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Davie and Lordan, Irish trawl metiers, highlights:

- The Irish trawl fleet has been divided into thirty three metiers
- Multivariate factorial and classification methods were applied (PCA, MCA and HAC)
- Metier dynamics over the period 2003-2006 are described
- The utility of metier definitions for assessment and management are discussed

Definition, dynamics and stability of métiers in the Irish otter trawl fleet

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Abstract

The Irish otter trawl fleet operates in a complex multi-species multi-gear fishery, spanning a wide geographic area, and involving around 275 trawlers. Factorial and clustering methods were applied to 2003 fishing trip data to define thirty three métiers. Definitions were based on six trip characteristics taken from logbooks, namely: fishing gear, mesh size, vessel length, species composition, area, and month. Métiers exploiting demersal species or species groups are characterised by single vessel bottom otter trawls, typically with mesh sizes of 70mm or more, operating year round. This includes nine *Nephrops* dominated métiers highlighting the importance of this species to the fleet. Many demersal métiers are characterised by groups of species, including mixed whitefish or slope species. Métiers exploiting pelagic species are often focussed on single species, and are typically seasonal, mid-water trawling (often paired) with mesh sizes less than 70mm. Pelagic métiers account for the majority of landings by over an order of magnitude in several cases. Demersal métiers account for the majority of fishing trips and effort, (primarily *Nephrops* métiers), and

vessels (primarily mixed species métiers). The new métier definitions were found to be appropriate remained relevant despite declining fleet landings and effort between 2003 and 2006. Species compositions within these métiers have generally remained similar to the proportions defined in 2003. These robust métier definitions present opportunities to improve fisheries sampling, assessment and management. Although métiers pose complexity challenge for such applications they can be used the building blocks for appropriate management units.

Key Words

Irish otter trawl fleet; Métiers; Multivariate analysis; Fleet dynamics; Mixed fisheries

1 Introduction

The poor performance of traditional single species stock management systems has lead to a change in management perspectives. Moves towards mixed or multi-species fisheries management are consistent with the nature of operation of most trawl fisheries. However, sound mixed-species fisheries management requires detailed knowledge of the multi-fleet nature of fisheries, and of the multi-species interactions that are taking place. In addition, an understanding the complexity, dynamics and adaptability within operating fisheries (Holley & Marchal, 2004) is very important, particularly in response to evolving management strategies.

Due to the heterogeneity of the fisheries exploited by Irish otter trawl fleet, it is generally inappropriate to attempt to manage such fleets as a single unit. Thus, there is a need to identify and segment fisheries and fleets into similar groupings, or métiers. A métier being “a homogeneous subdivision of a fishery by vessel type” which includes a spatial and temporal component (ICES, 2003), also called ‘fishing tactic’ (Pelletier & Ferraris, 2000), ‘fishing strategy’ (Holley & Marchal, 2004), or ‘fleet component’ (Silva et al., 2002; Campos et al., 2007) in the literature. Defining métiers allows landings (and effort) to be allocated into “sensible” sized units reflecting the fishing activities within them (ICES, 2003). The complexity of the Irish otter trawl fisheries and fleet require that the métiers are based on a variety of factors including species assemblage, vessel characteristics, fishing grounds and season.

The homogeneity within métiers can provide for more “accurate” catch per species and effort calculations in assessment, and for more effective partitioning of fishing mortality (Pelletier & Ferraris, 2000). Well-defined métiers can create building blocks, for use at a national level to stratify sampling and discard programs which can be incorporated into European sampling initiatives (namely the Data Collection Framework), aid in assessing fleet/fishery dynamics (e.g. Ulrich & Andersen, 2004), and are becoming increasingly important in management strategy evaluations and simulations (e.g. ISIS-Fish: Drouineau et al., 2006 and Vermard et al., 2008). Ultimately, well defined métiers provide the building blocks of more effective management.

The main technique previously used to identify and define métiers has been quantitative multivariate analysis, primarily forms of cluster analyses. This is either in conjunction with factorial/ordination analyses (for example Pelletier & Ferraris, 2000; Holley & Marchal, 2004; Ulrich & Andersen, 2004; Campos *et al.*, 2007) or through clustering methods alone (Duarte et al., 2009; Castro et al., 2010; Castro et al., 2011). These multivariate methods have also been recommended by the ICES Study Group on the Development of Fishery based Forecasts (SGDFF; ICES, 2003). The SGDFF group proposed a three step open framework approach, combining quantitative analysis with *ad hoc* qualitative classification to define métiers. First species groupings are identified using catch/landing profiles. Relationships between landing profiles and trip/vessel characteristics are then assessed, followed by hierarchical classification obtaining groupings which are subsequently defined into métiers with expert knowledge of the fisheries and fleets. This framework has been followed in several investigations including Ulrich and Andersen (2004), and Holley and Marchal (2004). The main advantage of this technique is that it reduces subjectivity and dependence on *a priori* knowledge.

The objectives of this study were to (i) identify métiers using 'best practice' multivariate techniques, (ii) describe and characterise these métiers, (iii) assess métier stability and persistence. The analysis was undertaken using data for the Irish trawl fleet. The utility and application of métiers to the Irish national sampling program and wider management are discussed.

2 Materials and Methods

2.1 Data

Irish otter trawl logbook data was used for analysis, from the Integrated Fisheries Information System (IFIS) database, provided by the Department of Agriculture, Fisheries and Food. The Irish trawl fleet consists of between 250 and 300 vessels. This fleet utilizes a variety of different gear configurations and lands over 100 species from various species assemblages annually. Total landings in 2006 were around 210,000 tonnes in live weight, worth approximately 250 million euro at first sale. This equates for around 75% of annual Irish landings in value.

Within this analysis the data for "trawl gears" is restricted to Irish ≥10m vessels utilising bottom and mid-water otter trawls and paired bottom and mid-water trawls (OTB, OTM, PTB, and PTM). All vessels 10 meters and over, fishing in European waters which are at sea on fishing voyages longer than 24hrs are required to complete a daily logbook during each fishing trip (CEC 1993). For each fishing trip the following data was recorded for the analysis: overall vessel length, gear type, mesh size (including non-recorded as zero), ICES area, landing date, and estimated live weight (using conversion factors) of all species landed from the "landing declarations". Fishing trips were considered independently from the vessel, once overall vessel length was established. Fishing trips from 2003 to 2006 were available for analysis, 33,717 trips by 396 vessels. Due to the size of the data set 2003 was used as a reference year to identify and define métiers for application to 2003-2006 data. This restricted the number of fishing trips to 9030 carried out by 282 vessels. All analyses were performed within the R language and environment for statistical computing (R Development Core Team, 2007).

Prior to analysis data was subjected to initial screening, to remove unusable records. Landed weights recorded as "mixed boxes" were excluded from weight calculations, as the species compositions are unknown (~0.2 % of total annual Irish landed weight). Four fishing trips were excluded from the analysis, two trips landing solely mixed boxes and two recording use of multiple gears within the trip. Species contributing less than 0.1% of total landings were grouped together into an "other" category thus reducing the influence of 'less abundant' species. Cumulatively this "other" category accounts for, on average, less than 1% of total Irish landings annually. To reduce the impact of uncertain identification and variation in logbook coding practices some individual species were grouped to a higher taxonomic level e.g. *Rajiformes*. This resulted in the use of thirty-eight species categories within analyses.

2.2 Typology of métiers

The methodology in this investigation is based on that used by Pelletier and Ferraris (2000), and Ulrich and Andersen (2004), following the three-step framework recommended for métier definition by SGDFF (ICES, 2003). This combines the use of quantitative multivariate analysis of landings and effort data with qualitative expert knowledge, avoiding prior assumptions on homogeneous groupings.

In the first step, groups homogeneous in relation to species composition (i.e. landing profiles) are identified. There has been debate on what species metrics are appropriate for defining métiers. Most previous investigations used either landed weight or first sale value. In this investigation, and an earlier Irish Sea study (Davie and Lordan, 2009), landing profiles are used based on the relative species proportions in trip landings. Weight was primarily chosen as accurate values were not available at the time of analysis. It is possible that species with low landed weights, but high relative values may have resulted in these species having a greater influence in defining métiers had values been used. Management is primarily focussed on maintaining biological and ecological imperatives where catch weight is more a relevant metric than value.

Landing profiles were identified using non-normalised Principal Component Analysis (PCA) allowing for species dominance. PCA reduces the dimensionality of the dataset and identifies the main reoccurring species combinations that explain the greatest variation. Components are presented in order of importance, with the greatest variation described by the first component (Fowler et al., 2004). Subsequent application of Hierarchical Agglomerative Cluster analysis (HAC, utilising Euclidean distance and Ward's algorithm (Ward, 1963)) created successive clusters based on previously identified clusters, and built a hierarchy from individuals to a single group. Determination of the appropriate number of clusters to employ was considered to be the level at which the increase in the proportion of variance explained levelled off (via sums of squares and r^2 values), similar to that in Ulrich and Andersen (2004). The relevance and size of clusters was considered in the formulation of landing profiles, considered as categorical variables for input to Multiple Correspondence Analysis.

