproductive ecology and habitat resource distribution (Went, 1978; Shark Trust, 2009; Varian et al, 2010; Clarke et al, 2016). Much of the elasmobranch related research has focused on commercial species (Ellis et al, 2005; Gallagher 2005a, 2005b). However, a considerable body of information exists through citizen science programmes and local indigenous knowledge systems. These sources are the main focus of this project.

Indeed, considering the demonstrated potential of shark and ray citizen science programmes around the world (wildbook.org), it seems fitting to build and develop on these knowledge streams in Ireland so that validated observer data may be synthesised and integrated with traditional modelling approaches in fish stock assessment and conservation management. This is especially the case for rare and endangered species which present difficulties in terms of low numbers and greater effort in terms of sampling effectiveness. Non-invasive survey techniques are also desirable when monitoring vulnerable species, and wildlife conservation research projects around the world are now focusing on innovation in this area (wildbook.org).

With this in mind, the core strategy for the present project has been to develop a method whereby data sourced through Purse Search, Ireland's citizen science programme for egglaying sharks and rays, may be used to provide reliable indicators of the abundance and health of nursery areas for threatened populations of endangered egglaying skates. This public participation programme encourages people to report their observations of shark and ray eggcases (aka mermaids' purses) washed up on beaches around Ireland's coasts. To date, 738 purse reports have been received from observers over a period of 11 years, with a total of 13547 eggcases from 13 species of shark, skate and ray reported from locations around Ireland's coastline. Analysis of data reported by volunteer observers through 2007-2017 has also highlighted several sites that are likely to serve as nurseries for threatened species, including the endangered Undulate Ray *Raja undulata* and critically endangered White Skate *Rostroraja alba* and Common Skate *Dipturus batis* (Varian et al, 2010). The Purse Search scheme works alongside, and in collaboration with, other elasmobranch sightings schemes, such as the UK's Great Eggcase Hunt and the Irish Basking Shark Sightings Scheme.

Not all of the threatened species identified as a priority for the study could be monitored in this way, eg. the Common Stingray and Angel Shark give birth to live pups. It is therefore envisaged that habitats and nursery areas for these species would be monitored through the Marine Institute's fisheries observer programme, working with commercial and recreational fishers in hotspot areas. Citizen science sightings programmes could also be initiated for these species with emphasis on public sightings of adult fish by anglers, divers, swimmers and snorkellers. Resulting information could then be shared with other similar European schemes, such as the Angel Shark Conservation Network (Angelsharknetwork.com, 2017).

Community based participation, stakeholder interaction and outreach (online and offline) are also key components of the current project, both in relation to the citizen science element and for encouraging a community driven conservation management approach.

This includes a targeted education programme, a dedicated website and stakeholder outreach developed for hotspot regions.

Methodology

Identification of regional and local hotspots for future intense research efforts – developing tools for ongoing monitoring

Regional and local hotspot nursery areas for threatened species of egglaying skate were identified through a series of steps:

Step 1

The first step involved a preliminary review of available existing scientific information relating to critical habitats and reproductive ecology of endangered skates and flat sharks in Ireland. This included results from the Purse Search Ireland Shark and Ray Eggcase Sightings Scheme, Inland Fisheries Ireland's Sportfish Tagging Programme, and the Marine Institute's Groundfish Survey and Fisheries Observer Programmes.

Step 2

A number of follow up exploratory surveys were then carried out by scientists, with focus on sites identified as possible critical habitat indicators through Step 1.

It was hoped that the surveys could be used to:

- Determine and validate the effectiveness of using citizen science as a tool for highlighting threatened skate nursery areas and hotspots.

- Explore the scientific robustness of using beach eggcase surveys conducted by biologists as a tool for monitoring nursery areas, including determination of factors that might bias or skew results.

- To select key indicator sites that may be used to monitor the health and recovery of endangered species populations through a long term monitoring programme.

The surveys were semi-quantitative, with biologists recording the number and location of skate eggcases along the strand lines at each site. Biologists searched an area of approximately 3 metres either side of the upper strand line, as well as the back of the beach, as they proceeded to a marked end point. The surveyors then returned to the starting point, searching for eggcases along the lower strand line. The surveys were generally conducted by 1 or 2 biologists.

A number of environmental parameters were recorded, eg. wind strength, seaweed cover, temperature, beach substrate type and state of tides. The effect of citizen science (through the removal of eggcases) on sites was also considered.

Step 3

A simple index, ie. the Nursery Hotspot Indicator (NHI) Index, was then developed using a scoring system based on data resulting from Steps 1 and 2 (Table 1). Sites scoring greater than or equal to 2 are considered to be high priority hotspots warranting further investigation by scientists through a targeted research and monitoring programme. They are also considered to be key indicator sites suitable for long term monitoring over time. Sites with a score of 1 are considered to be of interest but of less of a priority; they should continue to be monitored through citizen science. Weight was given to sites where more than one threatened species was recorded and also where a site showed repeat observations of eggcases from the same species, either through citizen science or exploratory scientific surveys.

