

Manx Marine Environmental Assessment
Ecology / Biodiversity
Protected Species

Basking Sharks



A basking shark in Manx waters. Photo: Anders Salesjö

MMEA Chapter 3.5

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Manx Marine Environmental Assessment

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Basking Sharks

Summary

- Basking sharks are fully protected under Isle of Man legislation and are on the OSPAR list of Threatened and Declining Species.
- Internationally, the global basking shark population is thought to be very small and the species is in the IUCN Red List Vulnerable category, with the Northeast Atlantic stock assessed as Endangered.
- The Isle of Man is now recognised as a global hotspot for basking sharks.
- Basking sharks are most commonly observed in Manx waters during the summer months (May to August). June and July are the peak months for sightings. Sightings are made from September through to April but are rare.
- Most basking sharks are reported from the coastal waters of the Isle of Man from Kirk Michael round to Langness, but they are frequently observed all along the west coast and they can be observed all around the Island.
- Between 2005 and 2016, an average of 332 basking shark sightings were reported each year by the public, ranging from 47 sightings in 2016 to 877 sightings in 2009.
- At least 90 different individual basking sharks have been identified in Manx waters using fin identification and the numbers continue to rise with additional survey effort.
- The Isle of Man is thought to be important for basking shark breeding, with many sharks observed engaged in what is thought to be courtship behaviour.
- There are also high incidences of young basking sharks and breaching basking sharks.
- Satellite tagging research has shown that the majority of sharks tagged in Manx waters remained in the Irish and Celtic seas. Only one tagged shark made a much longer migration, travelling 9589km across the Atlantic and reaching depths of 1264m.
- Based on initial analysis of genetic, satellite tagging and photo-identification data, sharks observed in Manx waters are thought to be a small numbers of individuals, mainly site-attached but occasionally joined by wider-ranging migrants.
- Bycatch in fisheries and intentional capture for fins continue to be threats to basking sharks globally. The main threats to basking sharks in Manx waters are currently thought to be the risk of boat collisions and disturbance by boating activity.
- Basking sharks are observed at the surface of the sea, but tagging work carried out in Manx waters has shown that they spend significant amounts of time at depth. Impacts on basking sharks at depth should therefore also be considered in Environmental Impact Assessments.
- Elasmobranchs (members of the shark family) are known to be affected by Electro Magnetic Fields (EMF) but no specific work has been done on the impacts of EMF on basking sharks.
- Environmental Impact Assessments for the development of electricity infrastructure in areas used by basking sharks should assess potential impacts of EMF on basking shark behaviour and ecology.

Introduction

Over the past two decades the Isle of Man has become known for its importance for basking sharks, and for basking shark research and conservation.

The Isle of Man was the first jurisdiction in the British Isles to give basking sharks statutory protection. Basking sharks have been protected under the Manx Wildlife Act since the legislation was implemented in 1990. Under the Manx Wildlife Act basking sharks are protected from injury, capture and also from disturbance, intentional or reckless.

The basking shark *Cetorhinus maximus* (Gunnerus, 1765) is currently listed as globally vulnerable and endangered in the North East Atlantic on the IUCN Red List of Threatened Species. <https://www.iucnredlist.org/search?query=basking%20shark&searchType=species>

It is also on the OSPAR Convention for the Protection of the Marine Environment of the North East Atlantic List of Threatened and/or Declining Species and Habitats, as under threat or in decline in all OSPAR regions.

The Manx Gaelic names for the basking shark are *Gobbag vooar*, which means big mouth, or *Sharkagh souree* which means summer shark. As planktivorous filter feeders, basking sharks may reach 10m or more in length and up to 7 tonnes. Very little is known about the reproduction of basking sharks. It is a very slow breeder, with a long gestation period that is estimated to be between 12-36 months, resulting in the birth of up to 6 live young of 1.5-1.8m length.



Figure 1. A feeding basking shark in Manx waters. Photo: M Mitchell.

Basking sharks are found worldwide in temperate seas (Compagno 1984). Recent tracking work in North America has also revealed that they also spend time travelling through tropical waters, in the Caribbean and off Brazil (Skomal *et al.* 2009). Anthropogenic impacts such as fishing and accidental by-catch are thought to have dramatically reduced the population size. Genetic work indicates that there appears to be global genetic mixing and that there may be only be a remnant global population of 6-8,000 breeding females (Noble *et al.* 2006). Recent research has suggested that the population in the North East Atlantic may now be showing signs of population recovery following overexploitation in the twentieth century (Witt *et al.* 2012).

Historically, basking sharks were hunted for their liver oil and they are still hunted for their fins in some places (Magnussen *et al.* 2007). They are still vulnerable to accidental capture in fisheries, for example in the New Zealand trawl and set net fisheries (Francis and Smith 2010).

Basking sharks are seen inshore in many coastal areas of the British Isles, with hotspots occurring around Cornwall, North-West Scotland and the Isle of Man (Bloomfield and Solandt 2008, Witt 2012). Figure 2 shows basking shark sightings reported to the Marine Conservation Society's Basking Shark Watch for 1987-2006 (reproduced with permission from Bloomfield and Solandt 2008).

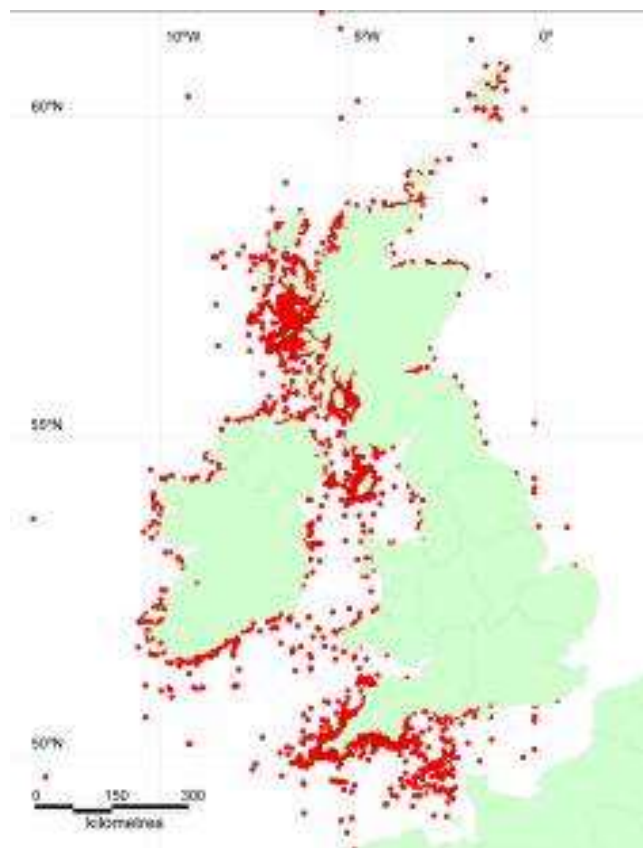


Figure 2. Marine Conservation Society public sightings 1987-2006 (from Bloomfield & Solandt 2008).

The Isle of Man is probably the best place in the world to study and watch basking sharks close inshore because most sightings are reported along a 40km-long stretch of the Isle of Man's south-western quarter. This gives good boat access to basking shark hotspots and also many opportunities to observe basking sharks from shore.

Manx Basking Shark Watch

There is a relatively long history of basking shark research in the Isle of Man. In the 1980s and 1990s The Basking Shark Project, run by Ken Watterson and supported by many local volunteers, carried out basking shark research and awareness-raising. The organisation helped to raise the global profile of basking sharks and played an important role in influencing policy to include basking sharks on protected species lists in the Isle of Man and the UK.

Manx Basking Shark Watch (MBSW) was a Manx Wildlife Trust (MWT) project. It was started in 2004 after the Marine Conservation Society (UK) asked the Marine Committee of the Manx Wildlife Trust to start a Manx basking shark sighting scheme to record basking shark sightings reported by the public to feed into the MCS Basking Shark Watch scheme. It is now a separate charity, established in 2015.

It has considerably extended its remit since then and MBSW now has three main aims, with the overall goal of better protection for basking sharks:

Main aims of Manx Basking Shark Watch:

- 1) Raise public awareness of basking sharks,
- 2) Research basking shark biology, behaviour and distribution,
- 3) Collaborate with other organisations to make best use of research for management.