Multiple Correspondence Analysis (MCA) is analogous to PCA but is applied to categorical variables. MCA was used to investigate relationships between the landing profiles and five descriptive variables, as recommended by SGDFF (ICES, 2003). These variables were: 1) ICES divisions, 2) gear type, 3) mesh size range[1], 4) over all vessel length[2], and 5) month (a proxy for season). The MCA output was also entered into an HAC (based on Euclidean distance and Ward's algorithm (Ward, 1963)) to cluster trips into homogeneous groups based on the relationships between variables. The appropriate number of clusters was again estimated using the proportion of variance explained, each of which was fully described using the categorical variables. Some clusters were pooled to avoid over complexity and excessive desegregation. This pooling was necessary in a small number of cases to retain important information on the structure of the dataset whilst preserving integrity for future analysis (Anon, 2005a).

[1] Mesh size range was based on groupings in Council Regulation (EC) No 850/98: EC, 1998.
[2] Vessel length overall was based on the category outlined by the RCM NEA October 2005 report (Anon, 2005a).

3 Results

3.1 Landing profiles

Principal Component Analysis to identify landing profiles indicates high variability in trip species composition, and thus a great complexity of species interactions. This accounts for the low percentage variation explained by individual components. The first four components, which were considered as relevant to depict the relationships between species, explained 22% of the variability associated with trip landings. Figure 1 is a bi-plot showing the first and second PCA components to illustrate the species differentiations between landings profiles. In this plot trips dominated by "deepwater species", "slope species" (inc. ling (*Molva spp.*), hake (*Merluccius merluccius*), forkbeard (*Phycis spp.*)), "*Nephrops*" (*Nephrops norvegicus*), megrim (*Lepidorhombus spp.*) & monkfish (*Lophius spp.*), haddock (*Melanogrammus aeglefinus*), and mackerel (*Scomber spp.*) & herring (*Clupea harengus*) clearly formed separate groupings. Trip distribution was more dispersed across the third and fourth components (not shown) showing groups of megrim & monkfish, rays & plaice (*Pleuronectes platessa*), black sole (*Solea solea*), and haddock.

All principal components were included in the Hierarchical Agglomerative Cluster analysis (HAC) due to the apparent complexity of species interactions and to maintain sufficient variation. Choice of the appropriate number of clusters was made based on the level of variance within the dataset explained by clusters (from sums of squares and r^2 values). Little increase in the explained variance occurred with groupings of greater than 40 clusters. Therefore 40 clusters were considered an appropriate level of resolution, explaining 73% of the variation. The number of trips within clusters varied considerably (from 1 to 1887) where the majority of clusters each contained less than 5% of all trips. Of those clusters representing a small proportion of fishing trips (<5%), only those clusters considered to represent realistic target species or assemblage were retained as valid landing profiles. The remainder were either recombined with the next nearest linked cluster when species compositions were similar or assigned as non-allocated (“A”). The latter occurred when the species composition was very rare (e.g. mussels) or where the species composition was considered unlikely (e.g. pelagic and shellfish species caught together). This resulted in sixteen landing profiles (Table 1) varying in the number of characteristic species, named as the dominant species by proportions and occurrence within clusters. The number of characteristic species within a profile varies from one (mainly pelagic species) to five (mainly demersal species). The largest landing profile, (21% of all fishing trips) is characterised by high proportions of *Nephrops*, generally over 50% of the landings.

3.2 Métier Identification and description

To obtain groupings of similar trips with respect to key trip factors Multiple Correspondence Analysis (MCA) was performed followed by HAC clustering. Six key trip factors (descriptive variables) were used; landing profile, ICES division, vessel length range, gear type, mesh size range and month (season proxy). MCA produced 134 factorial axes, each explaining a small portion of variance. The first three axes are considered as relevant to depict the dominant relationships between trip details, combined explaining 6% of the variability within the dataset. The percentage of variation explained on the first axes was almost twice that of the second axes, suggesting a particularly different group of trip characteristics from the remainder.

On the first and second axes (Figure 2) a well separated group of multi-ICES division trips linked to area VIII and vessels greater than 80m in overall length occurs, with no clear landing profile association. There is also second more centralised trip grouping associated with the mixed pelagic landing profile (L13) and ICES areas VIII, XII, and division IIa. The main grouping is also seen on the second and third axes (not shown). Trips associated with deepwater species (L16) and tuna (*Thunnus spp.*) (L14), linked to larger mesh sizes (>100mm) and multi-ICES areas to the north and west of Ireland (i.e. VIa, VIIb, VIIc and VIIk) are also separated.

All MCA axes were included in the HAC analysis due to the complexity of interactions (i.e. low level of variance explained by individual axis) to maintain sufficient variation. The appropriate number of clusters was estimated as the point at which the level of variance within the dataset explained by clusters levelled off with increasing numbers of clusters. This resulted in 103 clusters explaining 80% of total variation. Figure 3 depicts the resultant HAC dendrogram with 103 clusters. The number of trips within these clusters varied greatly, from 1 to 4668 trips. Many clusters contained a consistent variable factor, a single gear type, landing profile, mesh size range or ICES area. The majority of clusters contained a variety of vessel length ranges and months, indicating that these are not key factors. Clusters with low fishing trip numbers, less than 1% (equating to 90 trips) were recombined with closely related clusters, unless they were considered to represent a true métier.

Once clusters were fully described the trip characteristics (i.e. vessel length, gear type, mesh size, area and time) and parameters for minimum and maximum species compositions were used to define the 33 métiers within the Irish trawl fleet (Table 2). In addition a number of 'non-métiers' groups were established to cover trips with incomplete or misspecified logbook information and trips with landings profiles or other characteristics outside the métiers definitions outlined in table 2.

Métiers can be divided into two main groups. Ten utilise less than 70mm mesh mid-water and/or pair trawls with high proportions of pelagic species landings. The majority of trips and vessels employ 70mm or greater mesh bottom otter trawls dominated by demersal species, with a greater diversity, often as mixed targets. Pelagic métiers are mainly populated by larger vessels (≥24m), whereas the majority of demersal métiers are mainly populated by a smaller vessels (<24m). The demersal métiers include nine with high *Nephrops* proportions, divided by ICES divisions and proportion of *Nephrops* landed. There is also a deepwater métier reporting landings cardinal fish (*Apogonidae spp.*), grenadier (*Macrourus spp.* and *Coryphaenoides rupestris*), deepwater shark and fish species operating to the west of Ireland (VIa, VIIb, VIIc, VIIj and VIIk).

In several cases, a landing profile occurred within several métiers exhibiting different vessel and trip factors (e.g. 70-89mm or 100-119mm mesh). The reverse was also observed, where métiers are formed with similar factors yet differing landing profiles. This highlights the importance of utilizing both trip and vessel factors, and species compositions to define métiers.

3.3 Examining the importance and dynamics of métiers

Métier definitions were applied to fishing trips from 2003 to 2006, to observe temporal dynamics in relation to number of trips, vessels, landings, and effort. The identified métiers persisted throughout the period, with exception of pilchard and mackerel targeted mid-water otter trawling. This would indicate that the analysis and subsequent métier definitions successfully identified repeatedly occurring patterns of fishing activity within the Irish trawl fleet. .

3.3.1 Fishing Trips and Vessels

Métier allocated fishing trips accounted for between 70-76% of all trips annually, with 94-98% of all vessels operating in at least one métier (Table 3). These levels remained relatively stable. It must be noted that vessels may belong to several métiers annually (Figure 4), targeting different species compositions or utilizing varying gear configurations on different fishing trips.

Vessels targeting pelagic species rarely occur in a single métier, related to quota and seasonal restrictions on pelagic fisheries. Some vessels operating within pelagic métiers also fish demersal métiers, and visa versa. Not all vessels operate across all the areas in which the Irish trawl fleet occurs. *Nephrops* is a good example, vessels belonging to a VIIa métier are very likely to also operate in VIIg, but less likely to operate in VIIj, VIIc or VIIk. This may relate to vessel limitations or fidelity of vessels to fishing ports. Around half of vessels operate within two to four defined métiers (Figure 4). However, vessels have operated within up to eleven defined métiers within a year, with few specialising in a single métier. Therefore, the majority of vessels are polyvalent in relation to métiers, targeting different species, areas, or varying trawl gear and mesh size. For some vessels this may not be intentional, where trips do not obtain the minimum species thresholds to qualify, e.g. occurring in both mixed and clean VIIa *Nephrops* métiers. Although not included in this analysis, the authors also note, vessels occasionally employ different gear types during a trip, for example a trawl net and pots.

