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DAPSTOM - An Integrated Database & Portal for Fish Stomach Records

Version 3.6

John K Pinnegar & Mark Platts

Phase 3 - Final Report – 1st July 2011

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Background Information

Unlike the two previous reports of the DAPSTOM initiative, much of the text contained in this document was written for the purposes of a Final Report for the Defra (UK Department for Environment, Food & Rural Affairs) project MF1109, that provided the vast majority of the funding for Phase 3. Consequently the structure of this report is significantly different to its two predecessors that were specifically written as stand-alone reports for the DAPSTOM website. The Main text of the Defra 'SID 5' report is reproduced here in its entirety, but with the addition of appendices giving: (1) DAPSTOM Database – Field Descriptions and explanation; (2) the number of predator stomachs and prey records by research cruise (as of July 2011); and (3) the number of predator stomachs and prey records by species. Data collation and development work for Version 4 of the database has already begun and this is being funded through the EU FP7 project 'EuroBasin' as well as 'FACTS' (Forage Fish Interactions).

MF1109 SID 5 Report – [Attachment]

Background

The DAPSTOM initiative was established following a visit by two Cefas scientists to the Alaska Fishery Science Centre (AFSC), Seattle in 2005. Researchers at AFSC had developed a website for use by stock-assessment scientists and policy makers to help draft the now obligatory 'ecosystem' section of stock-assessment reports, and specifically to determine what a particular commercial species eats and what predators eat that species (as juveniles or adults). Cefas and its predecessor MAFF, had been collecting data on fish stomach contents for over a century, but it was recognised that much of this data was only available in paper form or alternately in hundreds of individual spreadsheet files on the hard-drives of scientists (where they were at risk of being lost forever). In 2006 the EU Network of Excellence programme 'Eur-Oceans' issued a call for 'data rescue' projects and DAPSTOM (Phase 1) was one of the first to be funded. 'Phase 1' was primarily concerned with collating data already available in electronic format, including the recovery of datasets from scientists who had recently retired. A web-based portal was constructed along the lines of that developed by AFSC, and this provided open access to some 104,000 records, spanning 1968-2006, including most species commonly occurring around the British Isles. 'Phase 1' was completed in October 2007 (see Pinnegar & Stafford 2007). 'Phase 2' of the DAPSTOM initiative was supported in a piecemeal fashion, drawing upon small amounts of staff-time from within existing contracts (including Defra MF1202 and EU-RECLAIM). The work was completed in September 2008 and presented at the ICES Annual Science Conference, Halifax, Canada where Pinnegar & Blanchard (2008) provided a preliminary examination of long-term changes in the North Sea diet composition over the past 100 years.

Objectives & Tasks

The DAPSTOM3 project had three main Technical & Scientific Objectives:

(a) to digitize additional fish stomach content data, particularly for commercial species in the Irish Sea;
(b) upload these records into the existing DAPSTOM database, and make this information available through the publicly-accessible web portal;
(c) use the existing and new data contained within the DAPSTOM database to parameterise multispecies models and to examine long-term changes in ecosystem structure and functioning.

The work was organised into 6 distinct work-packages, each of which was associated with a clearly defined milestone and deliverable:

1. Input Irish Sea stomach content records
2. Input other stomach datasets (historic and recent)
3. Upload dataset and make available through the existing DAPSTOM web-portal
4. Analysis of long-term changes in North Sea food-webs
5. Construct a Cod - Nephrops model for the Irish Sea
6. Final report including an update on the database and results of all analyses.

Results, Achievements & Outputs

In the following report we outline what has been achieved since July 2009. Progress is reported against each of the six stated milestones/tasks. Prior to the commencement of the DAPSTOM-3 project the DAPSTOM database contained 144,919 records of fish stomach contents around the UK and adjacent waters. DAPSTOM-3 has added an additional 33,023 records (from 66,073 stomachs), derived from 107 different research cruises and concerning 115 predator species.

Task/Milestone 1: All Irish Sea stomach content records from log-books etc. inputted in standard DAPSTOM data format.

Considerable effort has been dedicated to the digitisation of stomach content records from the Irish Sea, this has included the uploading of new datasets (from Cefas research cruises in 2009/2010) as well as historic data from earlier cruises in the 1960s and 1980s. A total of 9,194 additional records have been uploaded to the DAPSTOM database concerning fish in the Irish Sea, this has more than doubled (from 6181 records to 15,375 records) the quantity of data in the database from this region. This dataset is unique in that there is no other large repository of information on commercial fish feeding preferences in this region. The vast majority of the data concerns cod, plaice, whiting, and lesser-spotted dogfish (2228, 972, 1086 and 1003 records respectively – see figure 1) - although there are records for 60 other species including data on fish that are comparatively rare and of conservation importance such as angel-shark Squatina squatina, Aliss shad Allosa allosa and common skate Raja batis. Summary data from charter cruises of the vessels Silver Star and Albertus have been uploaded, in addition some data on the diet of juvenile and larval fish in the Irish Sea during the 1920s were digitized (from Scott 1922), as were data from logbooks of the charter vessel Cypris in the Isle of Man. Large quantities of data on plaice, dab, skate and ray diets were obtained from logbooks of the Cefas/MAFF research vessels Platessa and Tellina which operated extensively in the Red Wharf Bay area (off Anglesey) between 1962 and 1965 (2689 records) (see Macer 1967).

As suggested in the original proposal, contact has been made with Dr Paul Newton with regard to acquiring his datasets of Irish Sea fish diets in the 1990s. Dr Newton has agreed to provide his data, but it is currently not in a form that can be uploaded to the DAPSTOM database. It is hoped that this data can be digitised and uploaded within the near future, along with any remaining (Silver Star and Albertus) data from research cruises in the 1980s. Figure 2 shows that the vast majority of the Irish Sea data added to the DAPSTOM database concerns the 1980s, although major additions have also been made for the 1960s and 2000s. As far as we are aware there are no stomach data available for digitisation from the Irish Sea in the 1970s, although it is possible that the information collected by Boyd (1983) and by Hillis & Fannon (1981), from Northern Ireland and the Republic of Ireland respectively, may have extended into this decade but this data has not been located.

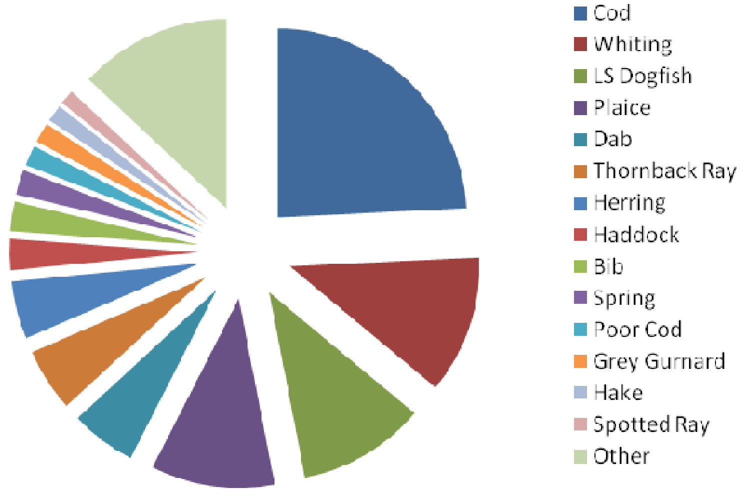

Figure 1. Species composition of Irish Sea data digitised as part of DAPSTOM-3 (number of records) [9,194 individual records].

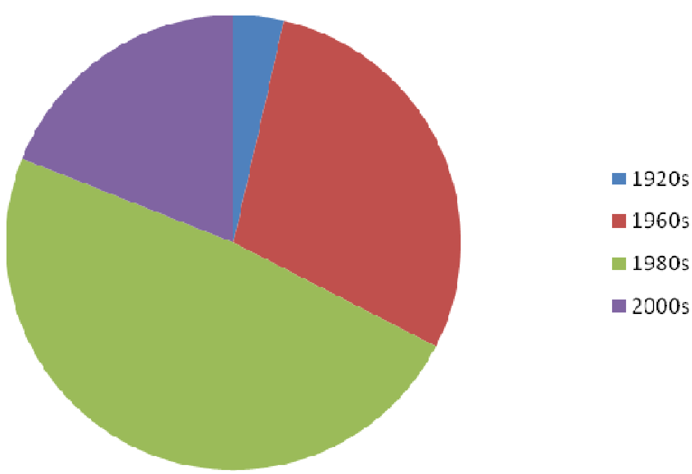

Figure 2. Temporal coverage of Irish Sea data digitised as part of DAPSTOM-3 (number of records) [9,194 individual records].

Task/Milestone 2: Other stomach datasets (historic and recent) available in standard DAPSTOM data format.

As originally planned, many other datasets (other than those in the Irish Sea) have been digitised for inclusion in the DAPSTOM-3 database (76 additional research cruises) including all data collected by MAFF/Cefas research vessels (Sir Lancelot, Platessa and Tellina) in the central North Sea during the 1950s, all data collected by MAFF/Cefas research vessels in the Arctic during 1949 and 1950 (and sporadic data from the 1930s, 1952, 1954 and 1964), data from charter vessel cruises in the North Sea and Arctic (e.g. the vessels Kingston Amber, Boston Beaver, Brucella and G.A. Reay), data on fish larval diets in the Channel collected by Lebour between 1914 and 1924, data collected by the Dove Marine Laboratory on the Northumberland coast between 1896 and 1907, data on herring diets in the North Sea (from Hardy 1924) and data on hake diets from Hickling (1927). In addition, modern data (collected in 2009) were added to the database from CSEMP monitoring cruises on the Dogger Bank. Figure 4 illustrates the species composition of this additional data, which is largely dominated by information on cod – since this was the main focus of sampling efforts in the Arctic, but also in the North Sea during the past 50 years. The newly acquired data (not including the Irish Sea data) comprised information on 90 fish species, although cod, haddock, herring and plaice represented the largest proportions (12604, 1726, 1955 and 2252 records respectively). Predator sizes ranged from 0.2 cm for a dragonet larva sampled off Plymouth in 1917, to 208 cm for a Greenland sleeper shark sampled in the Barents Sea during 1908. Data were available for 35 species that had never been recorded before in the DAPSTOM database (butterfly blenny, black seabream, ballan wrasse, connemarra clingfish, jelly catfish, capelin, spotted catfish, crystal goby, cuckoo ray, corkwing wrasse, Ekstroms topknot, European eel, garfish, goldsinny wrasse, common goby, great pipefish, Greenland shark, lancet, lesser forkbeard, Montague's blenny, Montague's sea-snail, Norwegian topknot, Nilsson's pipefish, painted goby, redfish, rock goby, shore clingfish, sand-sole, 19 spine stickleback, tompot blenny, topknot, transparent goby, two-spot clingfish, two-spot goby, worm pipefish).

Particular emphasis was placed on the digitisation of data from the 1950s (figure 5) since this period was not adequately covered during DAPSTOM phases 1 and 2. The addition of the DAPSTOM-3 data to the online data-portal brings the total number of records to 177,827, and the total number of species to 149. This represents a unique global resource, and many more datasets remain to be digitised (in Phase 4) within the Cefas paper archive, particularly from the area around Spitzbergen spanning the period 1951-1972, but also the North Sea throughout the 1930s, 1960s and 1970s. To date, limited data from the 1990s has been digitised (although see figure 11) because much of the information collected by MAFF research vessels during this decade was subsequently included in the ICES 'Year of the Stomach' database and is now available to download through the ICES data portal. We continue to pursue data on Irish Sea fishes during this period through contact with Dr Paul Newton, but unfortunately this data has not yet been forthcoming.