Jackie Hall has coordinated MBSW and its research since its inception. MBSW is supported by a growing team of volunteers. MBSW now runs a comprehensive research and educational program with many aspects including:

Educational activities

- The MBSW website features an active news site and educational material at: <http://www.manxbaskingsharkwatch.org/>
- MBSW online public sightings scheme where the public report their basking shark sightings and put their images online
- Working with TV companies and wildlife film makers
- Public presentations and news articles

Research Activities

- Analysis of public sightings data
- Effort based boat surveys and land-based surveys
- Satellite-tagging of basking sharks

- A dorsal-fin identification catalogue
- A 'Basking Shark Passport' programme
- Research into putative courtship behaviour
- Research into hormone mimics in the environment

Manx Basking Shark Watch Public Sightings Scheme

The Marine Conservation Society (UK) has run their Britain-wide 'Basking Shark Watch' since 1987. In 2004 the Manx Wildlife Trust worked in partnership with the Marine Conservation Society to set up Manx Basking Shark Watch as a local scheme for Manx waters, which is now run as a separate charity. The initial aim of the MBSW public sighting's scheme aim was to collect data from the general public about their basking shark sightings and to compile this in a way that is compatible with the MCS scheme. The success of this scheme has resulted in a large dataset of thousands of opportunistic sightings. Whilst these records are not necessarily scientifically robust, after 13 years of recording they provide a good indication of general patterns and trends in basking shark occurrence and distribution.

Collecting public sightings information also provides invaluable scientific data from all around the Island. This would not be possible if just a few volunteers or scientists were doing effort-based watches from a boat or from the shore. It not only makes the public aware of the basking sharks in Manx waters but it also gives them a sense of ownership and responsibility towards them. Public engagement is key to the continuing success of this project. The majority of sightings are now collected online on <http://www.manxbaskingsharkwatch.org/> All the reports and photographs are verified by a team of volunteers and then placed online for the public to see.

MBSW has a policy of sharing the public sightings data but the private details of the reporters are removed first. In return MBSW requires that it is recognised in any resulting publications. The scheme is enormously successful and popular with the Manx public and tourists. Nearly 900 people have registered to report their sightings but the majority of reports come from a smaller core group of people who are very keen basking shark watchers. Manx Basking Shark Watch also have a good relationship with many local boat skippers and receive up to date reports of sightings from vessels and individuals around the Isle of Man during the season.

Data from public sightings

Basking sharks sightings in Manx waters are highly skewed to the time period between the middle of May & middle of August so all the analysis presented in this chapter is restricted to these months.

The public sightings scheme has been collecting opportunistic sightings since 2005, with the online reporting system on the MBSW website starting in 2007. Figure 3 shows all verified public sightings from 2005 to 2016.

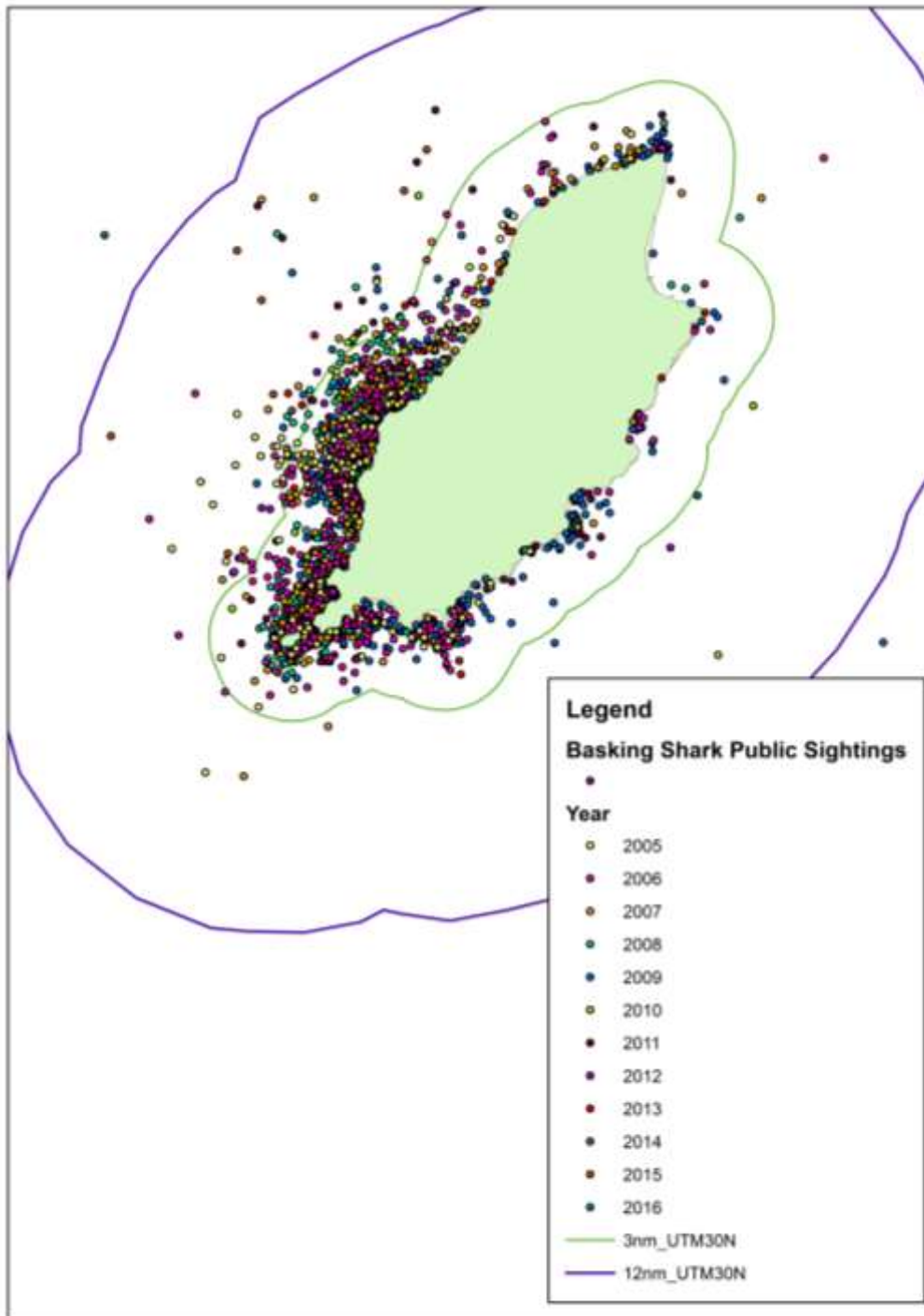


Figure 3. All verified public sightings reported to Manx Basking Shark Watch between 2005 and 2016.

Figure 3 gives a good overview of basking shark distributions albeit heavily influenced by where most people are watching basking sharks. The map shows how public sightings are particularly high in coastal waters from Kirk Michael on the west coast round to Santon on the east coast. There are also many additional sightings around other areas of the coast.

Although every sighting to the website is logged, it is recognised that several different people may be reporting the same shark. This is especially true in areas which have a high

public presence, such as Peel or Port Erin. However, it is difficult to be certain which records are repeats and which are not, therefore all records are included. Figure 4 shows the breakdown of numbers of sightings (which can be of more than one shark) seen each month.