Over time, the greatest increases in vessel numbers occurred in the same métiers as those with the greatest trip increases. Trip and vessel numbers more than doubled within the *Nephrops* OTB VIIc and VIIk métier. This increase was not universal among all *Nephrops* métiers, indicating an expansion of the deeper water *Nephrops* fishery on the Porcupine Bank (FU16). Mid-water blue whiting (*Micromesistius poutassou*) trawling in VIb, VIIc, VIIk and XII showed a substantial increase, doubling in both trip and vessel numbers. Two métiers have contracted by around 75% in trip and vessel numbers. These are the deepwater métier and ≥100mm mesh OTB for pollack (*Pollachius pollachius*), saithe (*Pollachius virens*), cod (*Gadus morhua*), whiting (*Merlangius merlangus*) and dogfish (*Squalidae* and *Scyliorhinidae*).

Within a métier trip increases do not necessarily result in increased vessel numbers and visa-versa. OTB trips targeting megrim and monkfish show an increased number of trips per vessel. Trip numbers in both the 70-99mm and ≥100mm mesh métiers increased by ~60%, although vessel numbers remained relatively stable. Conversely, the mackerel targeted métier across VIa, VIIb and VIIj shows greater vessel participation but with fewer trips per vessel. Vessel numbers showed an increase of 26% whilst trip numbers declined by 50%. This change can be related to management restrictions limiting individual vessel quotas.

Clean *Nephrops* in VIIa and the 70-99mm mesh plaice and ray OTB remained relatively stable across trip and vessel numbers. The stability suggests that there is consistent fisher participation within these métiers. Mixed *Nephrops* in VIIa and VIIg show stability in vessel numbers, whilst clean *Nephrops* métiers in VIIg and VIIb and *Nephrops* in VIIj show relatively stable trip numbers.

3.3.2 Landings

There is a wide variation in the total weight landed by each métier (Table 4). Pelagic métiers land the greatest volumes, the largest of which, characterised by blue whiting mid-water trawling, landed ~33kt in 2006. By contrast, the largest demersal landings originated from the 70-99mm mesh whiting métier of ~2.5kt. At the other end of the spectrum, *Nephrops* in VIa contributed just 35t. Overall demersal métier landings account for less than 13% of total weight landed by the fleet.

Mid-water trawling for blue whiting exhibits a marked increase in landings over the period (+102%). Significant increases in landings have occurred within three demersal métiers. Primarily, *Nephrops* in VIIc and VIIk (+276%), 70-99mm mesh whiting has shown an increase of nearly 200% and ≥100mm mesh megrim and monkfish increased by 73%. However, the majority of métiers showed declining landings over the period. The most substantial decline observed relates to the deepwater métier, declining from ~2kt to ~0.2kt, reflecting a major contraction in Irish deepwater fishing. Two mixed Irish Sea based demersal métiers have also shown marked declines, The 70-99mm mesh whiting, cod, haddock and dogfish, and ≥100mm mesh plaice and ray métiers based within the Irish Sea have shown a marked decline in landings. This results, in part, to restrictive effort and catch management as part of cod recovery measures. Mackerel in IVa was the most significant pelagic métier to decline, showing continuous reductions in landings in response to quota restrictions and changing fishing pattern. Landings in several métiers remained relatively stable. These included the pelagic métiers, Non-VIa herring pair trawling, and horse mackerel (*Trachurus spp.*) mid-water trawling, clean *Nephrops* in VIIb and VIIg, and ≥100mm mesh pollack, saithe, cod, whiting and dogfish.

Species compositions show the majority of demersal métiers land a wide variety of species (Figure 5), many as chance-catch, i.e. species not directly targeted but landed in low levels (<10%). Several species occur in the majority of demersal métiers as chance-catch. For example, both cod and hake occur to some extent in most demersal métiers. Highlighting the many mixed fishery interactions within waters fished by the Irish otter trawl fleet. The range of species is less extensive in pelagic métiers (Figure 5), which tend to be more mono-specific, indicating fewer mixed species interactions. The major pelagic species combination observed within Irish landings is European pilchard (*Sardina pilchardus*) and herring. Chance-catch species within pelagic métiers primarily include boarfish (*Caproidae*), horse mackerel and mackerel. In general, pelagic species can be targeted effectively by a métier due to mid-water shoaling behaviour which reduces the number of species interactions.

3.3.3 Effort

Below effort changes are examined here in days-at-sea, being every 24h period or part thereof from the time a vessel leaves port to the time it returns, as this measure of effort is often defined within European fisheries regulations. Fishing days and fishing hours were also available, although not detailed here. It should be noted that the relationship between days-at-sea, fishing days, and fishing hours can vary between métiers due, for example, to travel distances or target species behaviour.

Many demersal métiers average 4 to 5 days per trip. Longer trips, those averaging over 7, often include ICES areas further from Irish shores, including VIb and VIIc, likely resulting from longer travel times and/or longer trawl times within deeper waters. ≥100 mm mesh megrim and monkfish trawling trips in VIIj, also average over 7 days, trips within this métier are likely to occur toward the south-western corner of the division on the continental shelf slope, often crossing several ICES Divisions tracing the shelf edge.

Over the period examined total otter trawl fleet effort has declined, whilst the proportion assigned to métiers has fluctuated between 66% and 72%. This indicates métier definitions have remained relevant over time, encompassing the dominant fishing strategies of the Irish otter trawl fleet.

Several individual métiers have shown substantial effort increases (Table 3). In particular, VIIc and VIIk *Nephrops* and blue whiting mid-water trawling in which effort has doubled, or more, since 2003 indicating increased targeting by Irish fishers. Effort increases were also observed in the 70-99mm mesh whiting although, in this case little increase in trip numbers occurred and vessel numbers declined by 50% which indicates a change in métier fishing practice. For example, vessels increasing trip length and amount of fishing activity per trip.

Effort declined by 75% or more over the period in five métiers. Three demersal métiers; ≥100 mm mesh deepwater trawling, ≥100 mm mesh ling, witch (*Glyptocephalus cynoglossus*), forkbeard and hake, and ≥100 mm mesh plaice and ray. The later of which is unlikely to continue in coming years, given the declines observed. Two pelagic; mackerel mid-water trawling in IVa and sprat in VIa and VIIa. Several of these métiers have also shown large reductions in landings, trips and vessel numbers, indicating contracting métiers. Few métiers have shown little change. Only clean *Nephrops* in VIIg and mixed *Nephrops* in VIIa have remained relatively stable.

4 Discussion

Understanding fishermen's behaviour through the aggregated behaviour of fishing fleets is a key ingredient to successful fisheries management (Hilborn, 2007). The Irish fleet is diverse and complex with ~1,900 vessels registered[3], ranging in length

[3] Base on fleet register October 2007

from only few meters to one of the largest fishing vessels in the world at 134 m[4]. Trawling is the most common fishing method used by Irish fishing vessels ≥10 meters and is multi-species in nature, occurring across a wide spatial distribution. This investigation has succeeded in separating the large heterogeneous fleet into more homogeneous métiers, the definitions of which occur throughout the period examined. Case studies discussed below, highlight particular changes in behaviour, mixed species considerations, and impacts of external drivers. Possible contributions to sampling program design and national management advice are also considered.

This analysis framework applied similar statistical methodologies of ordination followed by clustering to several pervious métier studies (Pelletier & Ferraris, 2000; Holley & Marchal, 2004; Campos *et al.*, 2007). Alternative approaches such as Partitioning Around Medoids (PAM) algorithm (Duarte *et al.*, 2009) and an extension of this for large datasets, CLARA (Clustering LARge Applications) (e.g. Punzon *et al.*, 2010; Castro *et al.*, 2010; Castro *et al.*, 2011) have been used in recent studies. However, as cautioned by Castro *et al.* (2010), the CLARA algorithm samples subsets of the overall data matrix. As a result, clusters of information may be missed and/or oversimplified in complex datasets, such as the Irish trawl fleet. This is the first time métiers have been defined on a broad scale for Irish trawl fisheries, although investigation into métier definition was carried out in the Irish Sea (Davie and Lordan, 2009). The data available were in general of high resolution (i.e. detailed logbook), however it is prudent to point out that this analysis is only as reliable as the input data. Misspecified and misreported landings, changing discard practices and other data anomalies will have impacted the results obtained. This is exemplified by the large proportion of trips and effort allocated to “non-métiers”. Future studies should

[4] Note that the *Atlantic Dawn* one of the largest fishing vessels in the world was deregistered in Ireland in 2006.

minimise these through data screening and algorithms to correct anomalous logbook data. Discards have not been included in this analysis as recent sampling levels (<1% of trips) would not be sufficient to allow for a catch based analysis. Nevertheless, the purpose of the investigation was to identify métiers based on reported logbook information, which are conditioned on current management constraints, reporting and discarding practices.