Note that this index has been developed for use with threatened species of egglaying shark and ray (ie. species that have been classified as either vulnerable, endangered or critically endangered according to the World Conservation Union's Red List Assessment criteria), using discarded eggcases as a variable for monitoring. However, it is envisaged that the Index may be modified further to include additional criteria with relevance to species that give birth to live young, using observations of Angel Shark and Stingray pups by citizen scientists, eg. anglers, divers. It should also be possible to include observations of eggs and pups observed through fisheries bycatch monitoring programmes.

Community based participation, stakeholder interaction and outreach

A comprehensive outreach programme was developed, including:

- Stakeholder outreach and engagement,
- Shark and Ray citizen science engagement and online recording,
- Website design and development,
- A schools education programme,
- Press and media coverage.

Table 1: The Nursery Hotspot Indicator Index for threatened species of egglaying shark and ray, used to prioritise areas for further investigation and ongoing monitoring programmes conducted by scientists.

	Criterion	Score	Action
1	No elasmobranch eggcases reported through citizen science (Purse Search or Great Eggcase Hunt).	No score / no data	These sites may have been surveyed in a casual way by citizen scientists who have not reported the lack of sightings to project scientists. Casual surveys are bound to be carried out as a result of Purse Search outreach; however observers rarely report zero sightings. It is recommended that these areas are surveyed through follow up exploratory surveys conducted by biologists if they are adjacent to areas scoring 2 or more.
2	At least 1 elasmobranch eggcase reported through citizen science, but no threatened species.	0 points.	Continue to survey through citizen science.
3	Site has had at least 1 eggcase from at least 1 threatened species of shark or ray verified through citizen science.	1 point.	Follow up with an exploratory scientific survey.
4	Site has had at least 1 eggcase from at least 1 threatened species of shark or ray verified through exploratory surveys by biologists.	1 point.	If the site's total score is 1, conduct a repeat exploratory survey at a later date and continue to monitor with citizen science. If the score is 2, select site for further investigation and ongoing monitoring.
5	Site has had eggcases from the same species of threatened shark or ray verified through citizen science and recorded on more than one occasion (ie. on separate dates).	1 point	Follow up with exploratory survey, select for ongoing monitoring and more detailed quantitative investigation.
6	Site has had eggcases from 2 threatened species verified through citizen science or exploratory surveys.	1 point	Follow up with exploratory survey if necessary, select for ongoing monitoring and more detailed quantitative investigation.
7	Site has had eggcases from 3 threatened species verified through citizen science or exploratory surveys.	1 point	Follow up with exploratory survey if necessary, select for ongoing monitoring and more detailed quantitative investigation.
8	Site has had eggcases from 4 threatened species verified through citizen science or exploratory surveys.	1 point	Follow up with exploratory survey if necessary, select for ongoing monitoring and more detailed quantitative investigation.

Maximum total score is 6. Sites scoring 2 or above should be selected for ongoing monitoring and more detailed quantitative investigation. The higher the score, the higher the priority in terms of requirements for conservation management investment.

Results and Discussion

Identification of regional and local hotspots for future intense research efforts

Review of available existing scientific information and citizen science programmes

The Purse Search Ireland Shark and Ray Eggcase Sightings Scheme

(i) Eggcase sightings and data accuracy

Collation of skate eggcase location data reported through Purse Search was found to be an effective means of highlighting sites likely to serve as nursery areas for endangered egglaying species. The citizen science scheme, which has been running since 2007, assesses reliability and accuracy of observer sightings through operation of a protocol which involves 3 phases of action (Table 2, Varian et al, 2010). This involves a requirement for provision of photographs and/or eggcase samples by volunteer observers for the purpose of verifying species identification, thus enhancing accuracy of information. Of the reports received, 76% of observers sent eggcase samples or photographs on to the project scientists for identification, improving quality of information. A small percentage of eggcases (2%) could also be identified using the description provided by the observer on the purse sightings form. Spatial resolution of sightings is also assessed relative to specified criteria; groomed data presented in the maps in this report approximate an accuracy level of less than 2km.

Although there were some sightings of skate eggs underwater (with 3% of recording forms submitted by divers), the vast majority of eggcase records represent incidental sightings of discarded eggcases washed up on beaches around Ireland's coastline. A number of sightings were also referred on to Marine Dimensions by the Shark Trust's Great Eggcase Hunt in the UK (Varian et al, 2010).

(ii) Species identification and eggcase distribution

Figure 1 shows the distribution of all elasmobranch eggcase sightings reported by volunteer observers around Ireland from 07-17. Of the 12431 elasmobranch eggcases identified to species level by project scientists, 418 (3%) were found to be from endangered species of skate (Table 3). A number of sites on the west coast were also highlighted as being possible nursery hotspot indicator sites following review of the Purse Search Ireland Shark and Ray Eggcase Sightings Scheme data.

Although Undulate Ray eggcases were sighted most frequently, the vast majority were reported from beaches in the Tralee Bay area (Fig. 2), with only one confirmed sighting recorded further north on Ladies Beach in Ballybunion. Unconfirmed sightings were recorded in Dingle Bay and Galway Bay.