An analysis comparing the diet of key commercial fish species in the Dogger Bank region of the central North Sea during the early 1900s, with those in the 1950s and in the 2000s has now been carried out (see below) making use of the various datasets contained within the DAPSTOM database. A similar analysis has been carried out based on the data collected by MAFF scientists around Spitzbergen in the 1930s, 1949 and in 1950. This has revealed significant differences in feeding preferences depending on season and locality, and that the diet of cod may have been significantly different prior to the second World War with many more records of cod eating herring. However, cod diets were dominated by euphausiids (krill) throughout (figure 6), and the intention is that the DAPSTOM team will continue to digitise these arctic datasets (spanning 1949-1972) in collaboration with colleagues in Norway. Dr Pinnegar visited the Centre for Ecological and Evolutionary Synthesis (CEES) at the University of Oslo on 15th October 2010 and agreed to pursue further funding from Norwegian sources for technician support to digitise the remaining data. It should be noted that the number of stomachs sampled each year varies considerably (see caption). Relatively few individuals were sampled in the 1930s, and thus we should interpret any trends in these data with care. After 1949 sample sizes were consistently higher and therefore trends will be more robust. Thus, as more data are digitised from this region in the future, greater confidence in observed changes will be possible. This hitherto untouched resource is recognised as being of great value to Norwegian and Russian scientists since it pre-dates the information available in their own institutes and coincides with a period of dramatic ecosystem change in the Barents Sea/Spitzbergen region (Drinkwater 2006).

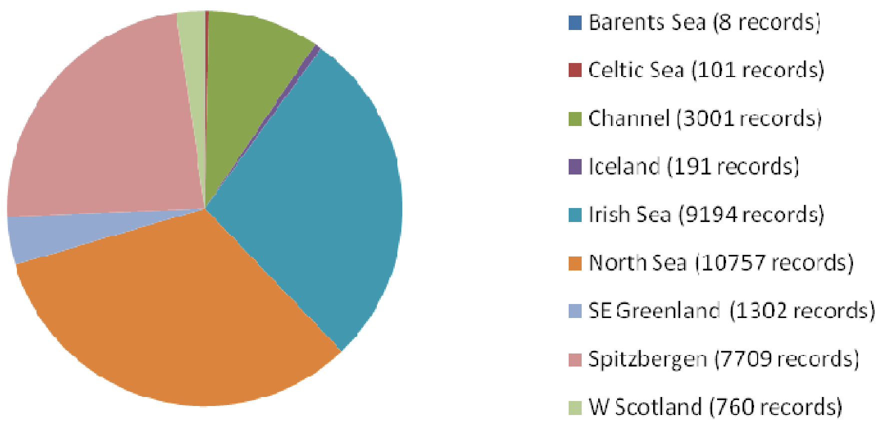

Figure 3. Number of additional records (by sea area) added to the DAPSTOM database as a result of the DAPSTOM3 project [Total 30,322 records].

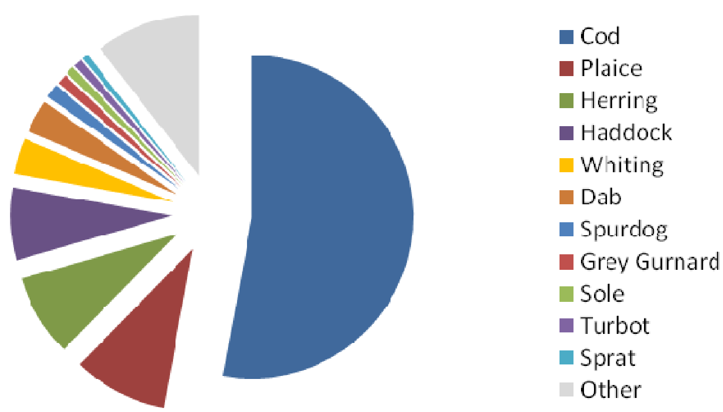

Figure 4. Species composition of the non-Irish Sea data digitised as part of DAPSTOM3 (number of records) [23,829 individual records].

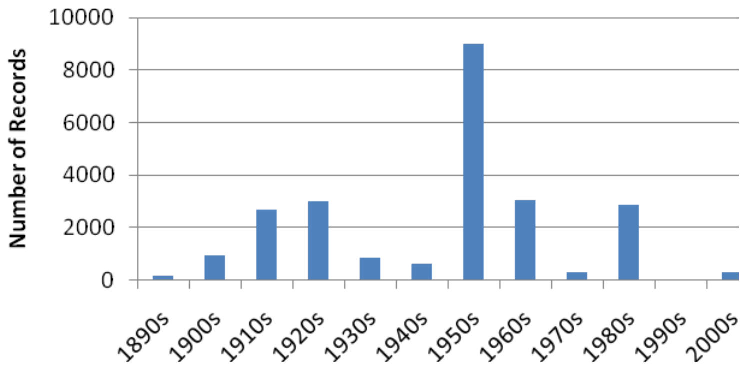

Figure 5. Temporal coverage of non-Irish Sea data digitised as part of DAPSTOM3 (number of records) by decade [23,829 individual records].

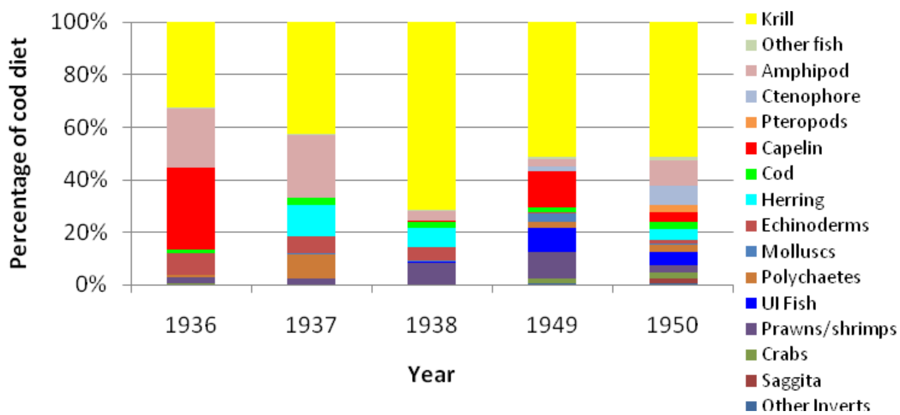

Figure 6. Proportion of diet represented by different prey types (number of prey items) in cod, for the area around Spitzbergen in 1936, 1937, 1938, 1949 and 1950 (number of records 67, 140, 329, 5004, 3136 respectively).

Task/Milestone 3: Upload datasets and make available through the existing DAPSTOM web-portal.

The DAPSTOM data portal has been fully updated to include all datasets that had been amassed by autumn 2009 (145,000 records), and this version was made accessible through the external Cefas internet site on 13th September 2010 (when the main Cefas site was 're-launched'). A final upload of the DAPSTOM-3 datasets to this website is anticipated within in July 2011, along with slight improvements in the functionality of the automatic pie-chart routine, such that sectors reflect broader taxonomic categories, rather than individual prey species.
The data-portal is now the subject of considerable interest among ecologists outside of Cefas. It has been used by a number of authors to construct ecosystem models and to conduct theoretical analyses of food-web properties in general (e.g. Brose et al. 2006; Barnes et al. 2008; Rossberg et al. in press). A particularly novel application has become apparent recently with researchers consulting the database in order to determine whether or not particular fish species are known to consume plastic debris, and whether the incidence of plastics among fish stomach contents has increased in recent years. Very little is known about the incidence of plastic litter in the marine environment and surveillance of fish stomach contents has been suggested as a relatively low cost means of monitoring this growing issue. All of the observations of plastics as a 'prey' item within the database (n = 22) were recorded after 1990, and mostly for generalist predators such as cod, whiting or grey gurnard.

At its most recent meeting (4-8th October 2010) in San Sebastian, Spain the ICES Working Group on Multispecies Assessment Methods (WGSAM) recommended that the ICES Data Centre work with Cefas to: "Consider the feasibility of expanding the ICES database to accommodate other datasets from the region, eg. explore complementarities with the Cefas 'DAPSTOM' dataset, which includes information on 130+ fish species". This follows on from considerable progress made by the ICES Data Centre together with the Working Group on Data and Information Management (WGDIM) to recover, correct and standardize datasets from the various 'Year of the Stomach' campaigns in the North Sea (see http://ecosystemdata.ices.dk/stomachdata/index.aspx). The two datasets are broadly compatible and non-overlapping, with similar database fields, but the DAPSTOM dataset would need further work to look for discrepancies as well as standardization of taxonomic categories. The DAPSTOM data portal will be used as a repository for new data, collected under the auspices of the recently agreed EU 'BASIN' project (see below).

Efforts have been made to move towards standard taxonomic nomenclature for all species, and the 'predator' look-up table (see annex 1) now includes a new field that contains TSN codes – defined by ITIS, the Integrated Taxonomic Information System. The corresponding 'prey' look-up table has not yet been updated, as this will require considerable additional effort.

Task/Milestone 4: Analysis of long-term changes in North Sea food-webs completed.

Considerable effort has been directed towards the digitisation of fish stomach data contained within scientists' logbooks from the central North Sea during the 1950s (in particular cruises of the MAFF research vessel Sir Lancelot). This was considered an important task because it is known that there have been major changes in fish communities, that became apparent in the late 1950s, and it was suspected that it would be possible to identify changes in food-webs between the early 1900s (data digitised as part of DAPSTOM-2) and the most recent period, (data digitised as part of DAPSTOM-1, but supplemented with additional data for dab in 2009). Figure 7 shows that the importance of large bivalve molluscs (red) as a prey item for plaice, dab and haddock has declined dramatically since the early 20th Century, whereas sandeels (yellow) have increased in importance, as have polychaete worms (green) to plaice and crabs (orange) to haddock. The importance of sandeels has also increased in whiting and grey gurnard stomachs (not shown), and these changes reflect real changes that are known to have occurred in the availability of certain prey items over the 100 year period. Benthic surveys conducted on the Dogger Bank in the 1950s and more recently have demonstrated that large slow-growing bivalve molluscs have largely disappeared from this region in recent years, whereas fast-growing polychaetes and crabs have proliferated (Kröncke 1992; Callaway et al. 2007). This work has been presented as part of invited keynote lectures in Berlin, Oslo, Korea and Japan (see publications, below). A draft manuscript has been prepared, and the intention is to submit this to a highly-rated scientific journal in the near future.

The findings above are important for a number of different reasons. Firstly, efforts are underway as part of commitments towards implementing the new EU Marine Strategy Framework Directive - MSFD (adopted by nation states in June 2008) to find indicators of good environmental status. The Strategy aims to achieve good environmental status for the EU's marine waters by 2021 and to protect the resource-base upon which marine-related economic and social activities depend. Scientists have been tasked with finding suitable indicators and in particular indicators that reflect the status of marine food-webs (one of eleven 'qualitative descriptors'). As part of this process policy makers will need to set baselines and thresholds that define good environmental status, but this can be very difficult if we know that food-webs have changed fundamentally in the past, and what we currently see may be a substantially 'altered' or a non-natural situation. It is thought that the changes observed in the Dogger Bank ecosystem may largely be a consequence of physical abrasion by successive beam trawling in the region, which has removed slow-growing, fragile species in favour of fast-growing, less vulnerable animals and this has had consequences for food-web structure, as evidenced from figure 7. The question remains however, as to whether the MSFD, but also the EU Habitats Directive (under which the Dogger Bank has been nominated as a potential Special Area of Conservation) will require that the ecosystem be 'recovered' to a more 'natural' system, such as existed prior to the 1950s, or whether they will simply require no deterioration from the system that exists today.

A further implication of the analysis described above concerns the types of prey items consumed by fish predators now, compared to the past. It is interesting to note that there has been a general switch away from species that lay down a hard calcareous shell or skeleton (e.g. bivalve molluscs) to soft-bodied animals such as polychaete worms and sandeels. There is currently much debate about what might happen in the future as the oceans become more acidic; a consequence of increased anthropogenic CO_2 emissions. In particular scientists have speculated about what might happen if calcareous species can no longer thrive or are less productive (Fabry et al. 2008). The results above show that fish predators can adapt and change their dietary preferences when calcareous prey types are less abundant, and therefore that commercial fin-fish stocks may not be affected to the extent as has be surmised (e.g. Cooley & Doney 2009). Further analysis of linkages between particular prey organisms and particular predators is now planned under the newly-funded NERC-Defra Ocean Acidification programme, using the DAPSTOM database (see below). This will establish whether there are particular dependencies, and whether different fish life-stages (e.g. larvae, juveniles, adults) are more or less vulnerable.