The métier definitions here are based on a “snap shot” in time, i.e. the reference year, 2003. Landing profiles and subsequent métiers definitions are impacted by species availability during this period. There is a certain circularity in the way métiers are identified, necessitating periodic review of métier definitions. This is in line with the conclusions of previous métier studies (e.g. Ulrich and Andersen, 2004, ICES, 2003). A review periodicity of 5-10 years would seem appropriate for the trawl fisheries examined here. Other studies utilised a range of years to identify métiers, inferring change through the persistence or occurrence of observations from different years within clusters (e.g. Campos *et al.*, 2007; Castro *et al.*, 2011) or carried out separate analyses on annual data (e.g. Holly and Marchal, 2004). These approaches may limit the ability to compare variation over time, and give little continuity between years.

The analysis showed gear, mesh size and landing profile as dominant factors in defining the thirty three métiers identified. Gear type and mesh size configuration can strongly influence species selectivity. What is evident from the analysis is that the fleet are able to utilise various gear configurations to target a specific species or assemblages (subject to management constraints e.g. catch composition rules; CEC, 1998), as well as a specific gear configuration to target multiple assemblages. Similar studies such as Pelletier and Ferraris (2000), Ulrich and Andersen (2004), and

Campos *et al.* (2007) have had similar results between assemblages or gears. This underlines the need to consider targeting behaviour in management as well as technical constraints.

This analysis here allowed for varying spatial distribution and several métiers span multiple ICES Divisions. Within the demersal métiers, those operating along the continental slope, for example, span six divisions, whilst others occur within a discreet area within a single division, such as the Irish Sea *Nephrops* métier. The spatial extent of pelagic métiers also varies. The west of Scotland (VIa) herring métier for example is spatially discreet, whereas the blue whiting and tuna métiers cover a much broader area spanning around six ICES Divisions. This type of result is informative from a sampling, assessment and management perspective since often there is a tendency to stratify fisheries and data based on ICES Divisions.

The majority of métiers show year round activity with the primary exception of pelagic métiers, therefore season appears to relatively minor importance in the definition of Irish métiers. This is a similar finding to Ulrich and Andersen (2004) for Danish fisheries. It is important to note that this does not mean that seasonal variations, in LPUE for example, do not occur within métiers. Rather that, subtle, seasonal variations in fishing activities or species assemblages were not identified due to the quantity and resolution of data analysed. Lewy and Vinther (1994) classified directed fisheries into two groups, those in which a wide variety of vessel size groups participated, “common fisheries”, while those with specific size groups were described as “special” fisheries. Vessel length showed little overall importance in métier definitions here. This was unexpected but may be explained by the greater importance of other factors in identifying métiers and the high variation in vessel length categories within many métiers. So while “special fisheries” exist, the majority of Irish activity occurs in "common fisheries", reflecting the polyvalent nature of the fleet.

The diversity of species targeted by the Irish other trawl fleet was highlighted by the identification of 16 landing profiles in the first stage of analysis with, up to five target species characterised landing profiles. Demersal métiers tend to be more complex (high diversity of species in the landing) with more mixed fisheries interactions than pelagic métiers. The occurrence of by-catch species within métiers is an important consideration when formulating species specific management measures. For example, cod is present to some extent in all demersal shelf and slope métiers. Therefore management measures to rebuild cod stocks need to take account both targeting and non-targeting métiers. The cod long-term plan introduced in 2009 (CEC, 2008a) seeks to encourage cod avoidance in all fisheries using derogations.

Of the demersal métiers, nine are defined by high landing proportions of *Nephrops* accounting for a third of otter trawl fishing trips reflecting the importance of this species to the Irish fleet. The largest *Nephrops* métiers operate within VIIa and VIIg and have remained relatively stable indicating that these are well established, stable fishing practices. Most *Nephrops* métiers appear to be reliable and low risk, where fishers are likely to obtain consistent catches to achieve adequate economic returns. In contrast, there was a substantial expansion of the *Nephrops* métier on the Porcupine Bank (VIIck) between 2003 and 2006. This "riskier" métier is carried out by larger vessels in deep water mainly in the second and third quarters when weather conditions and *Nephrops* emergence patters are more favourable. The métier expand rapidly between 2003 and 2006 due to a combination factors; good prices for large *Nephrops*, increasing at sea freezing of catches, stable LPUE of larger *Nephrops* (ICES, 2009a) and lack of other economically viable fishing opportunities for these larger vessels. This expansion of the fishery has subsequently been shown to be unsustainable since ICES have recommended a closure of the fishery in 2009 (ICES, 2009a).

This métier analysis exposes interesting changes in fishing practice due to economic, stock abundance and management changes. The megrim and monkfish targeting ≥100mm mesh bottom otter trawl métier in VIIj increased effort during trips suggesting a shift to closer fishing grounds than in 2003 most likely due to increasing fuel cost. Landings and effort per trip and vessel in the whiting, plaice and ray 70-99mm mesh métiers reflect behavioural changes in response to increased availability of those target species. The ≥100mm mesh bottom otter trawl mixed plaice and ray métier in area VIIa has contracted over time due to restrictive days-at-sea linked to a cod recovery plan. The contraction of this métier is unlikely to have resulted from reduced species availability since landings within the 70-99mm mesh plaice and ray métier in the same area have increased, as has effort within the métier. Vessels operating in this métier have increased their tendency to move between métiers, changing gear, mesh size or fishing ground.

The pelagic industrial métier targeting blue whiting showed expansion between 2003 and 2006 with increases in effort, landings, trips, and vessels. Simultaneously there were increased landings of blue whiting in areas not originally specified in the métier definition. In this case, the métier definition should be expanded to incorporate blue whiting trips outside of the métier. Development of this métier was due to good recruitment from the mid 1990s to mid 2000s, particularly 2001 with spawning stock biomass at its highest in 2003 (WGWIDE; ICES, 2009b). The blue whiting stock is migratory and widely distributed, involving a number of countries. This led to difficulties in agreeing and international TAC and national quotas prior to 2006

(WGNPBW; ICES, 2006) resulting in uncontrolled growth in catches. The expansion however was short lived as the recent trends show declining spawning stock biomass and low recruitment (WGWIDE; ICES, 2009b). This métier is a good example of an opportunistic fishery, where fishing practices rapidly expand when stock size is high and quota was available or unlimited. At present an Irish and Danish industrial fishery for boarfish appears to be showing a similar pattern to that of blue whiting. Exploratory trips targeting boarfish were observed within this analysis. A dedicated fishery developed in 2006 and has subsequently expanded rapidly. This fishery was unrestricted and unregulated up to 2011 when a TAC was introduced (CEC, 2011). Precautionary management is required given that the stock size and dynamics are unknown to prevent declines similar to the blue whiting fishery.

The Irish deepwater fishery developed in the mid to late 1990s, expanding into the early 2000s, peaking in 2002, landings had already fallen by over 75% in 2003 the first year of this analysis (Anon, 2009). The deepwater métier consisted of large vessels (18m-80m) using single trawls >100mm and reporting landings of cardinal fish, grenadier species and deepwater sharks. Between 2003 and 2006 this métier exhibited further large declines in effort, landings, trips and vessels. The declines can be partially attributed to the collapse of several deepwater stocks (ICES, 2009c), as well as the introduction of a number of management measures to reduce fishing pressure on these vulnerable species. These measures included permits (2002), TACs and quotas (initially set in 2003 and 2005) and effort limitation (2005). Since 2006 the Irish deep water métier has largely become insignificant.

The emerging data demands for fleet based and mixed fisheries management differs from that of stock based advice. This analysis used landings post-stratification to determine Irish otter trawl métiers and their importance. This information has subsequently been used to inform sampling programs and ensure adequate coverage. The main draw back of such an approach is that it may not be directly compatible to other international sampling frameworks such as the Data Collection Framework (DCF) introduced in 2009 (Council Regulation (EC) No 199/2008 (CEC, 2008b) and EC Decision 2008/949/EC (CEC, 2008c)). The DCF specifies stratification similar to the "Nantes matrix" (Anon, 2005b), to a level analogous to that of métier segmentation, incorporating mesh size and/or gear selectivity measures. The métier species assemblages identified within this analysis are more specific than those detailed by the broad DCF categories following the Nantes matrix. Therefore, métiers had to be merged to match the given species assemblages (e.g. demersal fish and small pelagic fish. Merging was mainly carried out on the basis of practical considerations rather than though statistical means, recommended by WKMERGE (ICES, 2010). Ultimately decisions to expanded or merge métiers for sampling should be based on catches (both landings and discards) and species size- and/or age-structure to ensure adequate coverage of stock and fisheries.

Although some of the pelagic métiers are already managed close to the métier level, though single species quotas and licences by area, it would not be possible to manage demersal fisheries on the basis of each métier identified here. A compromise is required between accounting for the complexity of métiers and the practical need to manage métiers in combination. This type of analysis helps to transparently highlight which métiers are the most important to consider in management. At present within Ireland, demersal quotas are allocated monthly or bi-monthly to vessels regardless of target assemblage. An alternative system, informed by this métier analysis, could be developed where vessel allocations by species are made according to métiers. Quota could then be distributed to métiers groups providing a higher allocations for target species and smaller allocations for non-target, and chance-catch quota species. Vessels could sign up for a métier group for a set period, for example 2 months, with maximum vessel participation to prevent excessive quota uptake. This could maximise quota uptake, and possibly reduce quota related discarding.