There were 30 confirmed reports of eggcases from the critically endangered Common Skate, which is now recognised as two species, the Flapper Skate and the Blue Skate. Flapper Skate purses were recorded at sites along the west coast, including Donegal, Sligo, Galway, Mayo, Clare, Kerry and Cork (Fig. 3).

Only one Blue Skate eggcase has been identified, with a confirmed sighting in Barley Cove, Co. Cork in 2010 (Fig. 4). This purse could not be identified correctly until 2013 (it was previously thought that it might be a Long Nosed Skate eggcase), when work by

the Shark Trust clarified the differences in eggcase morphology between the two Common Skate species.

A total of 56 eggcases were identified as being from the extremely rare and critically endangered White Skate, with the vast majority sighted in the Tralee Bay area (Fig. 5). Sightings were also confirmed for Tawin Island in Galway Bay and for Tullaghan Bay in Co. Leitrim. Three live White Skate embryos have been recorded throughout the course of the project, two of which were incidentally sampled during an inshore survey conducted by Tralee Institute of Technology on the Celtic Voyager in 2010; the other embryo was collected from the Galway Bay area by a fisherman in 2004 (exact location unknown). The fish was brought to Galway Atlantaquaria and was subsquently hand reared. This individual, named Valentine, was a popular attraction at the aquarium for a number of years. She started laying eggs in her 8th year. However, the fish unfortunately died in 2017 and a post mortem has now been carried out by the Marine Institute, the results of which are being prepared for publication.

Table 2: The three phases of action experienced by volunteer observers participating in the Purse Search Shark and Ray Eggcase Sightings Scheme.

Phase	**Action**	**Outcome**
1. Education and outreach	Potential volunteer observers are informed about the project through: (a) school workshops (b) public outreach events (c) press and media coverage (d) flyers (e) website info (f) social media Observers are asked to report their observations online through the Purse Search project page at marinedimensions.ie. It is also requested that they post a sample or send a photograph of the purse on to the project scientists in order to confirm species identification.	Public awareness is raised. Approximately 10,000 people per year are informed through face to face events, with many more informed through press and media coverage.
2. Exploration and discovery	Volunteers discover purses either (a) incidentally on a beach walk or (b) intentionally through a beach survey	Learning is consolidated through outdoor exploration and discovery. Observations may or may not be reported to Marine Dimensions at this stage.
3. Reporting	Volunteers report the sighting online through a recording form or via land mail. The observation may be reported in one of three ways: (a) with no description, photo or sample of the purse, (b) with a description or photo of the purse, but no sample, (c) with a description and/or photo, and sample of the purse. Following receipt of the information, the project scientist e-mails the observer to give them the results of their report and to thank them for their participation.	The sightings are included in the Purse Search database and species identified are classified as either confirmed or unconfirmed, depending on the quality of information provided by the observer through actions (a)-(c): (a) is classified as unconfirmed, (b) may be classified as unconfirmed or confirmed, depending on the quality of information provided, (c) is classified as confirmed once the eggcase is in good condition.

Table 3: Total number of eggcases identified for each endangered egglaying species, reported by volunteer observers to Purse Search from 2007-2017.

Species name	Common name	No. eggcases (confirmed)	No. eggcases (unconfirmed)
Raja undulata	Undulate ray	332	71
Dipturus batis	Common skate	30	1
Dipturus intermedia	Flapper skate	29	1
Dipturus flossada	Blue skate	1	0
*Rostroraja alb*a	White skate	56	1