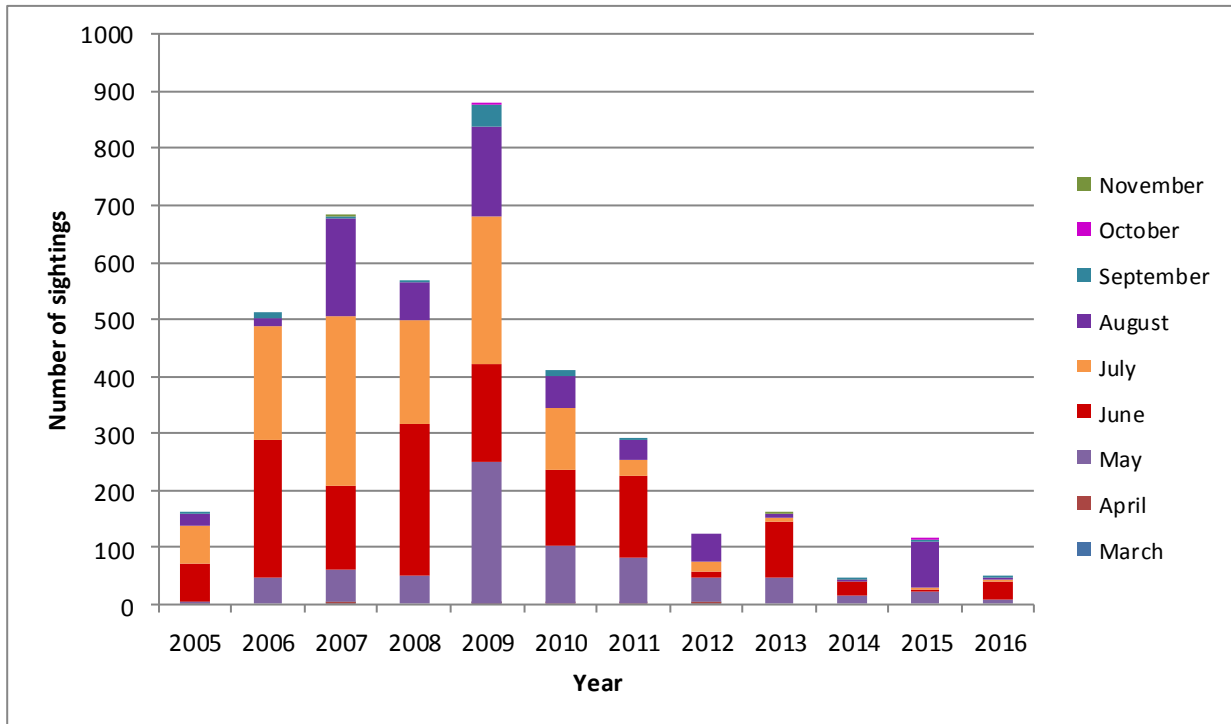


Figure 4. Total number of sightings per year showing numbers by month. (Note that online reporting began in 2007).

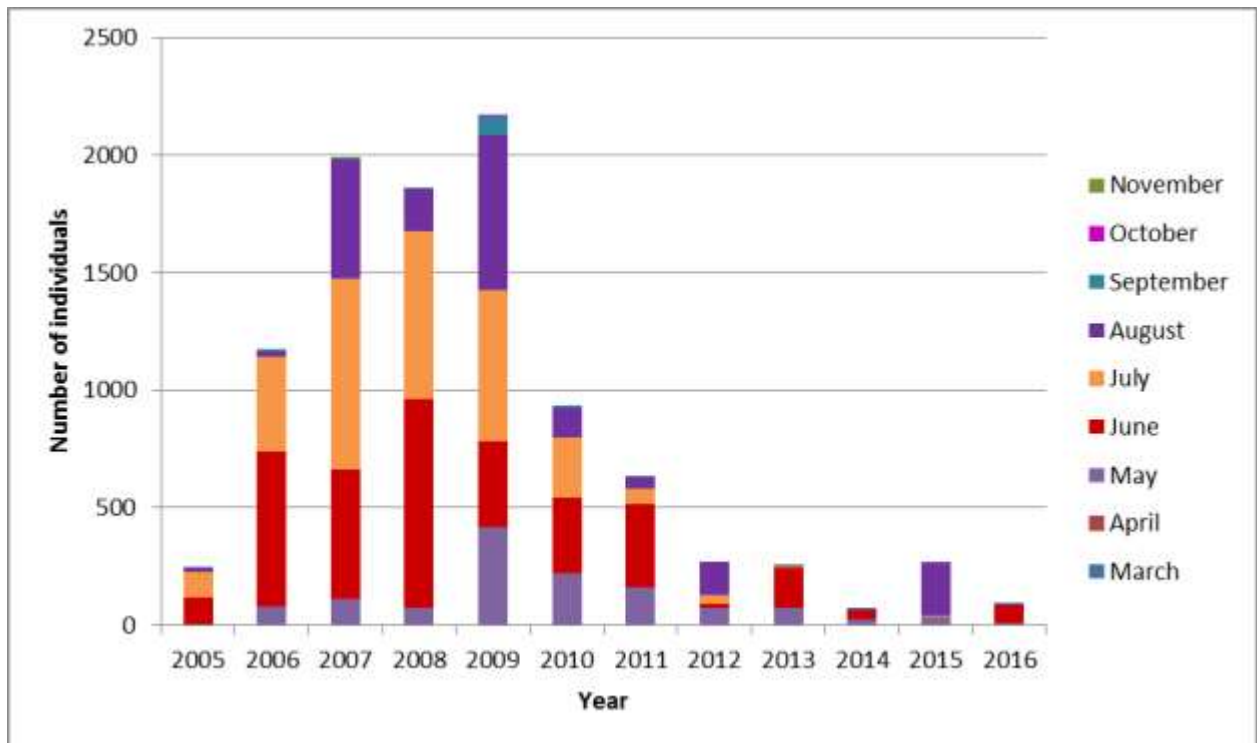


Figure 5. Total number of individual basking sharks reported per year showing numbers by month. (Note that online reporting began in 2007).

The average number of sightings is 332 per year and the average number of individuals is 830 per year, indicating just how important Manx waters are for basking sharks. It should be noted that the total number of individual sharks seen will be much smaller than this as repeat sightings have not been removed. These graphs show that there is a degree of inter-annual variation, with 2009 being a particularly good year for shark sightings with a decline in number after that period. The Manx Basking Shark Watch public sightings scheme only began in 2005 and was not widely known about, which is reflected in the very low number of sightings for that year. However, the reason for the declining records after 2009 is unclear. It is unlikely that the public are not reporting their sightings but more likely a reflection in the decline of basking sharks in Manx waters, which is a concern that needs to be addressed.

In general, June and July are the months with the highest number of basking sharks, which is to be expected as the first sightings are usually not till the middle/end of May and typically the last sightings are in the middle of August. However, the high number of sightings in 2009 is mainly attributable to an usually large number of May sightings and a higher number of sightings in August. In fact, in 2009, there were a good number of sightings well into September, indicating it was a particularly good season. In contrast, 2011 was remarkable for the very low numbers of sightings in July and August.

Table 1. The number of sightings each year from 2005 to 2016 in terms of all sightings reported.

Year	Sightings
2005	158
2006	511
2007	683
2008	567
2009	877
2010	410
2011	292
2012	125
2013	161
2014	44
2015	115
2016	47

Effort based watches

Whilst public sightings are great for providing lots of data and a snapshot of the main trends, the opportunistic nature of the sightings is not scientifically robust. Effort based watching records when sharks are not present, as well as when they are, and allows for better comparisons between sites and improved understanding of temporal variation. Effort related watching takes place from the land as well as on boat based surveys. Land watches provide small scale information from dedicated sights, whereas boat surveys provide more wide scale coverage.

Land-based watches

Land-based watches take place from seven sites around the coast (Marine Drive, Port St Mary, the Calf Sound East/West, Niarbyl, Peel and Lynague. Positions for watches are provided in the Cetacean chapter of this report. A detailed report of the results of these surveys are presented in Stone (2012).

Watches are carried out in three hour blocks, by a minimum of two observers, when the sea state is Beaufort 3 or below. Scanning is done both by eye & by binoculars (typically 8x50). Information about the time & environmental variables, as well as sightings information, is recorded, every fifteen minutes.

Some data is available for the years 2006-2009, however significantly more effort has been recorded in 2010 and 2011, due to the recruitment of dedicated research volunteers.

In total 629.5 hours of effort have been achieved (2010=296hrs, 2011=217hrs), although this is not evenly spread between the sites. For comparison purposes, basking shark presence is measured by the number of fifteen minute intervals which have basking shark sightings recorded (basking shark positive intervals). More up to date information is available from MBSW.

Table 2 shows there is considerable inter-annual variation in monthly distribution of sightings. For example, 2010 was particularly poor overall as was July 2011.

Table 2. Percent of watching intervals when basking sharks were observed, shown by month for all sites.

	May	June	July	August	Average
2006-2009	15.7	35.9	41.9	8.1	22.5
2010	7.9	4.6	9.5	0.0	6.1
2011	36.0	18.7	4.0	12.0	15.6
Average	13.5	13.2	13.8	7.7	

Table 3. Percent of watching intervals when basking sharks were observed, shown by site and year.

	2006-2009	2010	2011	Average
Marine Drive	8.3*	0.4	5.1	2.4
Port St Mary	6.7	0.0	15.7	7.0
Calf Sound East	4.8	0.4	13.9	6.9
Calf Sound West	21.2*	7.4	20.3	15.6
Niarbyl	35.1	9.2	21.3	22.3
Peel	77.8*	14.6	17.0	20.6
Lynague	No data	22.1	0.0*	20.3

***based on very small amount of effort data.**

As Table 3 shows, basking sharks are not evenly distributed across the different sites, with a higher presence on the west of the island. This table also shows inter-annual variation, with 2010 being a particularly poor year for basking shark sightings at all the watch sites.