The fishing industry is dynamic in nature, continuously changing, adapting and evolving to changing biological, economic, and management conditions. Fleet segmentation through métier definition is an important first step in the understanding of fine scale fleet dynamics. A critical understanding for formulation of effective mixed fisheries and fleet based management. A future step would be the investigation of métier dynamics at high spatial and temporal resolution through the integration of logbook data and vessel monitoring systems (as in Gerritsen and Lordan, 2011). Ultimately understating the métier composition and dynamics in mixed fisheries will be critical in the development of effective integrated mixed fisheries management plans.

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Table legends

Table 1. Landing profiles main target species identified by PCA and HAC of fishing trip species proportions within the Irish trawl fleet, 2003, detailed with the number of associated trips. A landing profile could not be identified for 60 trips.

Table 2. Irish trawl fleet métier definitions, detailing the métier code, name and the conditions of each métier in relation to species composition and fishing trip descriptive characteristics.

Table 3. Annual fishing trips, vessel participation and days-at-sea effort within métiers, 2003-2006 with relative change over the period.

Table 4. Average métier landings species composition (%) with average total landed (t), 2003-2006.

Figure legends

Figure 1. Principal Component Analysis scores of the first two axes from fishing trip species proportions within the Irish trawl fleet, 2003. Only those species considered to influence the axes are labelled. A number of species are differentiated on these axes: deepwater species (blue), slope species (purple), megrim and monkfish (red), pelagic species (green), haddock (light blue), and Nephrops (orange).

Figure 2. MCA scores of the first two axes from fishing trip descriptive characteristics within the Irish trawl fleet, 2003. Only those factors considered to influence the axes are labelled. Descriptive characteristics: mesh size range (mm); vessel length range

(m); month and gear (3 letter code); area (ICES Division); landing profile (see Table 1). A number of characteristics are differentiated on these axes: VIIIa retaliated multi-divisions and vessels >80m (blue); pelagic profiles L11 and L13, OTM gear, areas VIII, VIIe, VIIh, XII, and IIa (red); pelagic profiles L9 and L10, 40-80m vessels, PTM gear, 32-54mm and 55-69mm meshes, and areas V and VI (green).

Figure 3. Results from HAC of fishing trip descriptive characteristics within the Irish trawl fleet, 2003.Boxes identify the 103 clusters identified by r^2 values, explaining 80% of the total variation. Labels below clusters correspond to métiers detailed in Table 2.

Figure 4. The percentage of the Irish otter trawl fleet in relation to the number of métiers individual vessels operate in based on an average of 2003-2006 data.

Figure 5. Métier species diversity boxplot of species present within fishing trip landings (2003). Annotation (left to right): Target species category, métier code and number of identified target species (NTSpp).

Profile	Target Species	Fishing trips
L1	*Nephrops* Mixed	738
L2	*Nephrops* Clean	1 887
L3	Megrim, monkfish	742
L4	Haddock	449
L5	Black sole, plaice, ray species	145
L6	Pollack, saithe, cod, whiting, dogfish	1 268
L7	Ling, witch, lemon sole, forkbeard hake	1 381
L8	Ray species, plaice	544
L9	Mackerel, boarfish	538
L10	Horse mackerel	304
L11	Blue whiting	16
L12	Herring	588
L13	European pilchard, herring, mackerel	33
L14	Tuna	76
L15	Sprat	151
L16	Cardinalfish, grenadier, deepwater shark	112

Table 2 - Legend in manuscript

Metier ID	Metier Name	Gear Type	Mesh Size	Vessel Length	ICES Area	Period	Target	Species Composition: Lower Species Threshold	Species Composition: Special Conditions
1	Clean *Nephrops* OTB VIIa	OTB	70-89	12-40m	VIIa	All	*Nephrops*	≥80% *Nephrops*	
2	Mixed *Nephrops* OTB VIIa	OTB	70-89	12-40m	VIIa	All	*Nephrops*	≥45% *Nephrops*	<80% *Nephrops*
3	Clean *Nephrops* OTB VIIb	OTB	70-119	15-40m	VIIb	All	*Nephrops*	≥80% *Nephrops*	
4	Mixed *Nephrops* OTB VIIb	OTB	70-119	15-40m	VIIb	All	*Nephrops*	≥45% *Nephrops*	&, <80% *Nephrops* <30% Monkfish <30% Megrim
5	Clean *Nephrops* OTB VIIg	OTB	70-119	10-40m	VIIg	All	*Nephrops*	≥65% *Nephrops*	
6	Mixed *Nephrops* OTB VIIg	OTB	70-119	10-40m	VIIg	All	*Nephrops*	≥40% *Nephrops*	&, <65% *Nephrops* <30% Monkfish <30% Megrim < mesh related cod (25% 70-99mm, 30% 100-119mm)
7	*Nephrops* OTB VIIc & VIIk	OTB	70-119	18-40m	VIIc VIIk	Q2-4	*Nephrops*	≥50% *Nephrops*	
8	*Nephrops* OTB VIa	OTB	70-119	12-40m	VIa	All	*Nephrops*	≥40% *Nephrops*	<30% Monkfish <30% Megrim
9	*Nephrops* OTB VIIj	OTB	70-119	10-40m	VIIj	All	*Nephrops*	≥35% *Nephrops*	&, <30% Monkfish <30% Megrim
10	Megrim & Monkfish Small OTB VIa, VIIb,g,j	OTB	70-99	10-80m	VIa,VIIb VIIg,VIIj	ALL	Megrim & Monkfish	Or, ≥30% Megrim ≥30% Monkfish	<80% VIIb related *Nephrops* <65% VIIg related *Nephrops* <50% VIIc or VIIk related *Nephrops*
11	Megrim & Monkfish Large OTB VIIj	OTB	≥100	15-80m	VIIj	ALL	Megrim & Monkfish	Or, ≥30% Megrim ≥30% Monkfish	&, <20% Forkbeard <25% Hake
12	Haddock OTB VIIg & VIIj	OTB	ALL	10-40m	VIIg VIIj VIIg.j	ALL	Haddock	≥30% Haddock	&, < area related *Nephrops* % <30% Monkfish <30% Megrim <30% Whiting
13	Plaice & Ray Small OTB VIa, VIIa,b,g,j	OTB	70-99	10-40m	VIa VIIa VIIb VIIg VIIj	ALL	Plaice & Ray species	Or, ≥40% Plaice ≥40% Ray species	&, < area related *Nephrops* % <30% Megrim <30% Monkfish <30% Haddock VIIg, VIIj & VIIg.j <30% Pollack <25% Cod
14	Plaice & Ray Large OTB VIIa	OTB	100-119	15-40m	VIIa	ALL	Plaice & Ray species	Or, ≥40% Plaice ≥40% Ray species	&, <45% *Nephrops* <30% Pollack <30% Cod
15	BSPR OTB VIa, VIIa,b,g,j	OTB	ALL	10-40m	VIa VIIa VIIb VIIg VIIj	ALL	BSPR	Or, ≥30% Ray species ≥25% Plaice ≥20% Black Sole	&, < area related *Nephrops* % <40% Plaice <40% Ray species <30% Whiting when ≥ Plaice or Ray < mesh related cod (25% 70-99mm, 30% 100-119mm) < mesh related witch (25% 70-99mm, 20% 100-119mm) < area related and mesh specific megrim and monkfish < mesh related saithe (25% 70-99mm, 30% 100-119mm) <30% Haddock VIIa related, VIIg, VIIj & VIIg.j <25% Hake <30% Pollack <25% Lemon sole <25% Liing
16	Whiting Small OTB VIa,VIIa,b,g,j	OTB	70-99	10-40m	VIa VIIa VIIb VIIg VIIj	ALL	Whiting	≥60% Whiting	&, < area related *Nephrops* % <40% Plaice <40% Ray species <30% Megrim <30% Monkfish
17	PSCWD Small OTB VIa,VIIb,g,j	OTB	70-99	10-40m	VIa VIIb VIIg VIIj	ALL	PSCWD	Or, ≥30% Pollack ≥25% Saithe ≥25% Cod ≥30% Whiting ≥35% Dogfish	&, < area related *Nephrops* % If ≥25% Cod, <65% Nephrops in VIIg <60% Whiting <40% Plaice (when ≥35% Dogfish plaice <25%) <40% Ray species (when ≥35% Dogfish Ray <30%) <30% Megrim <30% Monkfish <30% Haddock in VIIg, VIIj, VIIg.j (unless ≥30% Whiting) <25% Hake <20% Black Sole If ≥35% Dogfish, <20% Witch & <25% Ling
18	WCHD Small OTB VIIa & VIIa.g	OTB	70-99	12-40m	VIIa VIIa.g	ALL	WCHD	Or, ≥30% Whiting ≥25% Cod ≥30% Haddock ≥35% Dogfish	&, <45% *Nephrops* <40% Plaice (when ≥35% Dogfish plaice <25%) <40% Ray species (when ≥35% Dogfish Ray <30%) <20% Black Sole <25% Hake <60% Whiting <30% area related megrim and monkfish
19	PSCWD Large OTB VIIa,g,a.g	OTB	≥100	15-40m	VIIa VIIg VIIa.g	ALL	PSCWD	Or, ≥30% Pollack ≥30% Saithe ≥30% Cod ≥30% Whiting ≥35% Dogfish	&, < area related *Nephrops* % If ≥25% Cod, <65% Nephrops in VIIg <30% area related megrim and monkfish <40% Plaice <25% Ling (unless saithe ≥30%) <25% Hake If ≥35% Dogfish, <30% Ray & <25% Plaice
20	PSCWD Large OTB VIa,b,VIIb,j	OTB	≥100	12-40m	VIa VIb VIIb VIIj	ALL	PSCWD	Or, ≥30% Pollack ≥30% Saithe ≥30% Cod ≥30% Whiting ≥35% Dogfish	&, < area related *Nephrops* % <30% area related megrim and monkfish <20% Forkbeard <25% Hake <40% Plaice <25% Ling (unless saithe ≥30%) If ≥35% Dogfish, <30% Ray & <25% Plaice
21	LWFH Large OTB VIa,b,VIIb,c,j,k	OTB	≥100	18-80m	VIa VIb VIIb VIIc VIIj VIIk	ALL	LWFH	Or, ≥25% Ling ≥25% Witch ≥20% Forkbeard ≥25% Hake	&, < area related *Nephrops* % <30% Saithe when Ling ≥25% <30% Pollack when Ling ≥25% <30% Cod <30% Haddock in VIIg, VIIj, VIIg.j If ≥25% Hake or ≥25% Forkbeard: <30% area related megrim and monkfish
22	LWLFH Small OTB VIa,b,VIIa,b,g,j	OTB	70-99	10-40m	VIa VIb VIIa VIIb VIIg VIIj	ALL	LWLFH	Or, ≥25% Ling ≥20% Witch ≥25% Lemon Sole ≥20% Forkbeard ≥25% Hake	&, < area related *Nephrops* % <25% Saithe when Ling ≥25% <30% Pollack when Ling ≥25% <40% Plaice <25% Cod <30% Whiting <40% Ray species <30% Haddock in VIIg, VIIj, VIIg.j , VIIa If ≥25% Hake or ≥25% Forkbeard: <30% area and mesh related megrim and monkfish
23	Deepwater Large Single Trawl VIa, VIIb,c,j,k	Single Trawl	≥100	18-80m	VIa VIIb VIIc VIIj VIIk	ALL	Deepwater species	Or ≥25% Cardinalfish ≥35% Deepwater shark ≥25% Grenadier	<20% Forkbeard
24	Mackerel Mid-Water VIa, VIIb,j	Mid-Water	<70	18-80m	VIa VIIb VIIj	Oct-May	Mackerel	≥70% Mackerel	
25	Mackerel Mid-Water IVa	Mid-Water	<55	24-80m	IVa	Oct-Jan	Mackerel	≥75% Mackerel	
26	Horse Mackerel Mid-Water VIa & VIIb	Mid-Water	32-69	24-80m	VIa VIIb VIa.VIIb	Sep-Mar	Horse Mackerel	≥80% Horse Mackerel	
27	Blue Whiting Mid-Water VIb, VIIc,k, XII	Mid-Water	32-54	24-80m	VIb VIIc VIIk XII	Feb-Mar	Blue Whiting	≥90% Blue Whiting	
28	Herring PTM VIa	PTM	<55	15-80m	VIa	Oct-Mar	Herring	≥80% Herring	
29	Herring Pair Trawl Non-VIa	Pair Trawl	32-54	15-80m	Non VIa	Jul-Feb	Herring	≥80% Herring	
30	Pilchard & Herring PTM VIIa,g,j	PTM	32-54	18-40m	VIIa VIIg VIIj	Oct-Jan	European Pilchard & Herring	&, ≥20% European Pilchard >5% Herring	<80% Herring <1% all other species
31	Pilchard & Mackerel OTM VIIe,h,VIIIb,e	OTM	32-54	40-80m	VIIe VIIh VIIIb VIIIe	Oct-Dec	European Pilchard & Mackerel	&, ≥20% European Pilchard ≥5% Mackerel	<1% all other species
32	Tuna PTM VIIj,k,VIIIa-d	Trawl	ALL	15-40m	VIIj VIIk VIIIa VIIIb VIIIc VIIId	Jul-Oct	Tuna	≥80% Tuna	
33	Sprat Otter Trawl VIa, VIIa	Otter Trawl	16-54	10-40m	VIa VIIa VIa.VIIa	Oct-Feb	Sprat	≥95% Sprat	