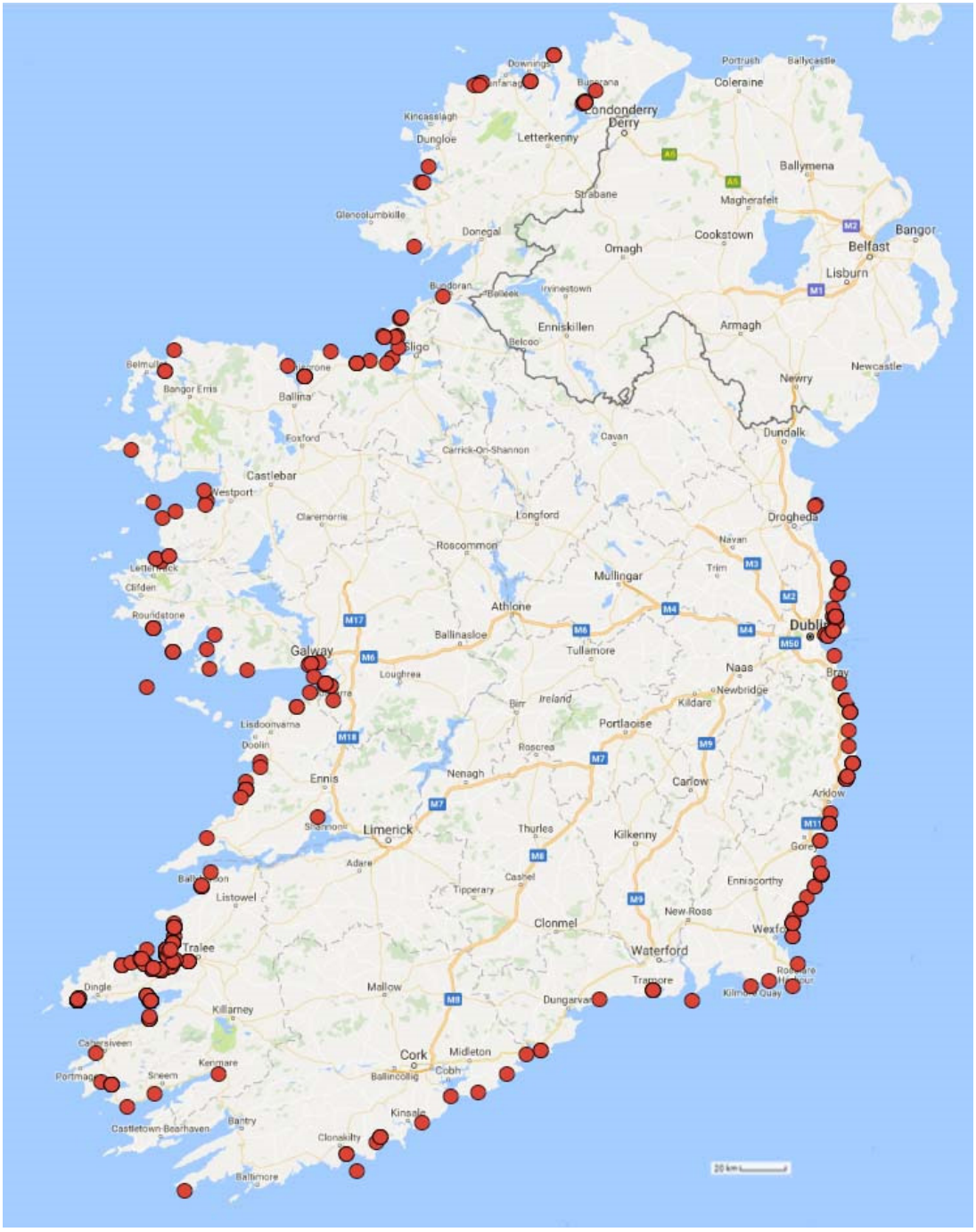

Figure 1: Distribution of elasmobranch eggcase sightings around Ireland's coastline reported to Purse Search Ireland by volunteer observers from 2007-2017.

Figure 2: Distribution of Undulate Ray, *Raja undulata*, eggcases around Ireland's coastline reported by volunteer observers through Purse Search Ireland from 2007 to 2017.