Several other authors have provided evidence for fundamental changes in North Sea food-webs during the same time window i.e. 1950s-1960s (Rijnsdorp & Vingerhoed 2001; Frid & Hall 2001). Christensen & Richardson (2008) have suggested that the diet of harbour porpoises may have changed appreciably in the 1950s/1960s, reflecting a greater importance of sandeels, and many seabirds (that rely on sandeels) also increased during this time (Tasker & Becker 1992). It may be possible to generate additional time-series of fish dietary data in the North Sea using the DAPSTOM-3 dataset in the future, for example making use of the recently digitised data from the Dove Marine Laboratory on the Northumberland coast (between 1896 and 1907), and comparing this with data from the same region in 1991 and 2006.

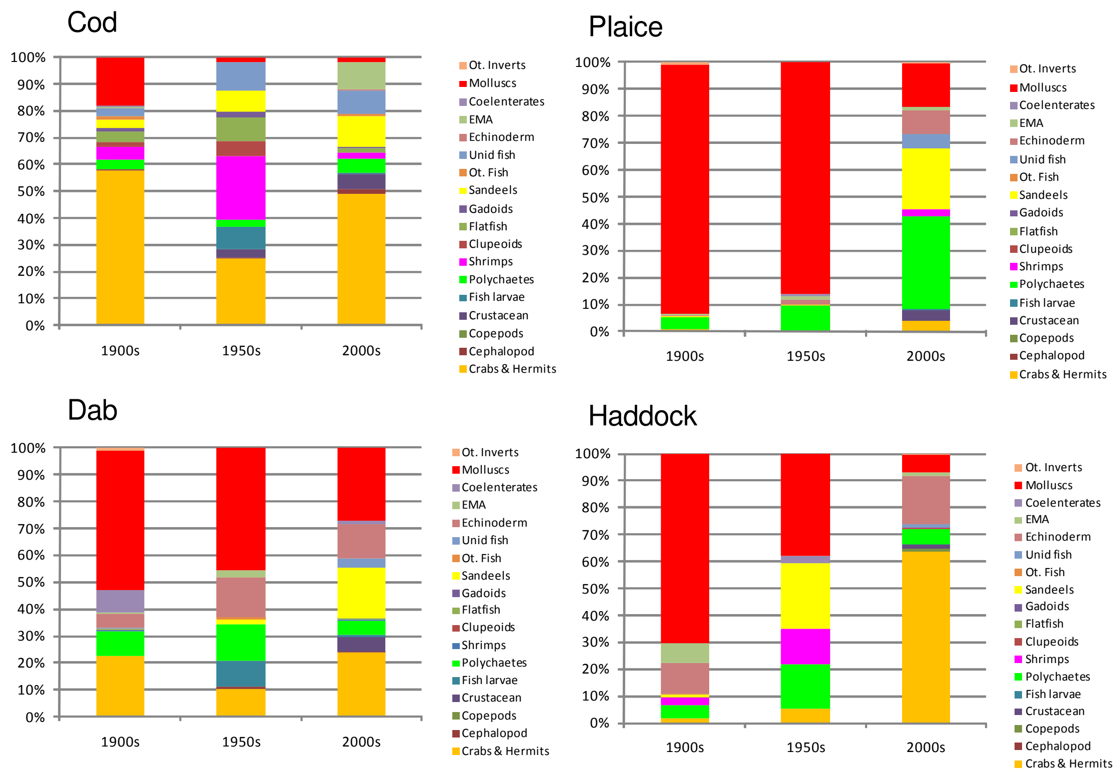

Figure 7. Proportion of diet represented by different prey types (number of prey items) in cod, plaice, dab and haddock during the early 1900s, the 1950s and the early 2000s for the Dogger Bank region of the central North Sea.

Task/Milestone 5: Finalized version of cod - Nephrops model for the Irish Sea, making use of recent stomach and survey datasets

In order to characterise the level of interaction between cod and Nephrops in the Irish Sea it was necessary to estimate the number of cod that exist within the key Nephrops grounds (west of the Isle of Man) at different times of the year, but also their size composition. Initial efforts were made to use the length-based multispecies, multi-area modelling framework 'Gadget' (Begley & Howell 2004) to estimate cod and Nephrops population numbers, but this proved exceedingly complicated given that cod migrate into and out of the Nephrops area during different seasons (Bendall et al. 2009) and the fact that there is a general lack of information with which to parameterise the migration model. Consequently it was decided to abandon this idea, and to take a more empirical approach, making use of outputs (numbers at age) from the ICES stock assessment model for cod in the Irish Sea downscaled to the level of the Nephrops fishing grounds. This modelling work built upon earlier work by Brander & Bennett (1986, 1989), but using updated information on cod stomach contents, as well as improved survey data for both species. Knowledge of Nephrops abundance and biology was very limited in the 1980s (when the model of Brander & Bennett was constructed). In recent years however, video survey techniques have evolved (at Cefas, AFBI and DARD) and hence it is now more feasible to examine the impact that exploitation of one species might have on the yield of another.

A first step involved calculation of cod numbers-at-age in each month of the year (for the whole Irish Sea), since the ICES stock assessment for cod only provides numbers for January 1st of each year (when juveniles nominally 'recruit' to the population). A simple cohort decay model was used to calculate the numbers of animals remaining at the end of each month, subject to fishing and natural mortality (F and M). This model was extended to a two area model with three distinct time phases. Phase 1 was months 1-3, where cod numbers increased on the Nephrops ground due to spawning. Phase 2 was months 4-6 where cod started to migrate away from the spawning ground. Finally Phase 3 was months 7-12 where it was assumed no net migration would take place. The migration parameters were fitted using cod landings-per-unit-effort (lpue) bycatch data from the Northern Ireland commercial Nephrops fleet (single-rigged Nephrops trawlers). In addition to this data, evidence given in the report of "MF160: Pilot study for fishery-independent monitoring of cod recovery in the Irish Sea by means of egg production surveys" suggesting that 50% of the cod SSB is on the Nephrops ground in the spawning period, and hence this value was also used. The parameterised model was then used to give the numbers at age both on and off the Nephrops ground during each month.

Because cod select their prey on the basis of size (both their own size and that of the prey) rather than age, it was necessary to convert numbers-at-age to numbers-at-length. This was achieved through the use of age-length datasets (spanning 1992-2003) provided by AFBI in Northern Ireland. Monthly data were aggregated (averaged) to quarters, since only quarterly age-length data were available, and a von-Bertalanffy growth function was fitted to this data. Data from all years were combined (because of the small sample sizes in particular years) and linear regression was used to establish the relationship between standard deviation (of the numbers-at-length per age group) and fish length, since it is known that the variability of fish lengths at age increase with size (i.e. young fish typically exhibit a narrow size range, but older cohorts typically exhibit a wider distribution of sizes). The resulting distributions (proportions of an age group falling in each 1cm length class) were then used to convert the numbers-at-age both 'within' and 'outside' the Nephrops area, into numbers-at-length.
Daily ration (food consumption) at length was estimated using a gastric evacuation model described in Armstrong et al (1991). The mean daily intake per unit body mass was computed by means of the expression derived by Jones (1974) for the rate of elimination of food by haddock, cod and whiting:

$$r = 24 \cdot (\frac{L}{40})^{1.4} \cdot w^{0.46} \cdot 10^{0.035\,(T_0 - T_C)} \cdot Q$$

Where r is the rate of elimination (g per day) of food from the stomach of a fish L cm long with mean stomach content mass w resulting from continuous feeding at an ambient temperature To ºC, and Q is the hourly rate of elimination of 1g of food of appropriate type from the stomach of a 40cm fish at an arbitrary temperature TC ºC. Armstrong et al (1991) suggested that Nephrops are evacuated from cod stomachs at approximately half the rate of fish prey, because of their thick exoskeletons. In view of this finding, it has been assumed that a value of Q = 0.075, i.e half the value for fish prey given by Jones (1974), would be appropriate for Nephrops. The expression above was applied to each length-class of cod to estimate the mean daily intake of food rj as a percentage of the mean mass of fish ($100 \cdot r_j / W^{cod}$) in each length class j, as follows.

First, the value of Q for Nephrops was applied in the equation above to estimate the daily intake for a situation in which 100% of the stomach contents comprised Nephrops. Multiplying the figure by the observed average proportion by mass of Nephrops in the stomach contents (at a particular length) gave an estimate of the mean daily intake of this species (see Armstrong 1982 for a worked example of this method). This procedure was repeated for the other food types, and the values of daily intake were summed over prey-types to give the overall daily intake of food per individual in each length class of cod. For the purposes of the present study, the prey items other than Nephrops and fish were treated as an aggregate with a value of Q = 0.12. The relative proportions of the different food items in the daily intake were re-estimated. As the mean mass of food in the stomachs during the first quarter of the year was found to be significantly lower (as was seawater temperature), separate estimates of food intake were made for each season.

Given the new stomach data collected in 2009/2010 (on Cefas cruises CEnd-02-09 and CEnd-04-10) and historic data contained in the DAPSTOM3 database it was possible to estimate the proportion of the diet (at length) that comprised of Nephrops in recent years. Figure 8 shows that Nephrops (orange) and fish (various shades of blue) represent increasingly important prey items for cod as individuals grow larger (whereas shrimps and crabs become less important). Figure 9 illustrates the resulting estimates of Nephrops consumption by cod in the Irish Sea. The analysis suggests that the quantity of Nephrops consumed has declined steadily since 2003 to around 150 tonnes/quarter (yearly totals for 2003-2007: 1.56, 1.08, 0.94, 0.68, 0.61 thousand tonnes), and this has largely been associated with a decline in the size of the Irish Sea cod stock (particularly the number of large individuals). Given the large size of the Nephrops stock on this side of the Irish sea (ICES 2009 Advice), this represents a relatively low mortality rate (especially compared to the 8.4 thousand tonnes removed by fisheries in 2007) and is much lower than the estimate provided by Armstrong (1991) for the period 1982-1983 (~1.7-5.4 thousand tonnes/year).

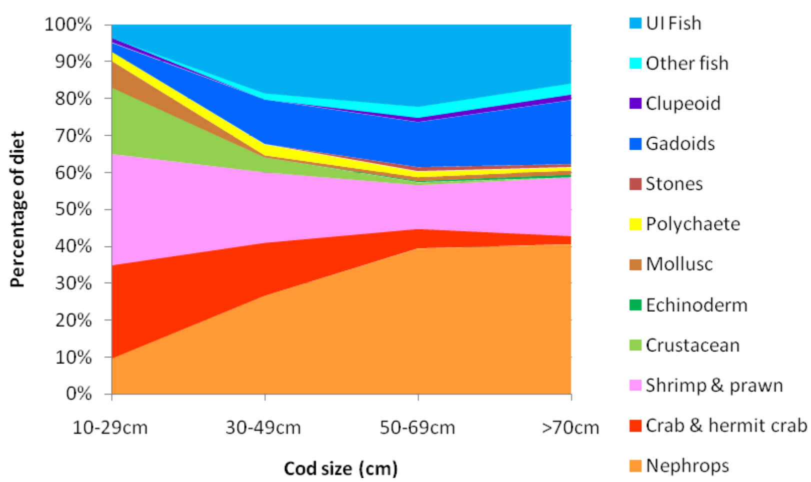

Figure 8. Percentage of cod diet represented by different prey types (number of prey items) in the Irish Sea (ICES rectangles 36E4 and 37E4), based on data collected in 2009 and 2010.