Table 3 - Legend in manuscript

		2003			2004			2005			2006					
Metier Name	**Code**	**Trips**	**Vessels**	**Effort**	**Trips**	**Vessels**	**Effort**	**Trips**	**Vessels**	**Effort**	**Trips**		**Vessels**		**Effort**	
Clean Nephrops OTB VIIa	1	755	52	2 157	895	39	2 549	822	41	2 427	837	(0.11)	49	(-0.06)	2 414	(0.12)
Mixed Nephrops OTB VIIa	2	379	51	1 449	323	44	1 234	393	52	1 468	318	(-0.16)	50	(-0.02)	1 290	(-0.11)
Clean Nephrops OTB VIIb	3	110	21	475	57	18	265	148	22	551	106	(-0.04)	31	(0.48)	440	(-0.07)
Mixed Nephrops OTB VIIb	4	215	30	972	167	23	785	164	28	703	141	(-0.34)	32	(0.07)	618	(-0.36)
Clean Nephrops OTB VIIg	5	396	61	1 868	284	55	1 423	511	82	2 551	446	(0.13)	72	(0.18)	1 986	(0.06)
Mixed Nephrops OTB VIIg	6	427	59	1 696	445	66	2 023	545	80	2 383	584	(0.37)	73	(0.24)	2 566	(0.51)
Nephrops OTB VIIc & VIIk	7	43	11	464	72	15	679	160	24	1 494	156	(2.63)	32	(1.91)	1 458	(2.14)
Nephrops OTB VIa	8	29	9	92	23	8	96	30	10	141	19	(-0.34)	6	(-0.33)	73	(-0.21)
Nephrops OTB VIIj	9	227	30	654	172	43	652	201	38	606	223	(-0.02)	40	(0.33)	533	(-0.19)
Megrim & Monkfish Small OTB VIa, VIIb,g,j	10	342	77	1 602	297	76	1 406	442	94	1 843	552	(0.61)	87	(0.13)	2 071	(0.29)
Megrim & Monkfish Large OTB VIIj	11	103	27	837	55	21	453	129	25	915	165	(0.6)	24	(-0.11)	1 237	(0.48)
Haddock OTB VIIg & VIIj	12	216	48	600	235	65	742	240	57	766	278	(0.29)	63	(0.31)	818	(0.36)
Plaice & Ray Small OTB VIa, VIIa,b,g,j	13	259	56	683	298	58	910	357	64	1 023	283	(0.09)	54	(-0.04)	831	(0.22)
Plaice & Ray Large OTB VIIa	14	252	14	674	100	10	259	64	6	197	32	(-0.87)	5	(-0.64)	112	(-0.83)
BSPR OTB VIa, VIIa,b,g,j	15	200	69	619	179	73	709	116	56	381	98	(-0.51)	51	(-0.26)	408	(-0.34)
Whiting Small OTB VIa,VIIa,b,g,j	16	161	39	501	108	24	422	276	36	1 459	187	(0.16)	21	(-0.46)	1 043	(1.08)
PSCWD Small OTB VIa,VIIb,g,j	17	433	91	1 681	340	82	1 359	377	91	1 544	243	(-0.44)	74	(-0.19)	1 119	(-0.33)
WCHD Small OTB VIIa & VIIa.g	18	106	23	242	67	25	230	65	28	217	26	(-0.75)	16	(-0.3)	81	(-0.67)
PSCWD Large OTB VIIa,g,a.g	19	148	30	606	73	17	340	39	14	211	38	(-0.74)	6	(-0.8)	235	(-0.61)
PSCWD Large OTB VIa,b,VIIb,j	20	112	32	733	52	15	377	49	17	339	53	(-0.53)	16	(-0.5)	317	(-0.57)
LWFH Large OTB VIa,b,VIIb,c,j,k	21	157	25	1 618	94	22	993	64	16	497	36	(-0.77)	10	(-0.6)	305	(-0.81)
LWLFH Small OTB VIa,b,VIIa,b,g,j	22	66	28	349	56	27	365	38	26	170	30	(-0.55)	19	(-0.32)	153	(-0.56)
Deepwater Large Single Trawl VIa, VIIb,c,j,k	23	97	9	957	76	6	784	46	5	441	14	(-0.86)	2	(-0.78)	108	(-0.89)
Mackerel Mid-Water VIa, VIIb,j	24	422	34	1 376	338	42	1 442	171	42	574	212	(-0.5)	43	(0.26)	740	(-0.46)
Mackerel Mid-Water IVa	25	71	16	351	74	24	368	48	18	199	14	(-0.8)	12	(-0.25)	65	(-0.81)
Horse Mackerel Mid-Water VIa & VIIb	26	245	25	673	200	33	535	155	27	505	141	(-0.42)	29	(0.16)	463	(-0.31)
Blue Whiting Mid-Water VIb, VIIc,k, XII	27	14	7	74	5	5	25	24	13	90	39	(1.79)	18	(1.57)	188	(1.54)
Herring PTM VIa	28	248	28	526	167	34	353	77	23	180	153	(-0.38)	39	(0.39)	348	(-0.34)
Herring Pair Trawl Non-VIa	29	269	30	625	317	27	611	254	35	508	158	(-0.41)	40	(0.33)	391	(-0.37)
Pilchard & Herring PTM VIIa,g,j	30	13	4	25	17	4	30	1	1	2	4	(-0.69)	3	(-0.25)	11	(-0.56)
Pilchard & Mackerel OTM VIIe,h,VIIIb,e	31	19	1	63	8	1	39	0	0	0	0	(-1)	0	(-1)	0	(-1)
Tuna PTM VIIj,k,VIIIa-d	32	76	22	782	37	14	368	30	10	254	28	(-0.63)	8	(-0.64)	232	(-0.7)
Sprat Otter Trawl VIa, VIIa	33	103	18	148	14	6	16	64	19	73	32	(-0.69)	7	(-0.61)	33	(-0.78)
Annual Total		6 713	264	26 172	5 645	273	22 842	6 100	260	24 712	5 646	(-0.16)	242	(-0.08)	22 687	(-0.13)