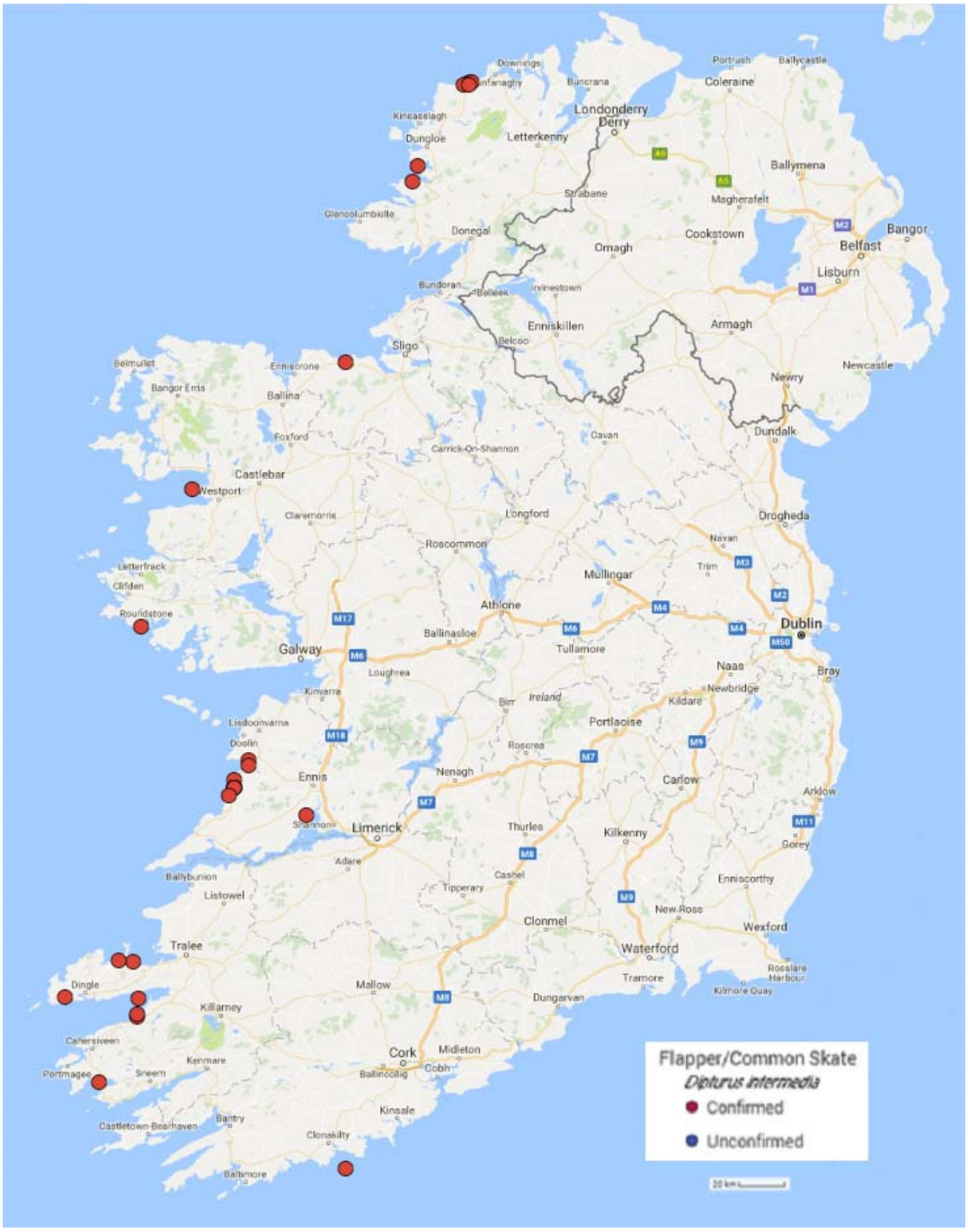

Figure 3: Distribution of Flapper Skate, *Dipturus intermedia*, (aka Common Skate, *Dipturus batis*) eggcases around Ireland's coastline reported by volunteer observers through Purse Search Ireland from 2007 to 2017.

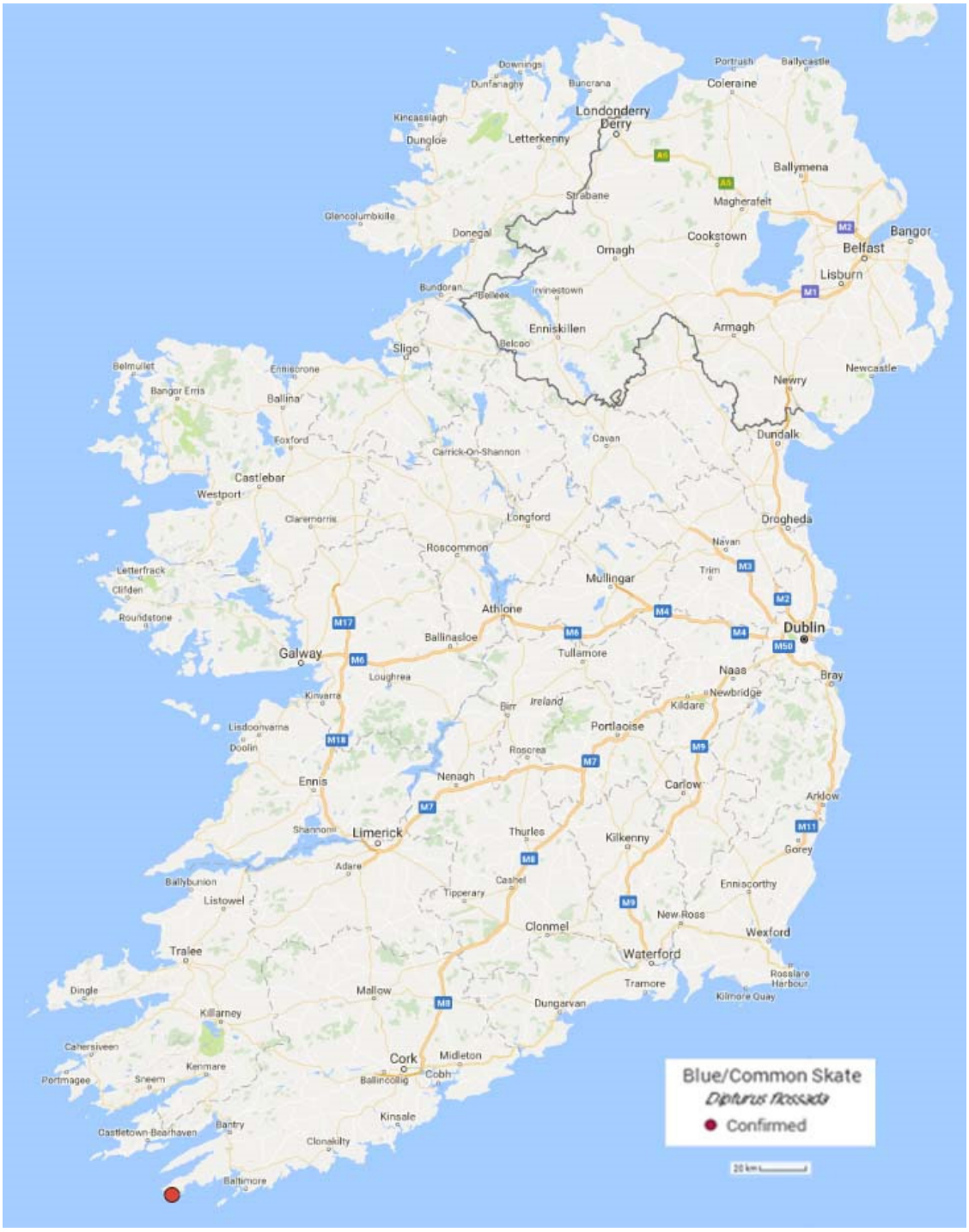

Figure 4: Distribution of Blue Skate, *Dipturus flossada*, (aka Common Skate, *Dipturus batis*), eggcases around Ireland's coastline reported by volunteer observers through Purse Search Ireland from 2007 to 2017.