Comparing the effort-based data with the opportunistic public sightings shows general consensus, however there are noticeable differences. For example, opportunistic sightings in 2011 were extremely low, however the percentage of basking shark positive intervals from land based watches was not significantly lower than the 2006-2009 average. More up to date information is available from MBSW.

Further analysis of the data may help to explain this and it is important that research continues, with high levels of effort based watching, to determine true patterns of basking shark occurrence.

Boat based surveys

The Manx Basking Shark Watch research vessel Happy Jack has been in operation since 2008. The boat is used for a wide range of basking shark survey work.



Figure 6. Happy Jack, the MBSW research boat: Photo: Manx Basking Shark Watch.

Effort-based basking shark surveys have been taking place on the dedicated MBSW research vessel since 2010. Although protocols have changed slightly between the years, the basic principle has remained the same. After travelling along recognised basking shark routes, five minute dedicated searches are performed at random intervals. During this time, the boat is stopped and all observers on board (typically four or five) watch 360° around the boat and all basking sharks are recorded.

In total, just over 253 hours at sea have been logged (2010=122hrs, 2011=131hrs 17mins) and 276 dedicated searches completed (2010=82, 2011=194). There is a marked contrast in the percentage of basking shark sightings between the two years. In 2010, 18.3% of dedicated searches were basking shark positive, whereas only 8.8% were in 2011. Of the basking shark positive searches, the average number of individual sharks spotted was 2.3 in 2010 and 2.2 in 2011 and many more sharks were recorded in 2010 than 2011. More up to date information is available from MBSW.

Satellite Tagging Work

MBSW has tagged 18 basking sharks with MK10m PAT satellite tags since 2007 working with Marine Conservation International (Gore et al. (2008) and APECS (France) Stéphan et al. (2010) and Stéphan et al. (2011). More up to date data are available from MBSW.

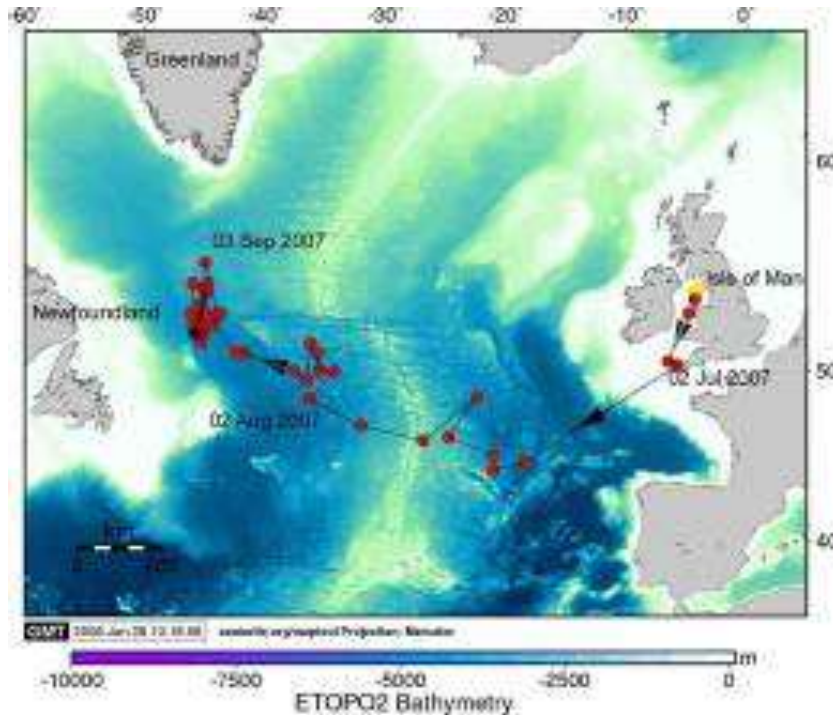


Figure 7. Map showing the track of 'Tracy' the basking shark tagged by MBSW in Manx waters who crossed the Atlantic in 2007 (reproduced from Gore et al. (2008)).

Gore et al. (2008) described how a basking shark tagged in Manx waters traveled across the Atlantic, providing the first evidence that basking sharks make this migration. Figure 7 shows the track of the tagged shark. The shark travelled 9589km and dived to a depth of 1264m (Gore et al. 2008). This was one of the first scientific papers to help explain why there is such a small amount of genetic diversity seen in the global basking shark population. This long-distance migration of a mature individual goes some way to explaining it as does Skomal (2009), showing the possible route for genetic mixing between disparate populations.

Stéphan et al. (2010 and 2011) describe the MBSW/ APECS tagging collaboration from 2008 and 2009. It was found that most of the sharks tagged in Manx waters spent most of their time in the Irish Sea and the Northern Celtic Sea. Unfortunately their deep-water overwintering grounds seem to overlap with areas of the Celtic Sea where basking shark by-catch in the deepwater trawling industry has also been records, as shown in Figure 8.



Figure 8. Basking shark by-catch: showing the area of the Celtic Sea where the reported by-catch occurred, blue dots are the tag pop-up locations, yellow and white dots are known basking shark by-catch. Map from Stéphan et al. (2011).

Sample sizes for tagging work are still relatively low and further tagging work will be required to provide more information about where Manx basking sharks go when they leave the Isle of Man. Manx Basking Shark Watch plan to tag with SPOT tags as well as MK10 PAT tags in future years and are currently developing new attachment method for SPOT tags. SPOT tags will give fine-scale positioning of the basking sharks in real time. These tags will enable more detailed studies of basking shark movements in Manx waters and they stay on for up to 3 years, unlike the 230-day maximum of the MK10 PAT tags. More up to date information on SPOT tags is available from MBSW.

The following three maps show the horizontal tracks of 3 basking sharks that Manx Basking Shark Watch have tagged with MK10 PAT satellite tags since 2007. All 3 of these animals were tagged in 2009. They all followed a similar track, traveling slowly southwards initially and doubling back up northwards to apparently spend time in the north of the Celtic Sea. More tagging data are available from MBSW.

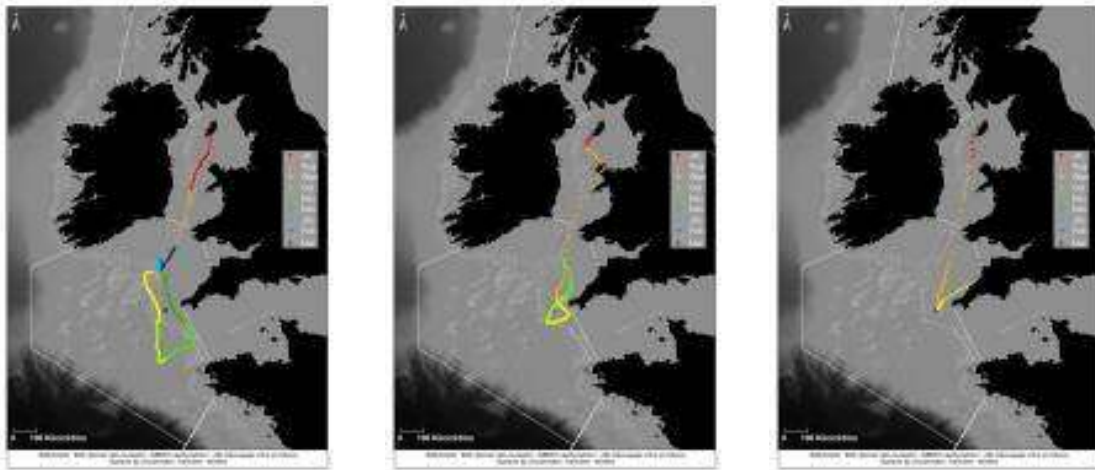


Figure 9. Three tracks from basking sharks tagging during the APECS/ MBSW research (Stéphan 2011).

Offshore Basking Shark Boat Survey

MBSW surveyed nearly 3000nm of sea off the Isle of Man in 2011 and 2010, recording basking sharks and cetaceans. This survey work has confirmed that the MBSW Public Sighting scheme is remarkably good at spotting and recording inshore basking sharks. The boat surveys rarely record sharks less than 1km from shore that have not also been recorded by a coastal or other boat watcher. However, the boat surveys are vital in recording the offshore sharks (up to 6nm offshore) that the coastal watchers do not often see. More of this offshore survey work is needed to help understand how basking sharks use the full extent of the Manx territorial sea. More up to date information is available from MBSW.