Metier Name	Code	Blue Whiting	Boarfish	Cardinalfish	Cod	Conger eel	Crab	Deepwater Shark	Dogfish	Pilchard	Forkbeard	Grenadier	Haddock	Hake	Herring	Horse Mackerel	John dory	Lemon Sole	Ling	Mackerel	Megrim	Monkfish	Nephrops	Other	Plaice	Pollack	Ray	Saithe	Scallop	Sole Black	Sprat	Squid	Tuna	Whelk	Whiting	Witch	Average
Clean Nephrops OTB VIIa	1				2.4								0.9	0.2				0.1	0.2			1.7	91.7	0.3	1.1	0.1	0.3			0.1					0.1	0.5	1,873
Mixed Nephrops OTB VIIa	2				7.2	0.1			0.5				4.4	0.7			0.2	0.4	1.4		0.2	4.2	68.4	1.5	2.9	0.7	3.7	0.2		0.4		0.1			1.1	1.5	973
Clean Nephrops OTB VIIb	3				0.3	0.1			0.2				0.9	0.5				0.2	0.1		3.7	3.1	88.3	0.3	0.1		0.7			0.5		0.1			0.4	0.3	341
Mixed Nephrops OTB VIIb	4				0.6	0.9	0.4		2.6				2.2	1.3			0.2	0.5	0.5	0.2	9.0	7.6	64.5	1.0	0.6		3.6	0.1		1.2		0.2			1.6	1.3	512
Clean Nephrops OTB VIIg	5				4.0	0.2			0.1				1.6	0.5			0.6	1.1	2.0		1.9	4.4	77.8	0.1	0.1	0.8	0.5	0.1		0.3					3.0	1.0	1,495
Mixed Nephrops OTB VIIg	6				5.4	0.4			0.6				5.1	1.6			1.0	1.5	2.8		6.5	8.0	53.2	0.3	0.2	1.5	1.5	0.2		0.3	0.1	0.1		0.1	7.6	2.1	1,302
Nephrops OTB VIIc & VIIk	7				0.1	0.5			0.1		1.3		0.1	4.7					1.8	0.1	1.9	15.0	71.9	0.3			0.1					0.3			0.1	1.5	500
Nephrops OTB VIa	8				1.2	0.2			4.6				5.2	4.8	0.2	0.1	0.4	0.4	0.5	0.3	6.6	8.8	55.8	0.8	0.7	0.2	2.8	0.2		1.0		0.1			2.3	2.8	52
Nephrops OTB VIIj	9				2.2	0.2	0.1		1.2		0.1		7.4	1.4	0.5		0.7	0.7	1.2	0.4	8.9	8.7	53.2	0.6	0.8	0.7	3.3	0.7		0.9		0.3			4.1	1.9	268
Megrim & Monkfish Small OTB VIa, VIIb,g,j	10				1.1	0.4	0.3		2.0		0.6		6.8	3.1			0.9	1.0	1.7	0.1	25.3	30.1	6.6	1.7	1.8	0.4	5.6	0.3		1.8		0.5			4.7	3.2	976
Megrim & Monkfish Large OTB VIIj	11	0.2			1.3	1.3	0.1		1.8		0.3	0.2	4.6	4.9			2.3	0.6	2.4		21.3	36.7	2.3	3.4	0.5	0.7	5.5	0.6		0.6		1.3			3.3	3.9	586
Haddock OTB VIIg & VIIj	12				3.2	0.5	0.1		1.5				43.6	1.4	0.1		0.9	1.6	1.5	0.1	8.8	8.1	3.7	1.1	3.0	1.7	3.8	0.2		2.1		0.6		0.1	11.5	0.9	454
Plaice & Ray Small OTB VIa, VIIa,b,g,j	13				2.2	0.5			3.5				3.6	0.3			0.8	1.3	0.3		1.3	3.5	2.2	3.7	11.9	0.7	59.9	0.1	0.1	1.9		0.4			1.5	0.3	526
Plaice & Ray Large OTB VIIa	14				4.8	1.1			2.2				2.0					0.8	0.1		0.1	1.8	0.3	2.3	19.2	1.1	62.6	0.1	0.3	0.5		0.2			0.3	0.1	259
BSPR OTB VIa, VIIa,b,g,j	15				2.2	1.3	0.2		10.6				6.4	1.0			2.1	2.0	1.4	0.1	5.4	5.1	5.2	4.9	9.6	0.9	29.8	0.3	0.7	3.3		1.5			4.2	1.8	316
Whiting Small OTB VIa,VIIa,b,g,j	16				1.7	0.1			0.8				4.3	0.4			0.6	0.9	0.9	0.3	0.4	0.8	0.9	0.3	0.2	1.1	1.2	0.5				0.4			83.6	0.2	1,914
PSCWD Small OTB VIa,VIIb,g,j	17				3.7	0.4	0.1		15.5		0.1		10.0	1.6			0.9	1.3	2.0	0.2	5.2	3.8	5.5	1.8	1.5	3.6	5.4	2.7	0.3	0.7		0.8			31.6	1.2	1,412
WCHD Small OTB VIIa & VIIa.g	18				10.6	0.4	0.2		14.0				15.0	0.9	0.3		0.6	1.3	1.8	0.7	0.6	3.9	7.6	1.4	3.2	3.5	4.6	1.1	0.2	0.3		0.8		0.2	26.2	0.6	147
PSCWD Large OTB VIIa,g,a.g	19				6.8	0.3			4.5				6.6	0.9	0.1		0.7	1.8	2.6	0.3	1.2	1.6	0.6	0.5	1.2	4.0	3.9	1.4		0.1		1.2			59.3	0.4	505
PSCWD Large OTB VIa,b,VIIb,j	20				2.4	0.6	0.1	0.3	10.2		0.1	0.1	11.6	1.8	0.3		1.1	1.4	3.4	0.3	7.9	3.5	0.6	1.8	0.4	8.7	4.0	13.4	0.2	0.3		1.4			21.8	2.5	480
LWFH Large OTB VIa,b,VIIb,c,j,k	21			2.5	0.5	2.9		0.2	0.6		13.6	0.5	1.4	19.1			0.5	0.4	10.4	0.1	6.8	11.1	7.7	3.1		0.7	1.7	1.9				3.0			1.0	10.0	704
LWLFH Small OTB VIa,b,VIIa,b,g,j	22				1.3	0.5		0.2	4.6		4.5	0.3	3.8	6.1		0.1	1.4	3.0	12.7	0.1	9.5	8.0	4.5	4.3	0.4	1.8	8.0	2.6		0.4		2.0			4.0	15.7	175
Deepwater Large Single Trawl VIa, VIIb,c,j,k	23			47.3		0.6		19.9	0.1		0.7	13.8	0.1	0.2					0.7		0.2	0.2	0.3	15.6								0.1				0.1	1,225
Mackerel Mid-Water VIa, VIIb,j	24	0.3	0.6												0.5	1.5				96.7				0.3													31,530
Mackerel Mid-Water IVa	25									0.2					1.8	0.2				97.8																	13,028
Horse Mackerel Mid-Water VIa & VIIb	26		0.2												0.1	98.2				1.5																	20,509
Blue Whiting Mid-Water VIb, VIIc,k, XII	27	100.0																																			16,682
Herring PTM VIa	28														99.7	0.1				0.1											0.1						11,596
Herring Pair Trawl Non-VIa	29									0.4					99.4													0.1			0.1				0.1		11,851
Pilchard & Herring PTM VIIa,g,j	30									43.0					56.9																0.1						419
Pilchard & Mackerel OTM VIIe,h,VIIIb,e	31									64.9										35.1																	1,701
Tuna PTM VIIj,k,VIIIa-d	32								0.1															1.0									98.8				427
Sprat Otter Trawl VIa, VIIa	33														0.1					0.1											99.7						709