Figure 5: Distribution of White Skate, *Rostroraja alba*, eggcases around Ireland's coastline reported by volunteer observers through Purse Search Ireland from 2007 to 2017.

Inland Fisheries Ireland Sportfish Tagging Programme

Inland Fisheries Ireland's Sportfish Tagging Programme has highlighted movement ecology for several endangered species, including capture/recapture records for the Undulate Ray, Angel Shark and Common Skate up to the year 2014 (WogerBauer et al, 2014). A meeting with the IFI and MI has taken place and strategic partnerships in relation to data gathering and analysis have been discussed.

Marine Institute Fisheries Observer Programme

A protocol has been set up for monitoring skate egg samples collected through the Marine Institute's nationwide Groundfish Survey Programme. Data relating to the distribution and abundance of endangered flat shark and egglaying skate species are also being collated by the Fisheries Ecosystems Advisory Service. Bycatch records resulting from the Tralee Bay Crayfish Diversification project are being used to inform prioritisation for research relating to the current project going forward.

The follow up exploratory survey programme

A total of 48 exploratory surveys were carried out by biologists at sites highlighted by the Purse Search review, including beach eggcase surveys conducted in Cork, Kerry, Clare, Galway and Donegal (Fig. 6).

The use of snorkel surveys in addition to beach eggcase surveys has also been investigated as a possible monitoring technique, with two snorkel surveys conducted in Tralee Bay. As a result, several subtidal sites, initially flagged by citizen scientists, have now been confirmed as hotspots for Common Stingrays. Preliminary observations also suggest that there may be an association between this species and seagrass beds in the bay.