Basking Shark Dorsal Fin Catalogue and Photo-Identification Work

Photo-identification uses naturally occurring markings on basking shark dorsal fins to distinguish between different individuals. These markings include nicks out of the edge of the fin, pigmentation patterns & scars. Over time, a catalogue is built up containing all the different animals that have been seen. Studying basking sharks in this way can determine whether the same sharks are returning year on year (site fidelity) as well as being able to track individual's movements through Manx waters. Through comparing the Manx catalogue with photos from other regions, it may also be possible to determine more wide scale movements. MBSW have been conducting dedicated photo ID since 2009, although some images exist from previous years as well.

To date (end of 2011), the MBSW catalogue consists of a minimum of 94 different individuals and within the catalogue are several sub categories, with animals characterised by how well marked their fin is. There are 42 'well marked' individuals, with clear

nicks/notches out of the trailing edge of the dorsal fin. These are easily recognisable and should be readily re-identified over time. The remaining individuals are in 'small nicks' or 'difficult to identify' categories, as well as a few which can only be identified from scars or pigmentation patterns on one side of the fin.

A total of 29 individuals have been re-sighted, showing site fidelity to Manx waters. This includes nine individuals which have been seen in more than one year and one animal which has been seen in three consecutive seasons. The maximum number of times any one particular individual has been seen is four. Figure 10 shows the same individual basking sharks, whose fin has been severely damaged at some point, seen in both 2005 and 2009. More up to date information is available from MBSW.

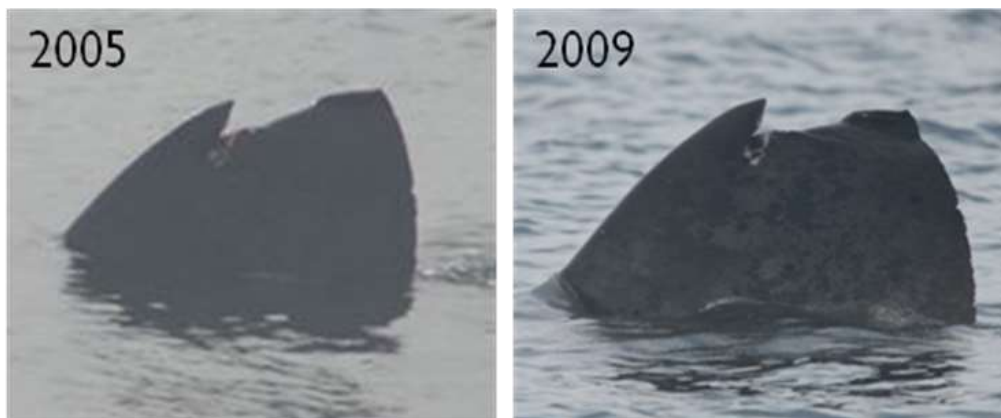


Figure 10. Shark with damage to dorsal fin, re-sighted in 2005 and 2009.

Although the technique of photo ID has been used for over 40 years on cetaceans, it is a relatively new method for studying basking sharks. In order to verify the technique, especially in light of the flexible nature of the basking shark dorsal fin and minor nature of some of the distinguishing marks, individual identification by genetic matching, carried out by Dr Leslie Noble's group at the University of Aberdeen, has been performed alongside the photographic matching. This has shown an almost 95% concordance between the two techniques, verifying the use of photo ID for studying basking shark populations (Stone et al. 2011, Hardman 2011).

Basking Shark Passport Project

MBSW started this initiative in 2009. Each basking shark 'passport' has a DNA profile, a high definition photograph of the right and left sides of the dorsal fin, a size estimate and a gender. Manx Basking Shark Watch has (up to the end of 2011) collected 25 complete "passports" for individual basking sharks and a further 9 passports are almost complete. More up to date information is available from MBSW. There have been many re-identifications within and between years. This will eventually give a much better picture of the shark population visiting the Island. The DNA sample is obtained using a non-intrusive method, gently rubbing the skin on the dorsal fin with a green scrubber pad wrapped around an extendable pole. The technique for getting a full passport was presented at the 2011 European Elasmobranch Association conference in Berlin (Hall et al. 2011).

Dr Noble's group processed the skin slime samples and compared the identification results from DNA analysis, using 5 microsatellite loci (see Figure 11), with that from our dorsal fin ID (Hardman, 2011). This study showed that the high definition dorsal fin photos work very well to identify individual basking sharks, with genetic profiles from basking shark skin swabs confirming the identity of individual sharks that had already been established from the fin photos taken by the Happy Jack team and analyzed by Eleanor Stone.

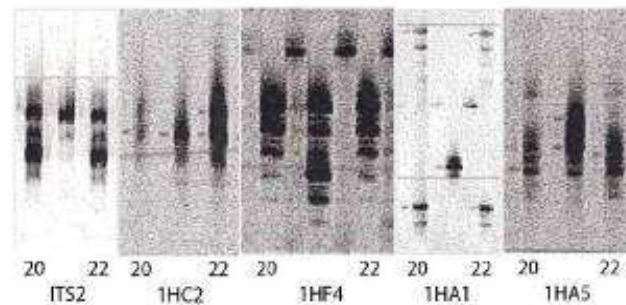


Fig. 3 Acrylamide gel images run on 21-Car of all five loci comparing samples BS-IM-10-20 and BS-IM-10-22.

Figure 11. A pair of genetic profiles from DNA slime samples 20 and 22, screened for 5 microsatellite loci (ITS2, 1HC2, 1HF4, 1HA1, 1HA5), show these are from the same individual (Hardman 2011).

A very interesting story seems to be unfolding about the population of sharks visiting Manx shores. Genetic techniques are being used to determine the relatedness of different populations of basking sharks to help understand interactions between populations and to estimate global population size. Initial results point towards a low global population size, reinforcing the need for active local and global conservation measures.

Basking Sharks as Samplers of Marine Pollution by Hormone Mimics

In 2011 MBSW started working on pollutants with Dr Noble's group, in collaboration with Dr Ed Routledge's research group from Brunel University. Their interest is in chemicals in the marine environment which act as hormone mimics (Clarke et al. 2009). These substances, also known as endocrine disrupting chemicals (EDCs), are produced during the breakdown of plastics. These EDCs can mimic oestrogens, progesterone and androgens. They are everywhere in our environment and may also affect humans, so this research has broad implications for food-chain pollution, not just for the sharks.

MBSW is collecting plankton samples, basking shark skin slime and seawater samples to test whether these pollutants are in the food chain that starts with plankton and whether they are in the basking sharks' bodies.

No results are yet available from this study, but this may prove to be an informative way to assess and monitor this far-reaching form of marine and global pollution as it becomes established throughout the global food chain.

Basking shark behaviour in Manx waters

Very little is known about where basking sharks breed, court, mate or give birth to their live young but it is thought that Manx waters may have particular significance for basking shark breeding.

The group swimming behaviour, which Sims *et al.* (2000) describe as 'putative' courtship behaviour is frequently seen in Manx waters. Putative courtship behaviour includes close nose-to-tail following, echelon following, groups of two or more sharks circling, head to head challenging, tail-thrashing and breaching, where the basking shark jumps clear out of the water. Basking sharks may be most vulnerable to human disturbance during these behaviours. Observations of putative courtship behaviour comes from many sources, the general public, commercial wildlife watching boats and from the Manx Basking Shark Watch (MBSW) research boat Happy Jack. Putative courtship episodes of up to 3 hours in duration have been observed (unpublished observations MBSW).

MBSW has been observing these behaviours for at least 10 years and there is increasing evidence for two main types of basking shark group behaviours seen in Manx waters, feeding-only groups and courtship groups. Research into these group behaviours is ongoing as part of a long-term research programme, but a preliminary interpretation of the results is provided here.

Feeding-only groups occur in areas of high plankton concentration. They involve a group of two or more sharks that may be of single or mixed sexes. Nose-to-tail swimming, echelon swimming, loose circle formation and gentle tail thrashing whilst diving in circular groups is seen. The shark groups are generally observed to be more relaxed, the behaviours less 'intense' than that observed during the putative courtship groups and their swimming movements less excitable (unpublished observations MBSW).

Courtship groups also occur in areas of high plankton concentration and all the behaviours displayed by feeding-only groups are seen, but the sharks display additional behaviours. Their tail thrashing is much more aggressive, they may breach clear of the water and individual sharks may breach several times in quick succession. The group circling of groups of two or three sharks may be very tight indeed. The head-on challenging behaviour that is sometimes seen may also be associated with courtship displays but the MBSW is still observing this phenomenon.