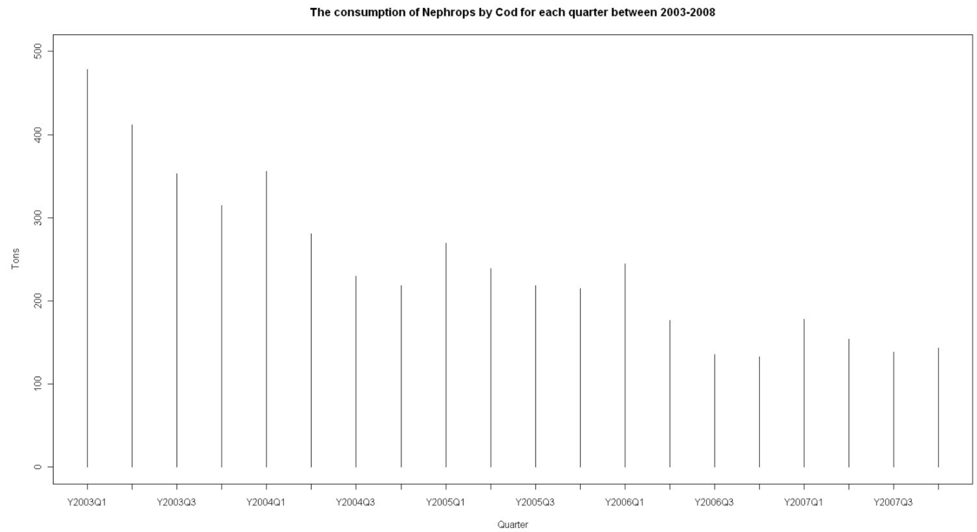

Figure 9. Consumption of *Nephrops* by cod in ICES rectangles 36E4 and 37E4, for the period 2003 to 2007, expressed by quarter (season).

Task/Milestone 6: Final report of the DAPSTOM-3 project, including an update on the database and results of all analyses.

On completion of the DAPSTOM-3 initiative the DAPSTOM database now contains 177,443 records from 157,351 individual predator stomachs and 149 species. As such, this represents one of the largest compilations of food-web data anywhere in the world. The vast majority of the data is derived from the North Sea (66.5%), but DAPSTOM-3 has added substantial holdings from the Irish Sea (8.5%) and the area around Spitzbergen (6.5%), where the UK used to have major fishery interests – see figure 10. 286 individual research cruises have been digitised and there is now coverage throughout the past 120 years (see figure 11). The earliest data were collected in December 1893, the most recent in February 2010.

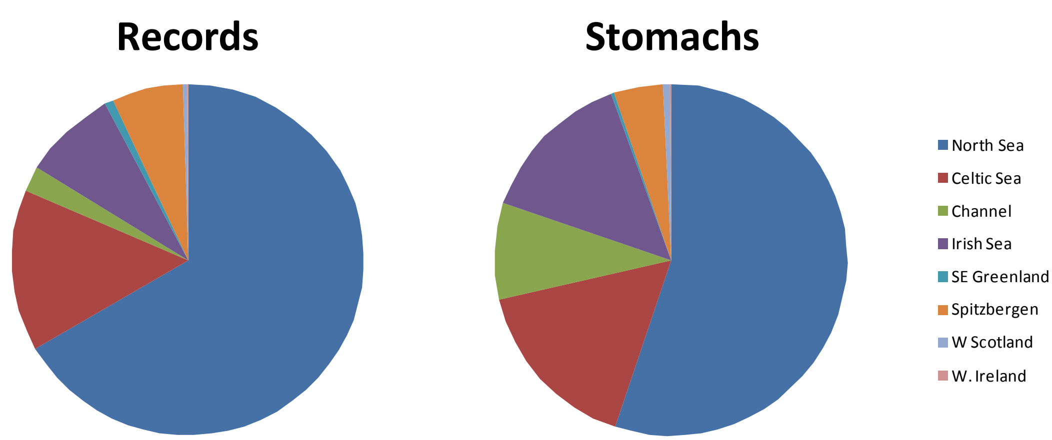

Figure 10. Proportion of all records and stomachs in the DAPSTOM database from each regional sea.

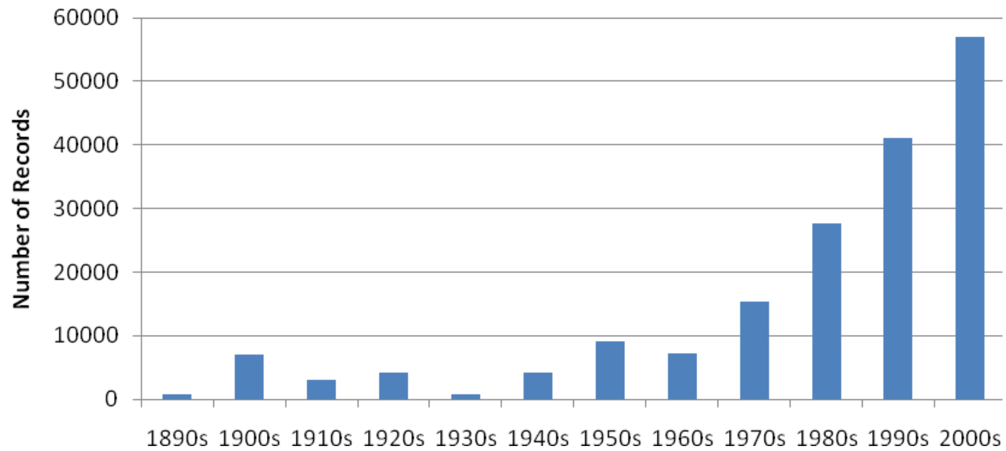

Figure 11. Temporal coverage of records contained in the DAPSTOM database by decade.

Discussion of the results and their reliability

The DAPSTOM dataset

Given that hundreds of different scientists have been involved in data collection and that some of the data are more than 100 years old, it should not come as a surprise that there are inconsistencies in the way that data were collected. The level of taxonomic detail used when identifying prey types, and the nomenclature used to describe both predators and prey have varied throughout the period – as have means of assessing 'fullness' or 'digestion stage'. Where possible data have been 'corrected' to modern nomenclature and a database structure has been designed that can accommodate almost any format of historic data and yet still yield useful output statistics and plots. However care must be taken when comparing or amassing data from different periods or different authors. Much of the data-entry was carried out following examination of 100s of hand-written log-books kept by the scientists involved. Not all scientists have equally legible handwriting and this sometimes created problems of interpretation. In other cases scientists only provided 'pooled' data for a number of stomachs, usually fish within a stated size range, and this has presented challenges in finding ways to analyse such datasets and provide meaningful summary statistics. Some authors (particularly recently) have provided weights and numbers of individual prey items, whereas others have simply listed the prey types observed in a particular stomach. Statistical methods are available to make use of both types of information (see Hislop 1980), but in the first instance we have applied a database field containing 'minimum number', which is assumed to be "1" if no quantity is provided. In the longer term it is hoped that a standard 'look up table' of prey weights might be developed to help convert numerical data to quasi-gravimetric (weight based) estimates.

Despite the stated problems, the DAPSTOM data-portal provides a very useful function in making previously inaccessible datasets (which are at risk of being lost forever), available to researchers and members of the public. In some cases data are presented on comparatively rare species, for which it is usually exceedingly difficult to find information, in other cases data are provided for species that are increasing in abundance around the UK (e.g. red mullet and John dory) and for which information can be useful in order to predict the consequences of invasion and spread.

Usually authors provide information about the number of 'empty' or 'everted' stomachs but this is not always the case, and so users of the database need to bear this in mind when carrying out data extractions.

Cod-Nephrops Model of the Irish Sea

The issue of cod-nephrops interactions in the Irish Sea has received considerable attention over the years (see Boyd 1983; Brander & Bennett 1986; Bennett & Lawler 1994; Armstrong 1991), given that both are valuable species of considerable commercial importance. Every effort has been made in the analysis described above to use as up-to-date information on cod and Nephrops populations as possible, but there are a number of key uncertainties and limitations in the analysis that should be highlighted.

Firstly we have comparatively poor information on cod distribution patterns throughout the year with Cefas groundfish surveys being conducted only in November and AFBI surveys in March and October. Consequently we have relied on bycatch data from commercial fleets in order to characterise seasonal migration patterns of cod, and as such the analyses are vulnerable to errors or biases associated with misreporting and discarding (mostly small cod). In addition, cod are now so few and far between in the Irish Sea (having decreased from 30,044 tonnes in 1973 to 1,987 tonnes in 2009), that survey and commercial datasets are very 'noisy' with marked variability between years and seasons. Consequently we have needed to average or aggregate datasets over multiple years in order to create meaningful age-length keys, or seasonal migration matrices/multipliers.

Suitable stomach datasets, that include gravimetric (weight-based) estimates of prey composition, were only available for two years (2009 and 2010), and only in the spring. Hence it is possible that we may have under or over estimated the contribution that Nephrops makes to the diet of cod during the rest of the year. We have however, attempted to calculate Nephrops consumption by cod on a quarterly basis assuming different cod population numbers within the area (a function of migration and recruitment), different size-frequencies of cod in each season, and corresponding differences in overall consumption rate (related to seawater temperature and dominant prey types). It was also necessary to aggregate the available stomach content data into cod size classes recognizing that very few individuals were sampled below a size of 42.5cm (total length) but more detailed data were available for fish that exceeded this length, which were grouped into 10cm categories up to a size of 82.5cm. Fish less than 42.5cm were observed to consume few Nephrops (<29% of diet by weight), and so data aggregation is unlikely to have resulted in major biases in the overall estimates of Nephrops consumed.

The estimates we provide here for Nephrops consumed by cod on a quarterly basis are of broadly similar magnitude (but lower, as a result of lower cod stocks) to those provided by Armstrong (1991) and Fannon & Hillis (1982). Although this can not be taken as validation in itself, it does offer confidence that nothing is seriously amiss within our calculations. In order to calculate the possible implication of this level of mortality on the Nephrops stock (see below) it is necessary to obtain some indication of Nephrops stock numbers in the region (denoted as stock area "FU15" by ICES). Unlike the time when Armstrong (1991) and Fannon & Hillis (1982) were writing, we now benefit from joint underwater television surveys (UWTV) of burrow densities on the main Nephrops fishing grounds by Northern Ireland and the Republic of Ireland (since 2003). In addition Northern Ireland have completed spring (April) and summer (August) Nephrops trawl surveys since 1994, and these provide data on catch rates, size composition and biological characteristics. The use of the UWTV surveys for the provision of Nephrops management advice was extensively reviewed by WKNEPH (WKNEPH, 2009) and potential biases were highlighted, including those due to edge effects; species burrow mis-identification and burrow occupancy. A cumulative bias correction factor estimated for FU15 was 1.14 which means that the TV survey is likely to overestimate Nephrops abundance by approximately 14%.

The main implications of the findings

Long term changes in fish diets

In addition to the two issues already discussed (above), namely the requirement to set sensible baselines and thresholds under the EU Marine Strategy Framework Directive (and Habitats Directive), and the indication that fish can switch diet and might not be affected by a general lack of calcifying prey species (associated with ocean acidification); there are a number of other implications that should be considered, and which have a bearing on policy and management. Firstly, the strong inter-dependencies observed between different commercial fish species (e.g. cod or whiting and sandeels in the North Sea), illustrated by our analysis, may suggest that current fishery management targets such as commitments to achieve 'maximum sustainable yield' across multiple species simultaneously, may actually be impossible given that species eat each other, and recovery of one species (such as whiting) may result in decline in another (e.g. sandeels). In 2008 the ICES Working Group on Multispecies Assessment Methods (WGSAM) reviewed this issue and concluded that predicted single-species yields (and therefore MSY targets) are simply untenable, since high yields at low fishing effort are 'eroded' by predation pressure. In addition WGSAM (2009) looked at predation of fish eggs and larvae by pelagic predators (herring, sprat, anchovy etc.), and using information extracted from the DAPSTOM-3 dataset, concluded that such predators can exert a substantial toll on other commercial species, such as plaice and cod, and hence greatly impact year-class strength and fisheries of such species.
The Arctic analysis we report here is of major relevance because stock assessments for Arctic cod already make use of stomach data and assume that when capelin or herring are a low abundance, then cod engage in cannibalism and this additional mortality has a major impact on future stock levels (Frøysa et al. 2002). Completion of data entry for UK research cruises around Spitzbergen in 1949 and 1950 has already yielded useful support for such hypotheses, and as more data is digitised in the future (see below), better process understanding – and hence better long-term management will undoubtedly follow.