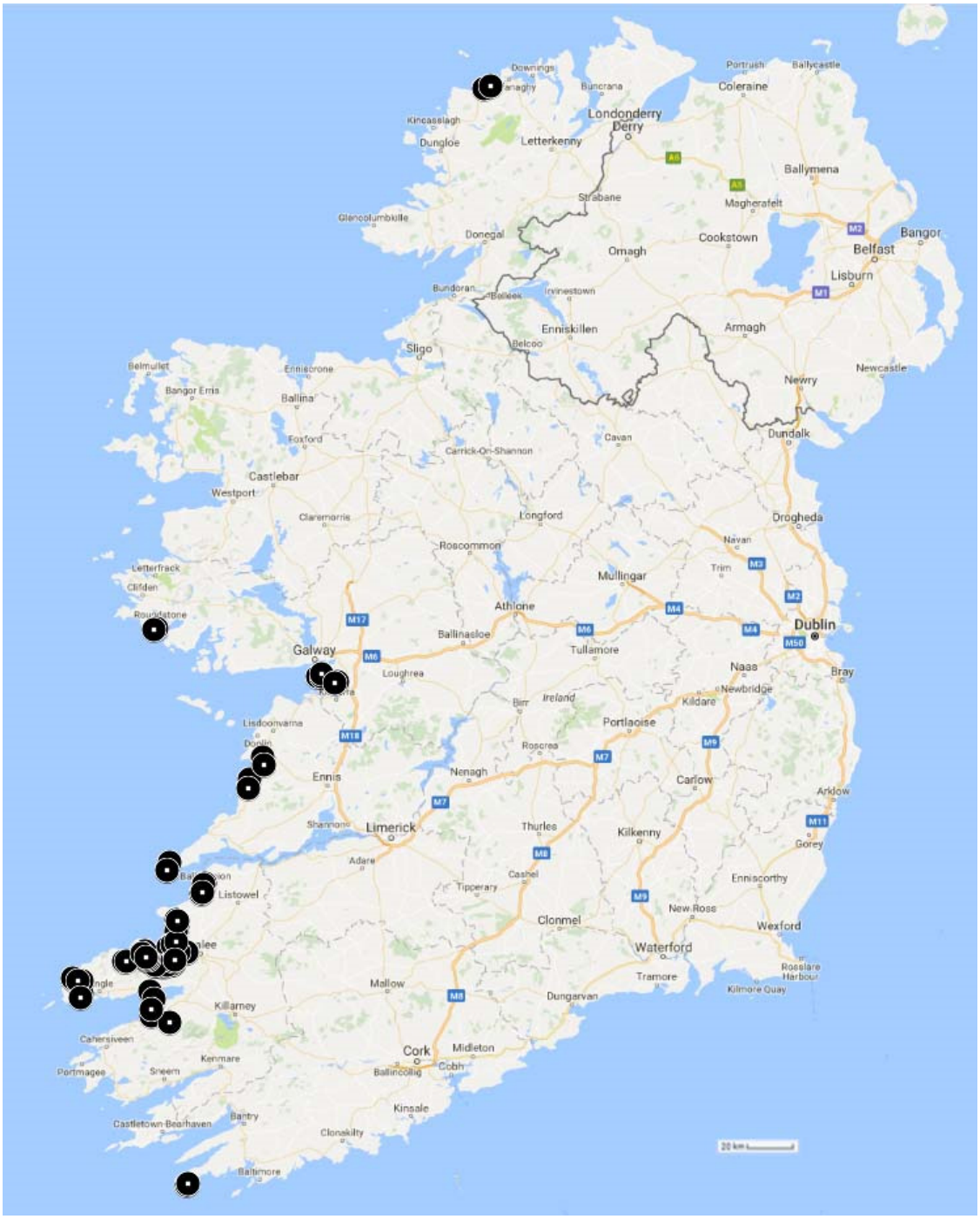

Figure 6: Follow up exploratory survey site locations conducted by biologists in areas highlighted by Purse Search as potential nursery areas.

The Nursery Hotspot Indicator (NHI) Index

All sites identified through Purse Search eggcase reports were evaluated according to the NHI Index score system and criteria outlined in Table 1. Several locations have been identified as being possible nursery and/or critical habitat indicator sites, with potential for tracking recovery of endangered species over time. These include sites along the Tralee Bay, Galway Bay and Donegal coastline. The maximum score calculated for any one site was 4; several of these high priority sites were located in Tralee Bay. The list of sites and related scores has been submitted to the Marine Institute.

Community-based participation, stakeholder interaction and outreach

Stakeholder outreach and engagement

Outreach relating to stakeholder interaction has focused on the Tralee Bay area to date; the site was prioritised due to its importance as a critical habitat and/or nursery area for 5 of the 6 species (identified through the evaluation of data in Step 1). The species are White Skate, Flapper Skate, Undulate Ray, Common Stingray and Angel Shark.

Initial meetings have taken place with key contacts in the community established as a result of previous outreach conducted through the Purse Search programme and Heritage Council funded projects (Varian et al., 2010), including liaison with recreational fishers, chartered angling skippers and volunteer Purse Search observers. The approach to date has been informal with communications prioritising a community driven approach.

Contact has also been made with Environmental Awareness Officers and Biodiversity Officers in Local Authorities of Counties on the west coast (eg. Kerry County Council, Limerick County Council, Clare County Council and Donegal County Council) with a view to running endangered species outreach programmes in the future.

A contact list of potential interviewees has also been compiled, including volunteer Purse Search observers, recreational fishers, commercial fishers, ecotourism operators, government agency officers, local authority officers and other interested community members.

Shark and Ray citizen science engagement and online recording

The Purse Search programme has been relaunched and the public are being actively encouraged to report their sightings of shark and ray eggcases again. New volunteer observers are constantly being recruited through Marine Dimensions' education and outreach programme, while existing volunteer observers, recruited as far back as 2007, are becoming active again.

Validated sightings of eggcases from endangered species of skate have been reported by volunteer observers since the project has been relaunched, including eggcases from the White Skate, Flapper Skate and Undulate Ray.

Awareness has been raised for Ireland's egglaying sharks and rays through the Purse Search project, with emphasis on the endangered species considered in the present study. Numerous public engagement events in libraries, festivals and schools, have taken place around the country, including workshops in Wexford, Donegal, Dublin, Wicklow, Clare,

Kilkenny and Limerick. Some of these events have received funding from relevant local authorities, the Department of Communications, Housing and Local Planning and the Agenda 21 Partnership Fund. In addition, festival events have also been sponsored by Dublin City Council and the Royal Dublin Society.

The project has also been promoted through Marine Dimensions' popular *Introduction to Marine Biology for Teens* course and *Kids Sea Camps*. Further promotion through social media and the publication of the new website is likely to further increase engagement for the project over the coming months.

Website design and development

A new website, https://raysawareness.ie, has been set up, incorporating a flexible Wordpress platform with a user-friendly interface suitable for citizen science style projects. The site will continue to be developed over time, with new content and social media engagement driving traffic to the site. The site will also be promoted through Marine Dimensions' active outreach programme and the Marine Institute's Explorer Education Programme.

A new improved online reporting tool has also been developed for the Purse Search project citizen science sightings at: https://marinedimensions.ie/mermaid-purse-sightings-form/). The tool accommodates uploading of images and site location; it is also mobile responsive, allowing observers to report sightings directly via their smartphone while in the field.

Schools education programme

A pilot education programme for endangered species of egglaying rays and flat sharks is currently being developed through the Marine Institute's Explorers Education Programme. This Programme currently delivers over 500 modules to schools around the country, with Education Centres targeting key areas of interest (eg. critical habitats and hotspot nursery areas) for the conservation management of endangered species.