Figure 12. Two basking sharks close nose-to-tail following in Manx waters. This is often observed during courtship episodes but it may also occur in single-sex pairs during feeding-only groups (unpublished observations MBSW). Photo: M Kelly.



Figure 13. Two basking sharks displaying echelon following in Manx waters. Photo: F Gell.

Echelon following describes the behaviour seen when the sharks swim next to but not exactly parallel to one another, one shark slightly further back than the other. Sharks are often observed to swap from nose-to-tail following to echelon following and back again. They have been observed to do this as either part of their ordinary feeding-only group behaviour or as part of their more intense putative courtship displays (unpublished observations MBSW).



**Figure 14. A group of four basking sharks feeding in a loose circle in Manx waters.
Photo: A Corkill.**

This loose-circling behaviour may be a prelude to more intense courtship displays but is more commonly seen associated with feeding-only group behaviour in an area of very high plankton concentration. It is often observed in single-sex groups (unpublished observations MBSW).



Figure 15. Three basking sharks in a very tight circling formation: Photo: D Shimmin.

The very tight circling of three very large mature individuals seen in the photo above is typical of that seen during intense putative courtship displays and although actual mating has not been photographed underwater yet it seem likely that this tight circling behaviour is a prelude to mating (unpublished observations MBSW).



Figure 16. Two basking sharks engaged in very close parallel swimming. Photo: M Kelly June 2006.

The pair of sharks may be almost stationary during this very close parallel swimming. They are normally sexually mature animals and this behaviour has been observed in mixed sex pairs. On several occasions they have been observed to go from this behaviour to one shark rolling under the other and agitated tail thrashing occurs. This may be mating but it has not been photographed underwater as yet (unpublished observations MBSW and Malcolm Kelly).



Figure 17. A male and a female in a very close tryst: Photo: F Gell July 2008.

Newborn and young basking sharks in Manx waters.

Many young basking sharks are seen in Manx waters. Based on public sighting data, more small basking sharks of 1.5m-2.0m are seen in Manx waters than are recorded in the whole of the rest of the British Isles (Hall et al. 2009). Sharks of this size are thought to be newly born. Figure 18 shows a newborn basking shark photographed in Manx waters. This very small 'newborn' basking shark of approximately 1.6m length was surface feeding with a

group of mature individuals. It had also been seen curled up in a 'C' shape on the surface the day before. It seems likely that it is a very young individual. The pig-like snub nose is quite different to that of mature individuals. It is thought that it is an adaptation to inter-uterine feeding behaviour before birth.



Figure 18. Newborn basking shark off Peel: Photo: S Stigant 2005.



Figure 19. Surface photograph of the same newborn shark. Note the very small size of the individual given by comparison with the kayak. Photo: S Stigant 2005.

Courtship and Breeding Study

What are thought to be newborn basking sharks, many young sharks and putative courtship behavior are all recorded in Manx waters. Manx Basking Shark Watch researchers are fairly confident that mating and birth do occur in Manx waters but more evidence is needed to be certain. If mating and birth do occur in Manx waters, it is particularly important that the areas used are well protected as they may be of international importance to basking shark populations.

The sharks become even less responsive to boat traffic than usual when courting and are therefore at extreme risk of boat strikes. It is therefore important to minimize the amount of disturbance to the sharks at this time. MBSW study basking shark group behaviour with minimal disturbance, by using photography, film and a small remote-controlled boat with underwater camera array ("Shark-Cam").

The historical and social context of basking sharks in the Isle of Man

Basking sharks are now seen as a prime tourist attraction for the Isle of Man during the summer months. In recent tourism surveys, marine wildlife and coastal activities consistently feature high on the reasons for visitors choosing the Isle of Man. For example, in a small scale survey of customers on wildlife watching boats, Clarke (2009) found that 23% of the tourists surveyed came to the Isle of Man in order to see basking sharks and 69% said that the presence of basking sharks had influenced their decision to visit the Isle of Man. Many Manx companies advertise basking sharks as a prime attraction of their scuba diving, kayaking and wildlife watching operations. These companies operate boats out of Peel, Port St Mary and Port Erin.



Figure 20. 'Gemini', a charter boat operating wildlife watching tours in Manx waters. Photo: J Chorlton 2008.

Through developing observation points and interpretation materials, Manx Basking Shark Watch and the Manx Wildlife Trust are encouraging tourists and residents to take advantage of the opportunities for shore-based watching around the Manx coast, particularly from Peel round to Port St Mary.



**Figure 21. Crowds watching a basking shark off Peel breakwater.
Photo: Y Cherrell 2009.**

There was never a targeted basking shark fishery based on the Isle of Man but basking shark fishing boats used to come to Manx harbours from Norwegian and Irish basking shark fisheries.



Figure 22. A basking shark fishing boat in a Manx harbour with harpoon at the prow. Photo M Craine, probably 1970s.

It has been reported that historically the Manx herring fishery often accidentally caught basking sharks. This was apparently regarded as an inevitable occupational hazard. There are also anecdotal accounts of basking sharks occasionally being trapped in lobster pot ropes but no formal reports of accidental bycatch in Manx fisheries have been made in the last 10 years at least.



Figure 23. Basking shark entangled in pot ropes in approx 1980's. It was released alive but it did not survive and its body was washed up later. Photo: M Craine.



Figure 24. A basking shark caught in herring nets on Peel lifeboat slipway, probably the early 1980s. Photo S Keith.



Figure 25. A large basking shark displayed overlooking Peel breakwater. It is thought that this was accidentally caught in herring nets in the 1950s. Photo: S Keith.

Existing threats to Manx Basking Sharks

The main risks faced by basking sharks which visit Manx waters are:

Photographs of apparently recently injured basking sharks suggest that basking sharks may have been involved in collision incidents with vessels in Manx waters, but risks and impacts associated with boating have not been quantified.

Whilst the majority of those watching basking sharks follow the codes of conduct and appreciate the importance of keeping their distance and minimising disturbance to the species, each year incidents of basking shark disturbance are reported.

The Manx Wildlife Act protects basking sharks and even unintentional injury or disturbance could result in prosecution. Every effort is made to ensure that the public is aware of the law and the Shark Trust's Code of Conduct but occasional incidents have resulted in warnings being issued by DEFA and the Isle of Man Constabulary's Wildlife Crime Officers.

The worldwide shark-fin industry.

Although basking sharks are legally protected from being targeted in Manx waters and many other area waters, shark fin prices are very high and basking shark fins are still found in Asian markets (Magnussen et al. 2007). Given that our basking sharks are known to be

global travellers (Gore et al. 2008) this cannot be ignored and Manx Basking Shark Watch supports the campaign for global protection of basking sharks. The Isle of Man is also signed up, via the UK, to the new Memorandum of Understanding on Migratory Sharks under the Convention of Migratory Species.

Accidental capture in fisheries

There are recent records from Scotland and Cornwall of basking sharks becoming tangled in gill nets, and a number of records from Scotland and elsewhere of basking sharks becoming tangled in the lines of crab and lobster pots and *Nephrops* creels (for example see Bloomfield and Solandt 2008).

There are historical records of basking sharks being caught accidentally in the Manx herring fishery but as the local herring fishery no longer exists this is not a current problem locally. However, it is known that some basking sharks are currently being by-caught in deep-water trawls in the Celtic Sea (Stéphan et al. 2011). MBSW satellite tagging research shows that this is an area where Manx basking sharks over-winter and more research is needed to assess this threat.

In New Zealand there are recent records of large numbers of basking sharks being accidentally caught in the trawl and set net fisheries (Francis and Smith 2010).

Managing threats to basking sharks

The southwestern waters of the Isle of Man, most notably from Peel to Langness, contain hotspots where humans and sharks are in potential conflict. This 40km stretch of water contains three busy ports, Port St Mary, Port Erin and Peel as well as the busy waterway of the Calf Sound.

The risk of boat-strike is particularly high in these areas and providing information and advice to boat-users is essential. Many less experienced boat users do not realise that when one shark is seen at the surface many more may be below. The sharks are at risk of boat-strike because they are very slow moving and they feed at or just below the surface.

Research work using fin identification has identified several different individual animals which show clear evidence of propeller injury. Boat-strikes are made more likely because, unlike many cetaceans, basking sharks do not always move away from sources of disturbance. This puts the responsibility for taking care of this endangered species firmly in the hands of boat users.