Model of cod-nephrops interactions

The main rationale for constructing a model of cod-Nephrops interactions in the Irish Sea was to determine the level of predation mortality inflicted upon the Nephrops population, and how this compares to other sources of mortality such as fishing pressure. The FU15 Nephrops fishery first developed in the late 1950s. Since then it has sustained landings of around 9000 tonnes for more than 35 years. Estimated Nephrops landings in 2007 were 8,424 tonnes from this region, and this equates to 511 million individuals landed (plus an additional 375 million individuals caught and discarded). Given an estimated Nephrops population size of 5.15 billion individuals in 2007 (WKNEPH 2009), then ~16% are thought to be removed each year by the fishery.

By contrast, we estimate that 610 tonnes were removed by cod predation, and this equates to around 32 million individuals or 0.6 % of the total Nephrops stock in 2007. This level of removals by cod is much lower than was previously assumed to have been the case (as indicated by Armstrong 1991). We also demonstrate that natural mortality on Nephrops is not constant from year to year or from season to season, and thus that usual assumptions in stock assessments (i.e. of constant natural mortality) may be violated. Cod populations in recent years are one tenth of what they were in the early 1980s. Assuming that the Irish Sea cod stock is allowed to recover to the stated MSY spawning biomass target of 10,000 tonnes (from 1658 tonnes in 2007), then this would imply a much greater level of predation pressure on Nephrops in the future, than is currently the case but this would still represent a much smaller toll than is imparted by the fishery.
In order to carry out the calculations above it was necessary to use an observed relationship between predator (cod) size and prey (Nephrops) size, using all such information contained within the DAPSTOM database. This included many records for the Irish Sea from cruises CEnd-04-2010 and Clion-11-1983 (n = 233) but also some records from the North Sea (n = 191; see Catchpole et al. 2006), in order to increase the sample size [figure 12]. Consumption of Nephrops (in tonnes) by cod length class was converted into numbers of Nephrops consumed by cod length class in each quarter. These numbers were then summed across all size categories and quarters.

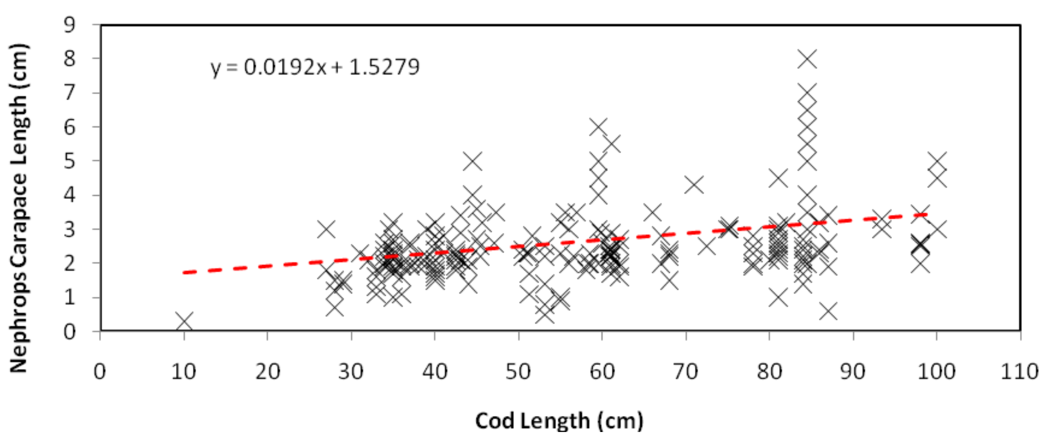

Figure 12. Relationship between cod size (total length in cm) and *Nephrops* size in cod stomachs (carapace length cm), based on all data contained within the DAPSTOM database (*n* =410).

A search of the DAPSTOM-3 database to establish whether or not other predatory fish species in the Irish Sea might possibly impart a similar predation toll on Nephrops has revealed records of haddock, plaice, gurnards and dogfish etc. consuming this prey type (table 1). However, the frequency of occurrence of Nephrops in the stomachs examined was considerably lower in other species, in comparison with cod. Hence it seems unlikely that any other fish predator (perhaps with the exception of haddock) would have a significant impact on the Nephrops stock given the recent dwindling influence of cod, although this can not be ruled out.

Table 1. Records contained in the DAPSTOM-3 database of fish predators consuming *Nephrops norvegicus* in the Irish Sea. Only predators >15cm in length were included in calculations of *Nephrops* per stomach.

Predator Name	Predator Name	Number of *Nephrops* consumed	Number of stomachs examined	*Nephrops* per stomach
COD	Cod	893	2061	0.433
HAD	Haddock	109	611	0.178
PLE	Plaice	33	8432	0.004
DAB	Dab	3	1250	0.002
MON	Monkfish	2	407	0.005
WHG	Whiting	4	955	0.004
GUG	Grey gurnard	11	787	0.014
TUB	Tub gurnard	3	197	0.015
GUR	Red gurnard	1	393	0.003
LSD	Lesser dogfish	20	1094	0.018
THR	Thornback ray	1	420	0.002
BIB	Bib	5	135	0.037
COE	Conger eel	2	14	0.143
DGS	Spurdog	2	91	0.022
SDR	Spotted ray	1	56	0.018

Possible future work

The DAPSTOM database has been included in a number of research proposals submitted to the EU and NERC/Defra over the past 12 months, specifically:

- EC FP7 proposal "BASIN" (submitted in Jan 2010) 'Sustainable use of the seas and oceans: importance of forage fish in the ecoregion'. [Call ENV.2010.2.2.1-1] Cefas will contribute to WP5 ('Dynamics of living resources and their utilisation') and in particular DAPSTOM will be applied across the whole project to hold incoming fish-stomach content data as well as being used to provide existing information on predators (and prey) of blue whiting in the Celtic Sea.
- EC FP7 proposal "CLIMARES" (submitted in Jan 2010) 'Climate change impacts on Arctic Economy & Society' [Call OCEAN.2010.1]. Cefas are leaders on the 'fisheries' part of the proposal and would make use of the recently digitised Arctic data in DAPSTOM (see above) to characterise the reliance of commercial species (most notably cod) on different prey species, in order to predict how ecosystems might be affected by future climate change.
- Proposal submitted (Nov 2009) under the joint NERC-Defra call on ocean acidification – Area C 'Benthic Species'. "Impacts of ocean acidification on key benthic ecosystems, communities, habitats, species & life cycles". Plan to use DAPSTOM outputs (in task 3.1) to determine how ocean acidification may affect the functioning of marine foodwebs, by

determining (from lab experiments) which invertebrate species will be affected by ocean acidification through interrogation of the DAPSTOM database- looking to see which species (both commercial and non-commercial) feed on these.

In addition the outputs of task 4 (above) will contribute directly to the EU FP7 project 'FACTS' (Forage Fish Interactions) – see www.facts-project.eu, which aims to 'provide insight and quantitative advice on the ecosystem-wide consequences of management actions directly or indirectly related to forage fish'. Specifically, Cefas are committed to an assessment of "long-term changes in relative importance of different forage fish species" as part of Deliverable 1.3 (Report on the potential for competition among forage fish species within each of the four FACTS case study regions including aspects of overlaps in diet and habitat and requirements).

Major aspirations for the future will include: (1) to work with the ICES Data Centre to develop common database structures for holding historic and incoming fish stomach records, and perhaps to work towards a single database encompassing fish from all geographic regions in the future; (2) further digitisation of UK stomach datasets from the area around Spitzbergen, working with the Centre for Ecological and Evolutionary Synthesis (CEES) at the University of Oslo as well as Norwegian and Russian fishery scientists - A joint PhD proposal will be submitted to the Fisheries Society of the British Isles in January 2011; (3) targeted action, together with the ICES Working Group on Multispecies Assessment Methods (WGSAM) to model past changes in predator-prey distributional overlap in the North Sea as well as the impact of emerging predators that are not currently included in multispecies models for this region (e.g. John Dory, seabass etc.); (4) further efforts to investigate preferences in relation to the availability of prey in the environment – see earlier work using DAPSTOM data by Pinnegar et al. (2003) and Pinnegar et al. (2006); (5) digitisation of extensive historic datasets on 'the food of fishes' contained within reports of the Fishery Board for Scotland spanning the period 1885-1909.

References cited in the text

Armstrong, M.J. (1982) The predator-prey relationships of Irish Sea poor-cod (Trisopterus minutus L.), pouting (Trisopterus luscus L.) and cod (Gadus morhua L.). J. Cons. Int. Explor. Mer, 40: 135-152.

Armstrong, M.J., Smyth, D., McCurdy, W. (1991) How much Nephrops is eaten by cod in the Western Irish Sea? ICES CM 1991/G:15, 18pp.

Barnes, C. (2008) Predator and prey body sizes in marine food webs. Ecology 89(3): 881.

Begley, J. & Howell, D. (2004) An overview of Gadget, the Globally applicable Area-Disaggregated General Ecosystem Toolbox. ICES CM 2004/FF:13.

Bendall , V., Ó Cuaig, M., Schön, P.S., Hetherington, S., Armstrong, M., Graham, N., Righton, D. (2009) - Spatio-temporal dynamics of Atlantic cod (Gadus morhua) in the Irish and Celtic Sea: results from a collaborative tagging programme ICES CM 2009/J06, 35pp.

Bennett, D.B. & Lawler, A.R. (1994) Irish Sea cod and Nephrops interactions – can the model be validated? ICES-CM-1994/K:34.

Boyd, R.J (1983) The feeding of cod in the North-west Irish Sea. ICES-CM-1983/G:6

Brander, K.M. & Bennett, D.B. (1986) Interactions between Norway lobster (Nephrops norvegicus L.) and cod (Gadus morhua L.) and their fisheries in