Outreach will also be included in Marine Dimensions Ocean School Programme which includes over 100 events in 2018. The school's Marine Experience workshop has been found to be highly effective and instrumental in motivating citizen science follow through in relation to eggcase sightings reported to the project by volunteer observers.

Feedback obtained from schools visited in the past has suggested that children attending workshops go on to educate and inspire their families as result of their experience.

Press and media coverage

An article has been published in The Irish Times by Sylvia Thompson announcing the relaunch of the Purse Search project. However, emphasis to date has been on face to face outreach events and online outreach. There is considerable scope for developing press and media coverage further as the project progresses into the future.

Establishing a programme to track recovery of species

It is recommended that the programme to track recovery of endangered species includes the following:

- Continuation of the Purse Search citizen science programme in order to monitor sites highlighted by the NHI index and continue engagement with the public.

- Prioritisation of research and conservation management at sites scoring greater than or equal to 2 by the NHI Index. High priority sites such as Tralee Bay should include:

    - Monthly beach eggcase surveys conducted by scientists to monitor health and restoration of endangered skate populations. These surveys would also likely shed light on the extent and duration of spawning seasons for White Skate, Undulate Ray and Flapper Skate.

    - Fine tuning of the semi quantitative survey technique relative to the influence of environmental parameters (abiotic and biotic) recorded.

    - An eggcase tagging experiment that could estimate the seabed to beach eggcase deposition ratio, ie the number of eggcases that are likely to wash up on beaches relative to the number of eggcases that are actually discarded by hatchlings on the seabed. Such a survey would allow finer resolution of dispersal patterns. It is envisaged that sightings of tagged eggcases washed up on beaches could also be incorporated into the local outreach programme for schools.

    - The development of non-invasive tools, such as photo identification and BRUV (baited remote underwater video) for tracking and monitoring movement of endangered species of skate and shark. Open source software (eg. Wildbook.org, 2017) that could link in with the new endangered species website could be used to run a citizen science project encouraging anglers, snorkellers and divers etc. to report and upload their photos of Undulate Ray and Common Skate. A number of photo ID projects are already being run successfully for Manta Rays and Whale Sharks (eg. *Manta Matcha*; www.mantamatcha.org and *Wildbook for Whale Sharks*; www.whaleshark.org), using the unique natural spot patterns of individuals as a basis for photo ID matching. It is likely that a similar methodology could be employed for skate species; Undulate Rays, White Skate and Flapper Skate display distinctive patterns and spots on their dorsal surface that appear to be unique to individuals. The project could also be easily linked in with the current network of observers developed through the Purse Search citizen science programme. The project idea has been discussed with Tralee Bay Sea Angling Club and they are keen to be involved.

    - Collection and analysis of DNA samples (using non-invasive methods) for endangered species.

    - An associated outreach programme targeting commercial fishers and anglers that would include information, education and training on how to

minimise the adverse effects of handling endangered species on board vessels.

Conclusions

The deliverables arising from the current project are likely to be far reaching, with methodologies being developed that may be used to monitor and raise awareness for threatened species of skate and ray on an international basis. Work to date has demonstrated the importance of Tralee Bay as a critical habitat for several endangered species and it is hoped that we will now be able to further refine the survey techniques being used to track recovery.

References

Clarke, M., Farrell, E.D., Roche, W., Murray, T.E., Foster, S. and Marnell, F. 2016. *Ireland Red List No. 11: Cartilaginous fish [sharks, skates, rays and chimaeras].* National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs. Dublin, Ireland.

Ellis, J.R., Cruz-Martinez, A., Rackham, B.D. and Rogers, S.I. 2005. The distribution of chondrichthyan fishes around the British Isles and implications for conservation. *J. Northw. Atl. Fish. Sci*., **35**: 195-213.

Gallagher, M.J., Jeal, F. and Nolan, C.P. 2005a. An investigation of the Irish ray fishery in ICES Divisions VIIa and VIIg. *J. Northw. Atl. Fish. Sci*. **35**: 1-13.

Gallagher, M.J., Nolan, C.P. and Jeal, F. 2005b. Age, growth and maturity of the commercial ray species from the Irish Sea. *J. Northw. Atl. Fish. Sci*. **35**: 47-66.

https://angelsharknetwork.com/. 2017.

http://wildbook.org. 2017.

Shark Trust, 2009. *Sharks: An identification guide to the Sharks, Skates, Rays and Chimaeras*. Volume 1: The British Isles. Chapter 1 – Skates and Rays. The Shark Trust. Plymouth, UK.

Varian, S. J., Dunagan, K. and Moloney, A. 2010. Purse Search Ireland: To investigate critical habitats for threatened species of shark and ray. Final Report Heritage Research Grant Project R00261.

Went, E.J. 1978. *Specimen skates and rays taken in Irish waters (1956 – 1975).* Report from the Irish Specimen Fish Committee. 19-30.

Wildbook.org, 2017.

Wogerbauer, C., O'Reilly, S., Green, P. and Roche, W. 2014. IFI Marine Sportfish Tagging Programme – Preliminary results for selected species. Inland Fisheries Ireland Report No: IFI/2014/1-4231.