Figure 26. Basking shark with dorsal fin damage typical of a boat propeller injury. Photo: MBSW 2011.

Given that basking sharks are a threatened and legally protected species it is extremely important that they are protected from disturbance during the Manx basking shark season. This normally starts mid-May and lasts until the middle of August but annual variations occur and basking sharks are sometimes present well into September. Clear guidelines for the behaviour of boats and divers near basking sharks in Manx waters are available online at: www.manxbaskingsharkwatch.org

The UK Shark Trust produces codes of conduct for basking shark watching: www.baskingsharks.org/content.asp?did=26602

Frequent joint press releases are made by DEFA, MBSW and the Isle of Man Constabulary Wildlife Crime Officers and posters are put up by MBSW at the start of each season. This is not just for the safety of the sharks, but also for boat users. Although basking sharks rarely pose a threat to people, incidents have been recorded. For example, three people drowned off Carradale, Scotland in 1937 when a boat was capsized during an interaction with a breaching basking shark.

It is therefore vital that water users are well aware of the need to give basking sharks plenty of room at all times but especially when breaching has been seen in the area.



Figure 27. Jet-skier unaware of the close proximity of group of basking sharks off Peel Breakwater. Photo: 2009 MBSW archives.

There are several areas in Manx waters where there is a real risk of conflict between human activities and basking sharks, because high levels of human use correspond with high numbers of basking sharks. The most notable are the Calf, Port Erin Bay, the area off Bradda head, Fleshwick, Niarbyl and Peel. Sharks are often seen within 10m of the shore within the bays of Port Erin, Niarbyl and Peel. Port Erin Bay is popular with boaters, sports anglers, swimmers and scuba divers and has a very active sailing school. Peel is an active fishing Port with several shark-watching tourist boats being based there. All these areas are popular with kayakers (see Tourism and Recreation Chapter).

The high concentration of basking sharks found at the hotspots are due to many factors but the key one is that the strong currents and topography of the coast mean that surface zooplankton concentrations are high in these areas. Reporting of basking sharks by the public to Manx Basking Shark Watch is high in these areas because there are lots of boat-users on the water and the high cliffs give good vantage points for the coastal watchers.

It is thought that several inshore and offshore tidal fronts form the key hotspots for the basking shark feeding. These are visible to the human eye as very long silvery lines in the water, with associated bubbles, seaweed and other floating debris. They normally start from headlands or across the mouth of bays, especially Port Erin Bay and Fleshwick Bay.

Research to identify the biological and physical features associated with basking shark hotspots is ongoing.

Large aggregations of 12-24 sharks are sometimes seen feeding and displaying what is thought to be courtship behaviour off Bradda Head, Fleshwick, Niarbyl and just north of Peel. On some rare occasions very large groups of up to 100 sharks have been seen congregating further offshore North of Peel. These are rarely seen by the general public from the shore or in coastal waters, but they are sometimes reported by offshore fishermen.

Basking Shark Strandings

The Department of Environment, Food and Agriculture has been recording strandings of protected marine species since 2004 and has been co-ordinated by Manx Wildlife Trust since 2013. Only two dead basking shark strandings have been formally recorded in Manx waters. In June 2011 a 7.28m shark was stranded dead in a small cove north of Niarbyl and the second washed up north of Kirk Michael in 2015.

Both carcasses were badly decomposed so it was not possible to determine a cause of death but extensive measurements were taken and a range of samples for future studies.



Figure 28. Dead, beached basking shark, north of Niarbyl, June 2011. Photo: F. Gell

National and International Links

Basking sharks are a globally occurring species, being found in Arctic to temperate waters. Tagging work by Skomal et al. (2009) has even shown that they over-winter in the deep cool waters of the Caribbean and travel across the equator from North America to Brazil. MBSW and Marine Conservation International tagged a basking shark in Manx waters which crossed the Atlantic to waters off Canada (Gore et al. 2008). The global nature of the basking shark population makes it essential that research into basking sharks is also global and linked wherever possible.

Basking Sharks – A Global Perspective Conference 2009

To this end the conference, 'Basking Sharks: A Global Perspective' was held in Port Erin, Isle of Man in August 2009. It was jointly organised by the Manx Government (DEFA or DAFF as it was then), Manx Basking Shark Watch and the Save our Seas Foundation.

One of the main aims of the conference was to promote international collaboration to establish the status of basking sharks globally. The conference achieved this objective as it was attended by over 100 participants including scientists and conservationists from all over the world including America, Canada, UK, Ireland, New Zealand, Norway and the Seychelles. The sharing of ideas and scope for collaborative research was remarkable and it has many successful projects have been initiated as a result.

Manx Basking Shark Watch currently has active basking shark research links with scientists in France, Scotland, Ireland, England and North America.



Figure 29. Former Chief Minister Tony Brown and MLC Mr Dudley Butt attending the basking shark conference with a few of the international speakers and event organisers (MBSW, DEFA, Save our Seas Foundation). Photo: H Leiodson.

Public awareness and education

One of the main aims of MBSW is to raise public awareness of basking sharks. Maintaining the interest of the visual media is vital to this aim and while a local TV item may attract several hundred thousand viewers, a repeated wildlife TV programme or film can attract many millions.

To this end Manx Basking Shark Watch have assisted film companies in the production of many international wildlife films, documentaries and BBC and ITV TV news articles.

Manx basking sharks and the work of MBSW have been featured in films produced by National Geographic, Disney, Galetée Films (France), Yannick Cherrel (France), ZDF (Germany), Belgian TV and several independent filmmakers. Since 2006 Manx Basking Shark Watch has helped make at least one TV news programme and one film per year in the short season of only 8-12 weeks per year.

All filming is carried out under strict government licensing conditions with a new license issued for each piece of film work at the discretion of DEFA officers.

One example of the impact that filming work can make is the production of a German film called, 'Basking Sharks: Gentle Giants', produced by Florian Guthknecht. This 50 minute wildlife documentary has been shown at least 30 times on public TV stations in Germany, France, Switzerland, France, Belgium, the Netherlands and Luxembourg and Austria. Significantly, it has now been sold to a company that will use it in Asian countries, where it is hoped to make an important contribution to changing public attitudes to the global shark fin trade. A translated English version is available for charitable use on the Island.

The most viewed TV programmes MBSW have helped to make are the BBC COAST program about the Isle of Man (2006, constantly repeated and on DVD) and the BBC 'Britain's Secret Sea's' programme from 2011 where they showed the collection of DNA swabs and called for worldwide conservation of basking sharks.

The film quality is excellent and most filmmakers are happy to share their footage at lower definition for scientific purposes. For example, MBSW have recently initiated a new collaboration between themselves, a USA researcher and 3 filmmakers working on the process of filter-feeding in basking sharks and manta rays.



Figure 30. Mirada Krestovnikoff filming Manx basking sharks for BBC COAST. Photo: J Hall 2006.

Summary of research findings and their implications for basking shark management

It is likely that a relatively small number of individual basking shark visit Manx Waters

Although its research is still in the early stages MBSW has identified that it is likely that only a relatively small number of basking sharks visit Manx waters. The MBSW programmes for basking shark fin ID and the basking shark 'passport' have so far identified less than 100 individual sharks. The implication for management is that the small number of individuals visiting Manx waters makes it even more important that they are protected whilst they are here than if there were thousands of sharks. Each individual shark should be identified and valued for its conservation and tourism potential.

Preliminary Genetic and satellite work indicates a distinct Irish Sea Population of basking sharks with some migrants passing through

Preliminary, (as yet unpublished) genetic work on the MBSW basking shark skin slime samples by Les Noble and his team at Aberdeen University indicates that the basking sharks sampled in Manx waters may show evidence of site fidelity. They appear to be more closely related to one another than to sharks sampled off Ireland. Also, most of the basking sharks satellite-tagged in Manx waters have stayed in the Irish and Celtic Sea, again hinting at a localised population. Only one individual tagged so far has proved to be a long distance traveller, crossing the Atlantic to Canada (Gore et al. 2008). Basking sharks satellite-tagged off France and the South of England and number-tagged off Ireland, have tended to take quite different routes, often travelling up to the north of Scotland (Stéphan et al. 2011, Sims et al. 2003). Taking the available MBSW genetic and tagging work together our current hypothesis is that basking sharks visiting Manx waters appear to be a local Irish Sea/ Celtic Sea population with some passing migrants. It must be emphasised that this is a hypothesis based on preliminary work after only a few years of research but it is interesting that the genetics and tagging appear concordant at this stage. This has strong implications for the local management of basking shark found in Manx waters. If there really is a local population there is a risk of losing it all together if it is not effectively protected. This may not be an overstatement. In the 1950s and 1960s at least 403 basking sharks were

intentionally culled along the west coast of Vancouver Island, Canada. This has resulted in the virtual disappearance of basking sharks from this area (Wallace and Gisborne 2006).