the Irish Sea. Canadian Special Publication on Fisheries and Aquatic Science, 92: 269–281.
Brander, K.M. & Bennett, D.B. (1989) Norway lobsters in the Irish Sea: Modeling one component of a multispecies resource. In: Caddy, J.F. (ed), Marine Invertebrate Fisheries: their stock assessment and management. Wiley, London.
Brose, U., et al. (2006) Consumer–resource body-size relationships in natural food webs. Ecology, 87: 2411–2417.
Callaway R., Engelhard G.H., Dann J., Cotter J., Rumohr H. (2007) A century of North Sea epibenthos and trawling: comparison between 1902–1912, 1982–1985 and 2000. Marine Ecology-Progress Series, 346: 27–43.
Catchpole, T.L., Frid, C.L.J., Gray, T.S. (2006) Importance of discards from the English Nephrops norvegicus fishery in the North Sea to marine scavengers. Marine Ecology-Progress Series, 313: 215–226.
Christensen, J.T. & Richardson, K. (2008) Stable isotope evidence of long-term changes in the North Sea food web structure. Mar Ecol Prog Ser 368: 1-8.
Cooley, S.R. & Doney, S.C. (2009) Anticipating ocean acidification's economic consequences for commercial fisheries. Environmental Research Letters, 4 (8pp)
Drinkwater K.F. (2006) The regime shift of the 1920s and 1930s in the North Atlantic. Progress In Oceanography, 68: 134-151.
Fabry, V.J., Seibel, B.A., Feely, R.A., Orr, J.C. (2008) Impacts of ocean acidification on marine fauna and ecosystem processes. – ICES Journal of Marine Science, 65: 414–432.
Fannon, E. & Hillis, J.P. (1982) Studies on cod prey with special attention to Nephrops norvegicus. ICES CM 1982/G:51.
Frid, C.L.J. & Hall, S.J. (1999) Inferring changes in North Sea benthos from fish stomach analysis. Marine Ecology-Progress Series, 184: 183-188.
Frøysa, K.G., Bogstad, B., Skagen, D.W. (2002) Fleksibest—an age-length structured fish stock assessment model. Fisheries Research, 55:. 87–101.
Hardy, A.C. (1924) The herring in relation to its animate Environment. Part I. The food and feeding habits of the herring with special reference to the east coast of England. MAFF Fishery Investigations, II, 7, (3):1-39.
Hickling, C.F., (1927) The Natural History of the Hake – Parts I and II. MAFF Fishery Investigations, Series II., Vol. X., No. 2, 79 pp
Hillis, J.P., Fannon, E. (1981) The role of cod as a predator on Nephrops norvegicus in the western Irish Sea. ICES-CM-1981/G:55
Hyslop, E.J. (1980) Stomach contents analysis—a review of methods and their application. Journal of Fish Biology, 17: 411-429.
Jones, R. (1974) The rate of elimination of food from the stomachs of haddock Melanogrammus aeglefinus, cod Gadus morhua and whiting Melangius merlangus. J. Cons. Int. Explor. Mer, 35: 225-243.
Kröncke, I. (1992) Macrofauna standing stock of the Dogger Bank. A comparison: III. 1950-54 versus 1985-87. A final summary. Helgoländer Meeresunters. 46, 137-169.
Lebour, M.V. (1919) Feeding habits of some young fish. Journal of the Marine Biological Association of the United Kingdom, 12 (1). pp. 9-21.
Lebour, M.V. (1919) The food of post-larval fish. No II (1918) Journal of the Marine Biological Association of the United Kingdom, 12 (1). pp. 22-47.
Lebour, M.V. (1920) The food of young fish. No. III (1919). Journal of the Marine Biological Association of the United Kingdom, 12 (2). pp. 261-324.
Lebour, M.V. (1918) The food of post-larval fish. Journal of the Marine Biological Association of the United Kingdom, 11 (4). pp. 433-469.
Lebour, M.V. (1921) The food of young clupeoids. Journal of the Marine Biological Association of the United Kingdom, 12 (3). pp. 458-467.

Lebour, M.V. (1924) The food of young herrings. Journal of the Marine Biological Association of the United Kingdom, 13 (2). pp. 325-330.
Macer, C.T. (1967) The food web in Red Wharf Bay (North Wales) with particular reference to young plaice (*Pleuronectes platessa*). Helgoland Marine Research, 15: 560-573.
Pinnegar, J.K., Blanchard, J.L. (2008) Long-term shifts in the feeding preferences of North Sea fish over the past 100 years: old data and new modelling approaches. ICES CM 2008/F:06.
Pinnegar, J. K. & Stafford, R. (2007) DAPSTOM—an integrated database & portal for fish stomach records. Final report, Centre for Environment, Fisheries & Aquaculture Science, Lowestoft, UK. See www.cefas.co.uk/dapstom.
Pinnegar, J.K., Trenkel, V.M. Tidd, A.N., Dawson, W.A., Dubuit, M.H. (2003) Does diet in Celtic Sea fishes reflect prey availability? Journal of Fish Biology, 63, suppl. 1, 197-212.
Pinnegar, J.K., van der Kooij, J., Engelhard, G.H., Blanchard, J.L., Warr, K.J., Righton, D. (2006) Small-scale variability in fish diet and whether or not this reflects local patterns of prey availability. ICES CM 2006/F:07.
Rijnsdorp, A.D. & Vingerhoed, B. (2001) Feeding of plaice Pleuronectes platessa L. and sole Solea solea (L.) in relation to the effects of bottom trawling. Journal of Sea Research, 45: 219-229.
Rossberg, A.G., Farnsworth, K.D., Satoh, K., Pinnegar, J.K. (2011) Universal power-law diet partitioning by marine fish and squid, with surprising stability-diversity implications. Proceedings of the Royal Society, B. 278: 1617-1625.
Scott, A. (1922) On the food of young plaice (Pleuronectes platessa). Journal of the Marine Biological Association of the United Kingdom, 12 (4). pp. 678-687.
Tasker, M. L. & Becker P. H. (1992) Influences of human activities on seabird populations in the North Sea. Neth. J. Aquatic Ecol. 26: 59-73.
WGSAM (2008) Report of the Working Group on Multispecies Assessment Methods (WGSAM), 6–10 October 2008, ICES Headquarters, Copenhagen. ICES CM 2008/RMC:06, 107pp.
WGSAM (2009) Report of the Working Group on Multispecies Assessment Methods (WGSAM), 5–9 October 2009, ICES Headquarters, Copenhagen. ICES CM 2009/RMC:10, 111pp.
WGSAM (2010) Report of the Working Group on Multispecies Assessment Methods (WGSAM), 4-8 October 2010, AZTI - San Sebastian, Spain. ICES CM
WKNEPH (2009) Report of the Benchmark Workshop on Nephrops (WKNEPH), 2–6 March 2009, Aberdeen, UK. ICES CM 2009/ACOM:33, 154pp.

Annex 1. DAPSTOM Database – Field Descriptions (as of 1st July 2011).

'Hauls' Table

1. Year – year in which samples were collected.
2. Cruise Name – usually includes the name of the vessel (or sampling programme) together with an identifying number and a 2 digit year code.
3. Station – the station number or area indicated in the original data. Where multiple station numbers are cited, or ICES rectangles then an over-arching 'A' number is used and more details are provided in the 'comments' column.
4. Haul ID – a unique identifier which is also replicated in the main 'DAPSTOM' database table (and forms the linking variable). It comprises the cruise name and station number.
5. Gear Type – the sampling method used to catch the fish, usually some sort if trawl.
6. Date – sampling date (when the net went into the water), with the format dd/mm/yyyy.
7. NEWDATE – a numerical representation of the date with the format yyyymmdd. If only the month is known then the 'day' is given as 00.
8. ICES Rectangle – a sea area covering 0.5° Latitude, 1° Longitude used by the International Council for the Exploration of the Seas.
9. Sub area – a large spatial unit used by the International Council for the Exploration of the Seas.
10. Division – a spatial sub-unit used by the International Council for the Exploration of the Seas. The North Sea is divided into 3 divisions (IVa,b,c), whereas the Channel is divided into 2 (VIId,e), the Celtic Sea into 5 (VIIf,g,h,j) and the Irish Sea is 1 (VIIa).
11. ICES Roundfish – a defunct spatial sub-unit used by the International Council for the Exploration of the Seas used in some stomach sampling programmes.
12. Sea – a broad geographical area used for DAPSTOM reporting. Includes: North Sea, Irish Sea, W Ireland, Celtic Sea, Channel, Biscay.
13. Shot Lat Deg – Latitude, in full degrees, of position where the net was deployed.
14. Shot Lat Min –minutes north or south (to be used with degrees field).
15. Shot Long Deg – Longitude, in full degrees, of position where the net was deployed.
16. Shot Long Min –minutes east or west (to be used with degrees field).
17. Shot EW – indicates whether the 'shooting' position is east or west of the Greenwich meridian.
18. Haul Lat Deg – Latitude, in full degrees, of position where the net was hauled.
19. Haul Lat Min –minutes north or south (to be used with degrees field).

20. Haul Long Deg – Longitude, in full degrees, of position where the net was hauled.

21. Haul Long Min –minutes east or west (to be used with degrees field).

22. Haul EW – indicates whether the 'hauling' position is east or west of the Greenwich meridian.

23. Shot Tm – time of day (hh:mm) when net was deployed.

24. Haul Tm – time of day (hh:mm) when net was hauled.

25. Depth m – bottom depth of shooting position (in metres).

26. Comments – additional information about the haul or station, sometime listing the group of stations or ICES rectangles included.

'DAPSTOM' Table

1. ID – a unique identifier for each record (automatically added by the MS Access software).

2. Haul ID – a unique identifier which is also replicated in the main 'Hauls' table (and forms the linking variable). It comprises the cruise name and station number.

3. Pred – the predator species, indicated by a 3 digit code (and linked to the 'Predator' look-up table).

4. Pred Length – the length (in cm) of the individual predator.

5. Pred sex – sex of the individual predator, M = male, F = female, U = unkown.

6. Pred mat – maturity stage of the individual predator (as listed in the original paper source). Sometimes given a numerical value (spanning 1-7), or simply I = immature, M = mature.

7. Pred weight – weight of the individual predator (in grams).

8. Pooled – an indicator of whether or not the record represents a group of individuals or a single animal. y = yes (pooled), n = no (a single animal).

9. Size category – used when the record represents a group of individuals, to indicate the size range included (if known).

10. Mean length – used when the record represents a group of individuals, to indicate the average (or median) size (in cm).

11. PRED ID – a unique identifier for the individual predator animal (or group of animals). This is needed because there is sometimes more than one prey item within a single stomach.

12. Number of stomachs – indicates how many individuals the PRED ID represents. This has a value of '1' where the data has been collected at the individual animal level, however it may be higher for pooled data.

13. Num empty – indicates the number of empty stomachs included within the PRED ID.

14. Fullness – an index of stomach fullness (as listed in the original paper source). Sometimes spanning 0-1, 1-10, % or Full, Partially full, Empty.

15. Total stom wgt – total weight (in grams) of all contents within the individual predator stomach.

16. Total stom vol – total volume of all contents within the individual predator stomach (as listed in the original paper source).

17. Prey – prey type, as listed in the original paper source. This is used as a linking variable to the 'Prey' look-up table.

18. Prey number – prey number given in the original paper source (sometimes blank – see MIN NUM).

19. Prey length – length or size of individual prey item (in cm).

20. Digestion – an index of digestion state (as listed in the original paper source). Usually spanning 0 (pristine) to 4 (unidentifiable).

21. Indprey wgt – the weight of the individual prey item (in grams).

22. Ind prey vol – the volume of the individual prey item (as listed in the original paper source).

23. MIN NUM – where the prey number is given, this is reproduced in this column. Where no prey number is given, then a minimum of '1' is indicated.

'Predator' look-up table

1. SCIENTIFIC – the latin name of the predator species.

2. COMMON – the common (English) name of the predator species.

3. Pred – the predator species, indicated by a 3 digit code (and linked to the main 'DAPSTOM' table). These codes were derived from those used by the UK Ministry of Agriculture, Fisheries & Food (MAFF).

4. NODC – international identifier (now defunct) for the predator species (10 digit).

5. TSN CODE – defined by ITIS, the Integrated Taxonomic Information System.

'Prey' look-up table

1. Prey – prey type, as listed in the original paper source. This is used as a linking variable to the main 'DAPSTOM' table.

2. MAFF – a 3 digit code used as an identifier for the species, derived from those used by the UK Ministry of Agriculture, Fisheries & Food (MAFF).

3. VALID NAME – – the common (English) name of the prey species.

4. LATIN – the 'correct' latin name of the prey species.

5. GROUP – category of animal, used for broad scale taxonomic analyses (e.g. crab, shrimp, amphipod, copepod, teleost, polychaete, bivalve, gastropod etc.).

6. TYPE – higher-level category, used for broad scale taxonomic analyses (e.g. crustacean, fish, worm, mollusc, echinoderm etc.).

7. NODC-10 – international identifier for the prey species (10 digit).

Annex 2. Number of predator stomachs and prey records by research cruise, included in the DAPSTOM database (as of 1st July 2011).

Cruise Name	Records	Year	Sea	Stomachs
ALBE01-75	70	1975	Irish Sea	251
ALBE01-76	30	1976	Irish Sea	172
ALBE01-77	43	1977	Irish Sea	240
ALBE02-75	30	1975	Irish Sea	254
ALBE02-76	50	1976	Irish Sea	406
ALBE02-77	50	1977	Irish Sea	624
ALBE03-76	39	1976	Irish Sea	321
ALBE03-77	45	1977	Irish Sea	202
ALIDA-1925	10	1925	W Scotland	616
ALSF	1420	2005	North Sea/Channel/Irish Sea	605
BEAULIEU	54	2001	Channel	40
BEAVER-1962-I	241	1962	North Sea	203
BEAVER-1962-II	126	1962	North Sea	86
BRUCELLA-1961	51	1961	SE Greenland	40
CEND02-09	758	2009	Irish Sea	412
CEND-04-10	1745	2010	Irish Sea	1289
CEND-10-09	324	2009	North Sea	199
CIRO03-78	2256	1978	North Sea	2004
CIRO07-78	1478	1978	North Sea	1754
CIRO-09-1982	359	1982	Irish Sea	206
CIRO09-77	4086	1977	North Sea	3374
CIRO09-82	371	1982	Irish Sea	397
CIROL03-86	1246	1986	Celtic Sea	891
CIROL03-87	759	1987	Celtic Sea	694
CIROL03-91	8113	1991	Celtic Sea	6778
CIROL03-92	12746	1992	North Sea	4229
CIROL03-93	2123	1993	Celtic Sea	1761
CIROL03-94	103	1994	Celtic Sea	87
CIROL04-92	2029	1992	Celtic Sea	1680
CIROL05-86	764	1986	Celtic Sea	473
CIROL10-91	548	1991	Celtic Sea	316
CIROLANA-02-90	1258	1990	North Sea	527
CIROLANA-07-82	1165	1982	Irish Sea	2953
CIROLANA-07-89	22	1989	North Sea	20
CIROLANA-1984-9	434	1984	North Sea	251
CLION02-75	62	1975	North Sea	30
CLION03-71	30	1971	Irish Sea	28
CLION-05-1982	144	1982	Irish Sea	109
CLION05-82	26	1982	Irish Sea	35
CLION-06-1982	90	1982	Irish Sea	75

CLION06-82	44	1982	Irish Sea	64
CLION-07-1982	43	1982	Irish Sea	25
CLION07-68	330	1968	North Sea	156
CLION07-82	12	1982	Irish Sea	17
CLION09-86	235	1986	Celtic Sea	131
CLION10-79	40	1979	Irish Sea	321
CLION-11-1983	2504	1983	Irish Sea	1360
CLION-12-1981	416	1981	Irish Sea	380
CLION-12-1982	173	1982	Irish Sea	83
CLION12-81	151	1981	Irish Sea	323
CLION12-82	274	1982	Irish Sea	399
CLION-5A-1980	261	1980	Irish Sea	262
CLION-68	52	1968	North Sea	21
CLUPEA-1991	2929	1991	North Sea	1773
COMMERCIAL-1903	1	1903	North Sea	6
COMMERCIAL-1904	16	1904	North Sea	10
COMMERCIAL-1905	13	1905	North Sea	48
COR04-04	2390	2004	North Sea	2178
COR09-04	3626	2004	North Sea	2658
COREL02-68	287	1968	North Sea	227
COREL04-68	212	1968	North Sea	133
COREL04-73	618	1973	North Sea	244
COREL05-74	711	1974	North Sea	381
COREL06-68	139	1968	North Sea	106
COREL07-68	199	1968	North Sea	124
COREL07-72	4710	1972	North Sea	1206
COREL07-73	81	1973	North Sea	43
COREL07-74	12	1974	North Sea	4
COREL09-68	290	1968	North Sea	149
COREL-10-1968	723	1968	North Sea	482
COREL-12-1980	122	1980	Irish Sea	109
COREL13-1981	166	1981	Irish Sea	375
CORYSTES-1988-8	3995	1988	North Sea	1380
CORYSTES-1992-7	4605	1992	North Sea	1848
CYPRIS-05-1965	293	1965	Irish Sea	184
DISCARDS-82	12	1982	Irish Sea	43
DOVE-1896	188	1896	North Sea	142
DOVE-1900	87	1900	North Sea	74
DOVE-1901	117	1901	North Sea	103
DOVE-1902	149	1902	North Sea	136
DOVE-1903	127	1903	North Sea	119
DOVE-1904	120	1904	North Sea	110
DOVE-1905	127	1905	North Sea	120
DOVE-1906	134	1906	North Sea	127
DOVE-1907	55	1907	North Sea	50

DUBUIT-1977	134	1977	Celtic Sea/Channel	97
DUBUIT-1978	181	1978	Celtic Sea	144
DUBUIT-1979	115	1979	W Scotland	76
DUBUIT-1981	770	1981	Celtic Sea/W Scotland	422
DUBUIT-1982	143	1982	Celtic Sea/W Scotland	86
DUBUIT-1983	600	1983	Celtic Sea/Biscay	523
DUBUIT-1984	6589	1984	Celtic Sea	2416
DUBUIT-1985	1435	1985	Celtic Sea	1008
DUBUIT-1986	247	1986	Celtic Sea/Biscay	234
DUBUIT-1987	143	1987	Celtic Sea/W Scotland	88
DUBUIT-1988	118	1988	Celtic Sea/Biscay	105
ELMA01-94	6696	1994	North Sea	1722
END03-08	1075	2008	Irish Sea	1024
END07-05	3065	2005	North Sea	2688
END11-06	3492	2006	North Sea	2928
END16-05	2963	2005	North Sea	2468
END17-06	2400	2006	North Sea	1703
END19-06	90	2006	Celtic Sea	63
ERN-HOLT-1949-I	118	1949	Spitzbergen (Greenland Sea)	21
ERN-HOLT-1949-II	40	1949	Spitzbergen (Greenland Sea)	15
ERN-HOLT-1949-IV	1515	1949	Spitzbergen (Greenland Sea)	56
ERN-HOLT-1949-IX	123	1949	Spitzbergen (Greenland Sea)	114
ERN-HOLT-1949-V	623	1949	Spitzbergen (Greenland Sea)	54
ERN-HOLT-1949-VI	1359	1949	Spitzbergen (Greenland Sea)	645
ERN-HOLT-1949-VII	497	1949	Spitzbergen (Greenland Sea)	231
ERN-HOLT-1949-VIII	1477	1949	Spitzbergen (Greenland Sea)	763
ERN-HOLT-1950-I	314	1950	Spitzbergen (Greenland Sea)	240
ERN-HOLT-1950-II	98	1950	Spitzbergen (Greenland Sea)	39
ERN-HOLT-1950-III	275	1950	Spitzbergen (Greenland Sea)	175
ERN-HOLT-1950-IV	237	1950	Spitzbergen (Greenland Sea)	190
ERN-HOLT-1950-IX	536	1950	Spitzbergen (Greenland Sea)	412
ERN-HOLT-1950-V	389	1950	Spitzbergen (Greenland Sea)	311
ERN-HOLT-1950-VII	774	1950	Spitzbergen (Greenland Sea)	388
ERN-HOLT-1950-VIII	756	1950	Spitzbergen (Greenland Sea)	490
ERN-HOLT-1952-V	1251	1952	SE Greenland	460
ERN-HOLT-1954-I	77	1954	Spitzbergen (Greenland Sea)	55
ERN-HOLT-1954-II	702	1954	Spitzbergen (Greenland Sea)	419
ERN-HOLT-1964-VI	826	1964	Spitzbergen (Greenland Sea)	470
ERN-HOLT-1964-VII	752	1964	Faeroes/W Scotland	669
ERN-HOLT-1970-03	294	1970	North Sea	198
FSP13(a)-06	3961	2006	North Sea	3578
FSP13(b)-06	4181	2006	North Sea	2963
GA-REAY-03-82	667	1982	North Sea	2320
GA-REAY-04-81	36	1981	North Sea	350
GA-REAY-09-81	24	1981	North Sea	452

GA-REAY-11-82	964	1982	North Sea	2881
GRAHAM-1923	1106	1923	North Sea	3705
HARBASINS	604	2007	North Sea	361
HARDY-1922	697	1922	North Sea	4796
HARDY-1923	819	1923	North Sea	8709
HARDY-1924	11	1924	North Sea	330
HEINCKE147-01	23849	2001	North Sea	274
HIAWATHA-1914-V	64	1914	North Sea	46
HULL-TRAWLER-1936	191	1936	Iceland/Spitzbergen	500
HULL-TRAWLER-1937	262	1937	Iceland/Spitzbergen	731
HULL-TRAWLER-1938	54	1938	Spitzbergen (Greenland Sea)	203
HUXLEY-1902-III	85	1902	North Sea	117
HUXLEY-1903-IX	36	1903	North Sea	22
HUXLEY-1903-V	32	1903	North Sea	98
HUXLEY-1903-VIII	102	1903	North Sea	803
HUXLEY-1903-X	376	1903	North Sea	1136
HUXLEY-1903-XI	38	1903	North Sea	76
HUXLEY-1903-XII	189	1903	North Sea	353
HUXLEY-1903-XIII	24	1903	North Sea	55
HUXLEY-1903-XIX	53	1903	North Sea	143
HUXLEY-1903-XV	215	1903	North Sea	368
HUXLEY-1903-XVI	32	1903	North Sea	49
HUXLEY-1903-XVII	27	1903	North Sea	61
HUXLEY-1903-XVIII	150	1903	North Sea	286
HUXLEY-1903-XX	19	1903	North Sea	27
HUXLEY-1903-XXI	76	1903	North Sea	178
HUXLEY-1903-XXIII	58	1903	North Sea	164
HUXLEY-1904-XL	77	1904	North Sea	190
HUXLEY-1904-XLI	83	1904	North Sea	120
HUXLEY-1904-XLIII	20	1904	North Sea	73
HUXLEY-1904-XLIV	24	1904	North Sea	119
HUXLEY-1904-XXIX	141	1904	North Sea	226
HUXLEY-1904-XXVIII	196	1904	North Sea	303
HUXLEY-1904-XXX	213	1904	North Sea	360
HUXLEY-1904-XXXI	216	1904	North Sea	446
HUXLEY-1904-XXXII	10	1904	North Sea	11
HUXLEY-1904-XXXIII	16	1904	North Sea	50
HUXLEY-1904-XXXV	21	1904	North Sea	63
HUXLEY-1904-XXXVI	3	1904	North Sea	11
HUXLEY-1904-XXXVII	3	1904	North Sea	2
HUXLEY-1904-XXXVIII	20	1904	North Sea	26
HUXLEY-1905-L	136	1905	North Sea	291
HUXLEY-1905-LII	4	1905	North Sea	5
HUXLEY-1905-LIV	5	1905	North Sea	2
HUXLEY-1905-LIX	332	1905	North Sea	601

HUXLEY-1905-LV	2	1905	North Sea	1
HUXLEY-1905-LVI	356	1905	North Sea	552
HUXLEY-1905-LVII	52	1905	North Sea	118
HUXLEY-1905-LVIII	259	1905	North Sea	508
HUXLEY-1905-LX	12	1905	North Sea	31
HUXLEY-1905-LXI	129	1905	North Sea	472
HUXLEY-1905-LXIII	124	1905	North Sea	359
HUXLEY-1905-LXIV	40	1905	North Sea	84
HUXLEY-1905-LXV	67	1905	North Sea	135
HUXLEY-1905-LXVI	86	1905	North Sea	132
HUXLEY-1905-XLIX	198	1905	North Sea	289
HUXLEY-1905-XLVII	66	1905	North Sea	260
HUXLEY-1905-XLVIII	62	1905	North Sea	259
HUXLEY-1906-LXIX	5	1906	North Sea	2
HUXLEY-1906-LXX	5	1906	North Sea	2
HUXLEY-1906-LXXIII	57	1906	North Sea	37
HUXLEY-1906-LXXIV	7	1906	North Sea	3
HUXLEY-1906-LXXVII	110	1906	North Sea	58
HUXLEY-1907-LXXXIX	170	1907	North Sea	75
HUXLEY-1907-LXXXV	144	1907	North Sea	62
HUXLEY-1907-LXXXVI	97	1907	North Sea	24
HUXLEY-1907-LXXXVII	51	1907	North Sea	28
HUXLEY-1907-LXXXVIII	165	1907	North Sea	62
HUXLEY-1907-XC	61	1907	North Sea	35
HUXLEY-1908-CI	56	1908	North Sea	32
HUXLEY-1908-CIV	2	1908	North Sea	1
HUXLEY-1908-XCIX	55	1908	North Sea	43
HUXLEY-1908-XCVII	42	1908	North Sea	12
HUXLEY-1909-CVI	3	1909	North Sea	2
HUXLEY-1909-CVIII	17	1909	North Sea	4
JACINTH-2002	279	2002	North Sea	238
KIMMERIDGE	61	2001	Channel	40
KINGS-AMBER-1938	275	1938	Spitzbergen (Greenland Sea)	223
LANCASHIRE-1893	33	1893	Irish Sea	64
LANCASHIRE-1894	600	1894	Irish Sea	1921
LANCASHIRE-1906	451	1906	Irish Sea	337
LANCASHIRE-1913	277	1913	Irish Sea	1610
LANCASHIRE-1921	317	1921	Irish Sea	754
LANCELOT-06-1957	333	1957	North Sea	263
LANCELOT-06-1958	154	1958	North Sea	102
LANCELOT-07-1957	160	1957	North Sea	117
LANCELOT-09-1953	43	1953	North Sea	22
LANCELOT-09-1957	198	1957	North Sea	111
LANCELOT-10-1959	11	1959	West Scotland/Celtic Sea	7
LANCELOT-16-1954	8	1954	North Sea	4