Bycatch in the Celtic Sea

Stéphan et al. (2011) showed that most basking sharks tagged in Manx waters stayed in the Irish and Celtic Seas and also that basking sharks are being accidentally caught in fisheries the northern Celtic Sea. This is an area known to be used by the Manx sharks at the times of year that the bycatch occurred. The map shows both the positions where basking sharks were by-caught and the pop-off locations of several of the Manx-deployed tags. The implication for management is that every effort should be made to assess the true extent of basking shark bycatch in the Irish and Celtic Seas and to look at approaches to reducing bycatch.

Manx basking shark hotspots have been identified

MBSW has 13 years of public sightings data that clearly show hotspots of basking shark occurrence, including areas known to be frequented by large feeding or courting groups. Most of this activity is located along a 40 km long stretch of coastline on the southwest of the Island and the potential for human/ basking shark conflict is at its highest in a few key areas. It is also clear that relatively high numbers of newborn and very young basking sharks are found in inshore Manx waters. There are many implications for local management. We know where, when, and under what weather conditions the basking sharks are likely to be at higher risk of human impact. Sensitivity maps showing the 'hotspot' zones according to concentrations of sightings and probability of encountering large groups of feeding or courting sharks would be a useful tool to improve management. This work was started with the Coastal Code produced with DEFA and DOI but more work is needed.

Basking sharks are known to breach in certain hotspots

Basking sharks are known to breach clear of the water in certain hotspots in Manx waters, especially during intense courtship events. Inevitably, this kind of activity tends to attract the attention of the keen wildlife watcher but the implication for management is that the public must be made aware of the dangers of approaching any group of sharks in case one breaches, to avoid risk of human injury.

Confidence and knowledge gaps

As with all research into highly mobile wild animals, there are certain limitations to the data and more study is needed to increase understanding of basking sharks in Manx waters, the Irish Sea and further afield. With regard to the data collected by MBSW, the caveats that should be applied to the data include:

- 1) Basking sharks are a long lived, slow breeding, highly migratory species. Conclusions as to the health of the population or true patterns of distribution and abundance cannot be drawn after only a few years study. A more long term data set will be needed to accurately determine the true status of the population.

- 2) The vast majority of the public sightings data has been contributed by non-specialists, i.e. members of the general public who have seen a shark and want to report it. It is known that the public's ability to judge sizes and distances at sea is limited. Additionally, there is no facility on the website to report the bearing of the sighting. Thus the precision of the locations of the sightings is limited and often may only be accurate to within approximately a one square kilometre.
- 3) Public sightings are also influenced by anthropogenic variables such as the weather, which may affect the number of people out at the coast watching for sharks. Although this will introduce a degree of variation in the numbers of sightings, nevertheless the large sample size is evidence of the high basking shark presence in Manx waters.
- 4) Land based watches provide more accurate data but there is currently not enough effort at some of the sites to draw firm conclusions.

Main knowledge gaps:

- 1) Although photo ID can provide an indication of the minimum number of different sharks that have used Manx waters, there is still no definitive measure of abundance of basking sharks, or whether the basking shark population is increasing or declining.
- 2) Both very small and very large individual basking sharks have been reported in Manx waters. Additionally, social swimming behaviour and breaching is regularly observed, indicating that this may be a courtship ground and/or nursery area for basking sharks. If this were the case, it would increase further the importance of protecting basking sharks and Manx waters.
- 3) Further work needs to be done to examine basking shark distribution and use of Manx waters when they are not at the sea surface. Satellite tagging data analysis can be used to examine this, but more tagging is required to draw general conclusions.

References

- Bloomfield A. and Solandt J-L. (2008). Marine Conservation Society Basking Shark Watch: 20 year report (1987- 2006). Marine Conservation Society, Ross on Wye, UK.
- Clarke J. (2009). An assessment of anthropogenic disturbance to the basking shark, *Cetorhinus maximus* and a valuation of the shark tourism industry on the Isle of Man. MSc Thesis, Marine Environmental Management, University of York.
- Clarke N., Routledge E.J., Garner A., Casey D., Benstead R., Walker D., Burkard Watermann K., Gnass K., Thomsen A. and Jobling S. (2009). Exposure to Treated Sewage Effluent Disrupts Reproduction and Development in the Seasonally Breeding Ramshorn Snail (Subclass: Pulmonata, *Planorbium corneus*). Environ. Sci. Technol. 43(6): 2092-2098
- Compagno L.J.V. (1984). Sharks of the World: An Annotated and Illustrated Catalogue of Shark Species Known to Date (Volume 4). Food and Agriculture Organization of the United Nations, Rome.
- Francis M.P. and Smith M.H. (2010). Basking shark (*Cetorhinus maximus*) bycatch in New Zealand fisheries, 1994–95 to 2007–08. New Zealand Aquatic Environment and Biodiversity Report No. 49.
- Gore M.A., Rowat D., Hall J., Gell F.R. and Ormond R.F. (2009). Transatlantic migration and deep mid-ocean diving by basking shark. Biol. Lett. 4: 395-398.
- Hall J., Solandt J-L., Jung A., Berrow S., Stone E. and Maddrell B. (2009). Evidence of Newborn Basking Sharks and a Possible Basking Shark Birth in European Waters. Conference Paper from "Basking Sharks: A Global Perspective, Isle of Man 2009."
- Hall J., Hall G., Noble L. and Stone E. (2011). Passport for a basking shark. European Elasmobranch Association Conference presentation, Berlin 2011.
- Hoelzel A.R., Shivji M.S., Magnussen J. and Francis M.P. (2009). Low worldwide genetic diversity in the basking shark (*Cetorhinus maximus*). Biol. Lett. 2: 639-642.
- Hardman E. (2011). Concordance of genetic and fin photo identification in the basking shark, *Cetorhinus maximus*, in the North East Atlantic. BSc Thesis, University of Plymouth
- Magnussen J.E., Pikitch E.K., Clarke S.C., Nicholson C., Hoelzel A.R. and Shivji M.S. (2007). Genetic tracking of basking shark products in international trade. Animal Conservation, 10: 199–207.
- Noble L.R., Jones C.S., Sarginson J., Metcalfe J.D., Sims D.W. and Pawson M.G. (2006). *Conservation Genetics of Basking Sharks Final report for Defra*
- Sims D.W., Southall E.J., Quayle V.A. and Fox A.M. (2000). Annual social behaviour of basking sharks associated with coastal front areas. Proc R Soc Lond B. 267: 1897-1904.
- Sims D.W., Southall E.J., Richardson A.J., Reid P.C. and Metcalfe J.D. (2003). Seasonal movements and behaviour of basking sharks from archival tagging: no evidence of winter hibernation. Mar Ecol Prog Ser 248: 187-196.
- Skomal G.B., Zeeman S.I., Chisholm J.H., Summers E.L., Walsh H.J., McMahon K.W. and Thorrold S.R. (2009). Transequatorial Migrations by Basking Sharks in the Western Atlantic Ocean. Current Biology 19(12): 1019-1022.
- Stéphan E., Gadenne H., Jung A., Lefranc A., Hall J., Hall G., Bessudo S., Soler G., Royer F. and

Calmettes B. (2010). Satellite Tracking of Basking Sharks in the North East Atlantic. European Elasmobranch Association Conference presentation, Galway 2010.

Stéphan E., Gadenne H. and Jung A. (2011). Satellite tracking of basking sharks in the North-east Atlantic ocean. APECS Final report.

Stone E., Hardman E., Hall J., Hall G., & Noble L. (2011). Using genetic analysis to validate photo identification of individual baskingsharks (*Cetorhinus maximus*). European Elasmobranch Association Conference presentation, Berlin 2011.

Stone E. (2012). Marine megafauna in Manx waters. Final Report. Manx Wildlife Trust.

Wallace S. and Gisborne B. (2006). *Basking sharks: the slaughter of BC's gentle giants*. Transmontanus/New Star Books, Vancouver.

Witt M.J., Hardy T., Johnson L., McClellan C.M. and others (2012). Basking sharks in the northeast Atlantic: spatio-temporal trends from sightings in UK waters. *Mar Ecol Prog Ser* 459:121-134.