LANCELOT-16-1958	133	1958	North Sea/Channel	125
LANCELOT-18-1958	138	1958	North Sea	133
LANCELOT-19-1956	231	1956	North Sea	218
LEBOUR-1914	133	1914	Channel	2949
LEBOUR-1917	466	1917	Channel	2302
LEBOUR-1918	593	1918	Channel	1176
LEBOUR-1919	1503	1919	Channel	3244
LEBOUR-1920	40	1920	Channel	164
LEBOUR-1921	16	1921	Channel	34
LEBOUR-1924	203	1924	Channel	1577
LUC-2002	411	2002	North Sea	252
NUCEL11-78	4	1978	North Sea	4
OITHONA-1901	113	1901	Channel	294
OITHONA-1904	1	1904	North Sea	22
OITHONA-1906	66	1906	North Sea	46
ONAWAY-07-1959	80	1959	North Sea	46
PLATESSA-04-1958	239	1958	North Sea	187
PLATESSA-06-1962	536	1962	Irish Sea	515
PLATESSA-07-1965	52	1965	Irish Sea	38
PLATESSA-08-1962	19	1962	Irish Sea	18
PLATESSA-10-1962	1293	1962	Irish Sea	1100
PLATESSA-11-1959	315	1959	North Sea	240
PLATESSA-12-1951	89	1951	Irish Sea	72
PLATESSA-17-1962	226	1962	Irish Sea	187
PLATESSA-18-1962	28	1962	Celtic Sea	25
PLYMOUTH-1930	25	1930	Channel	23
PLYMOUTH-1931	22	1931	Channel	18
PRINCE-1925	15	1925	Celtic Sea	1666
RADIANT-2002	158	2002	North Sea	127
SALPA-1928	430	1928	Channel	942
SALPA-1929	475	1928	Channel	943
SCOTIA	129		W. Ireland	116
SILST-01-1982	19	1982	Irish Sea	21
SILST01-78	34	1978	Irish Sea	169
SILST01-79	21	1979	Irish Sea	191
SILST01-80	48	1980	Irish Sea	407
SILST01-81	37	1981	Irish Sea	277
SILST01-82	48	1982	Irish Sea	341
SILST01-83	191	1983	Irish Sea	184
SILST-02-1981	28	1981	Irish Sea	38
SILST-02-1982	79	1982	Irish Sea	98
SILST02-78	57	1978	Irish Sea	296
SILST02-79	52	1979	Irish Sea	253
SILST02-80	51	1980	Irish Sea	335
SILST02-81	37	1981	Irish Sea	288

SILST02-82	70	1982	Irish Sea	271
SILST02-83	56	1983	Irish Sea	61
SILST-03-1981	53	1981	Irish Sea	83
SILST03-78	62	1978	Irish Sea	387
SILST03-79	46	1979	Irish Sea	167
SILST03-81	23	1981	Irish Sea	331
SILST03-82	143	1982	Irish Sea	482
SS-ROMAN-1908	8	1908	Barents Sea	4
STRANDLINE-1987	827	1987	North Sea	708
ST-ROSE-1930	37	1930	Norwegian Sea/Spitzbergen	381
SYKES-1926	8	1926	W Scotland	288
TAMURA-1925	20	1925	W Ireland	878
TAMURA-1926	66	1926	W Ireland/Celtic Sea	5619
TELLINA-04-1963	127	1963	North Sea	90
TELLINA-05A1-1965	10	1965	Irish Sea	9
TELLINA-05A4-1965	41	1965	Irish Sea	35
TELLINA-05B2-1965	26	1965	Irish Sea	20
TELLINA-06-1963	56	1963	Irish Sea	49
TELLINA-06B1-1967	54	1967	Irish Sea	32
TELLINA-11-1961	197	1961	North Sea	124
TELLINA-5A-1964	31	1964	Irish Sea	26

Number of cruises 286
Number of stomachs 157351
Number of records 177443

Annex 2. Number of predator stomachs and prey records by species, included in the DAPSTOM database (as of 1st July 2011).

Latin name	Code	Records	Stomachs
Gadus morhua	COD	50364	24355
Merlangius merlangus	WHG	45784	25399
Melanogrammus aeglefinus	HAD	17220	12328
Pleuronectes platessa	PLE	9868	17974
Eutrigla gurnardus	GUG	7612	6663
Scomber scombrus	MAC	4773	3674
Lepidorhombus whiffiagonis	MEG	4140	3761
Clupea harengus	HER	3366	19271
Limanda limanda	DAB	3327	5721
Sprattus sprattus	SPR	2662	1328
Echiichthys vipera	WEL	2549	2354
Scyliorhinus canicula	LSD	2467	1721
Merluccius merluccius	HKE	2255	11017
Pollachius virens	POK	2086	902
Ammodytes spp.	SAN	1389	278
Trisopterus minutus	POD	1243	1164
Aspitrigla cuculus	GUR	1035	989
Raja clavata	THR	1004	304
Squalus acanthias	DGS	832	899
Microstomus kitt	LEM	777	1228
Trachurus trachurus	HOM	760	699
Trisopterus esmarki	NOP	755	2312
Trisopterus luscus	BIB	700	530
Solea solea	SOL	682	1132
Gurnards (unidentified)	GUX	607	320
Lophius piscatorius	MON	555	674
Callionymus lyra	CDT	540	749
Platichthys flesus	FLE	537	574
Zeus faber	JOD	439	451
Raja naevus	CUR	393	270
Engraulis encrasicolus	ANE	364	107
Chelidonichthys lucerna	TUB	346	382
Hippoglossoides platessoides	PLA	330	360
Scopthalmus maximus	TUR	322	321
Pollachius pollachius	POL	306	234
Capros aper	BOF	304	288
Raja montagui	SDR	302	184
Hyperoplus lanceolatus	GSE	290	370
Lepidorhombus boscii	LBI	266	250
Micromesistius poutassou	WHB	223	244

Scophthalmus rhombus	BLL	190	296
Arnoglossus laterna	SDF	187	618
Mullus surmuletus	MUR	181	130
Lophius budegassa	WAF	157	131
Microchirus variegatus	TBS	153	657
Raja radiata	SYR	149	128
Ciliata mustela	FVR	136	160
Labrus bergylta	BNW	135	153
Molva molva	LIN	133	131
Sardina pilchardus	PIL	124	448
Glyptocephalus cynoglossus	WIT	115	112
Raja batis	SKT	106	106
Agonus cataphractus	POG	101	52
Dicentrarchus labrax	ESB	95	62
Galeorhinus galeus	GAG	95	71
Ammodytes tobianus	TSE	89	209
Taurulus bubalis	SSN	85	99
Phrynorhombus norvegius	NKT	82	485
Raja brachyura	BLR	75	70
Enchelyopus cimbrius	FRR	62	53
Gobius spp.	GOB	60	54
Mustellus maculatus	SDS	57	22
Ctenolabrus rupestris	GDY	53	55
Salmo trutta	TRS	52	48
Helicolenus dactylopterus	RBM	51	46
Pholis gunnellus	BTF	49	28
Anguilla anguilla	ELE	47	27
Pomatoschistus minutus	SDG	47	78
Anarhichas lupus	CAA	46	21
Chelon labrosus	MTL	46	40
Gobiusculus flavescens	TSG	46	68
Raja fullonica	SHR	45	27
Arnoglossus imperialis	ISF	44	43
Myoxocephalus scorpius	BRT	39	44
Conger conger	COE	37	31
Lepadogaster candollei	CAC	35	35
Gobius paganellus	RKG	33	47
Lophius spp.	ANF	28	26
Mustellus mustelus	SMH	28	11
Labrus mixtus	CUW	26	16
Gaidropsarus vulgaris	TBR	26	89
Pegusa (Solea) lascaris	SOS	25	4
Trigloporus lastoviza	GUS	24	15
Scyliorhinus stellaris	DGN	22	10
Trachurus mediterraneus	HMM	20	12

Brosme brosme	USK	20	20
Squatina squatina	ALS	18	12
Pomatoschistus pictus	PTG	18	23
Gaidropsarus spp.	ROL	18	26
Crenilabrus melops	CWG	17	20
Belone belone	GAR	17	22
Pomatoschistus microps	GMG	17	24
Alloteuthis subulata	ATS	16	16
Blennius ocellaris	BBY	16	24
Buglossidium luteum	SOT	16	14
Gadiculus argenteus	SYP	15	38
Hippoglossus hippoglossus	HAL	14	6
Syngnathus rostellatus	NPF	14	8
Syngnathus acus	GPF	13	5
Cyclopterus lumpus	LUM	11	7
Zeugopterus punctatus	TKT	11	40
Diplecogaster bimaculata	TSC	10	10
Anarhichas minor	CAS	9	2
Liparis montagui	MSS	9	8
Raja microocellata	PTR	9	2
Spinachia spinachia	SSS	9	7
Spondyliosoma cantharus	BKS	7	7
Trachinus draco	WEG	7	43
Callionymus spp.	DTX	6	6
Somniosus microcephalus	GSK	6	2
Loligo vulgaris	LLV	6	6
Mugil spp.	MUL	6	3
Ciliata septentrionalis	NNR	6	5
Chimaera monstrosa	RBF	6	22
Phrynorhombus regius	EKT	5	15
Blicca bjoerkna	FSB	5	5
Gadidae	GAD	5	3
Coryphoblennius galerita	MBY	5	3
Raja circularis	SAR	5	5
Lepadogaster lepadogaster	SCF	5	6
Osmerus eperlanus	SME	5	5
Crystallogobius linearis	CLG	4	4
Macrorhamphosus scolopax	SNI	4	2
Parablennius gattorugine	TBY	4	3
Nerophos lumbriciformis	WPF	4	3
Argentina spp.	ARG	3	3
Perca fluviatilis	FPE	3	2
Rutilus rutilus	FRO	3	3
Syngnathidae	PFX	3	1
Maurolicus muelleri	PLS	3	3

Sebastes spp.	RED	3	3
Galeus melastomus	DBM	2	2
Leuciscus leuciscus	FDC	2	2
Phycis blennoides	GFB	2	2
Alosa alosa	AAS	1	1
Anarhichas denticulatus	CAJ	1	1
Mallotus villosus	CAP	1	1
Flatfish (unidentified)	FLX	1	1
Amphioxus lanceolatus	LCT	1	1
Raniceps raninus	LFB	1	1
Cepola rubescens	RPF	1	1
Salmo salar	SAL	1	1
Aphia minuta	TPG	1	2
Gasterosteus aculeatus	TSS	1	1

Number of species	144
Number of stomachs	157351
Number of records	177443