Figure 1 - Legend in manuscript (colour)

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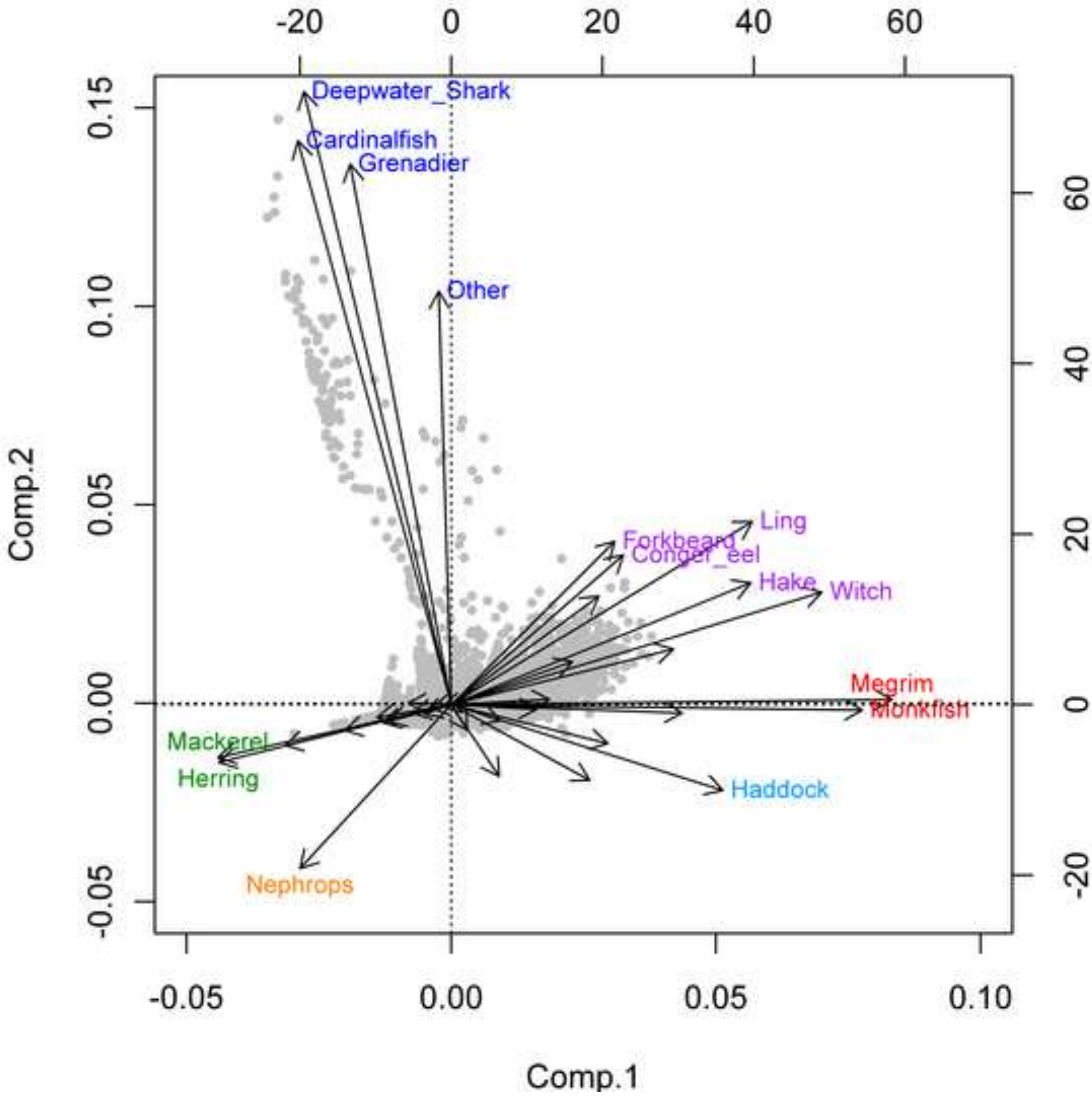

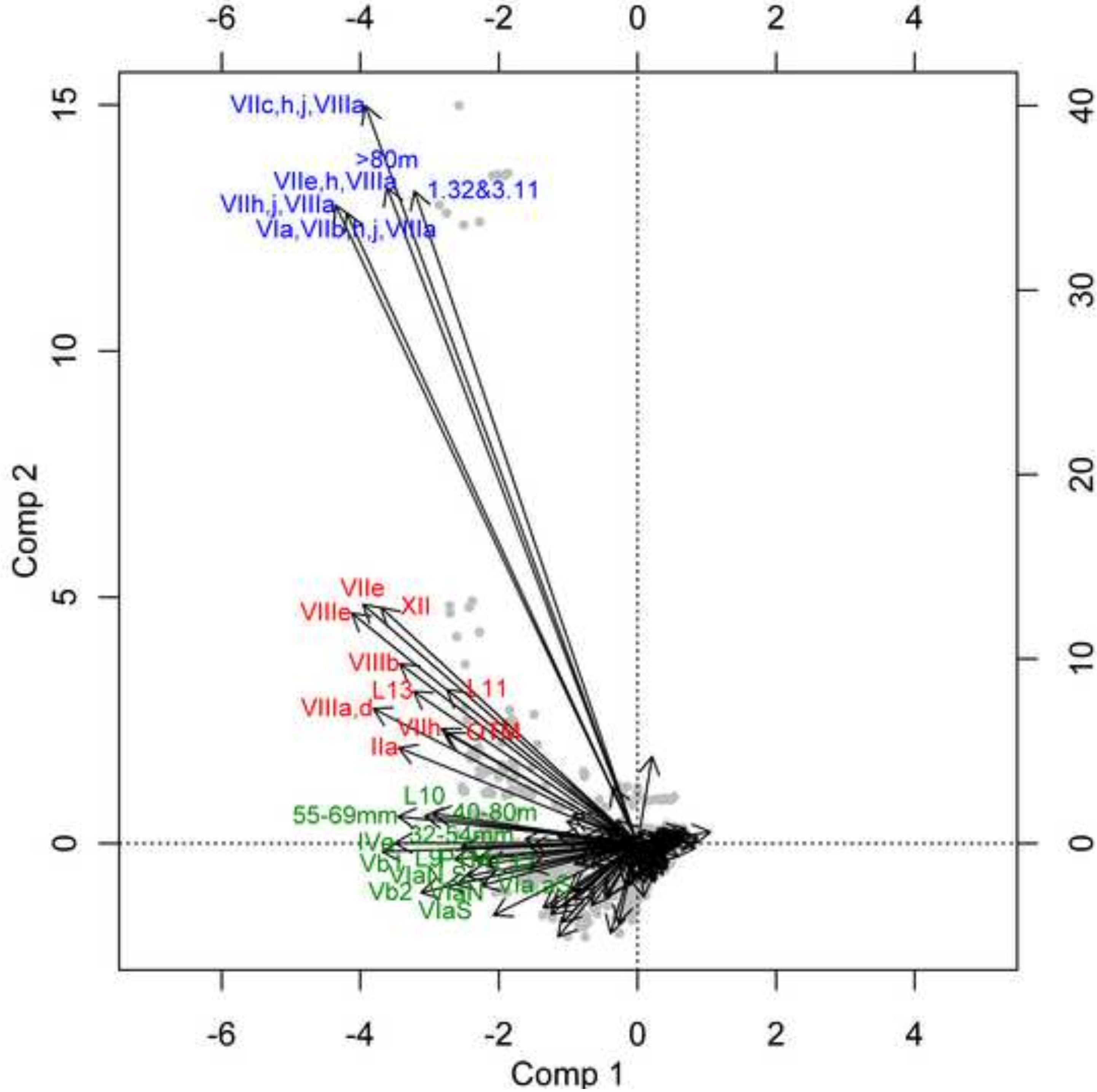
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Comp 2
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VIIe,h,VIIIa
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VIIh,j,VIIIa
VIa,VIIb,h,j,VIIIa
VIIe
VIIIe
XII
VIIIb
L13
L11
VIIIa,d
VIIh
IIa
L10
55-69mm
40-80m
32-54mm
IVa
Vb1
Vb2
VIaS
VIaN
-6
-4
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4
15
10
5
0
40
30
20
10

Figure 3 - Legend in manuscript (colour)
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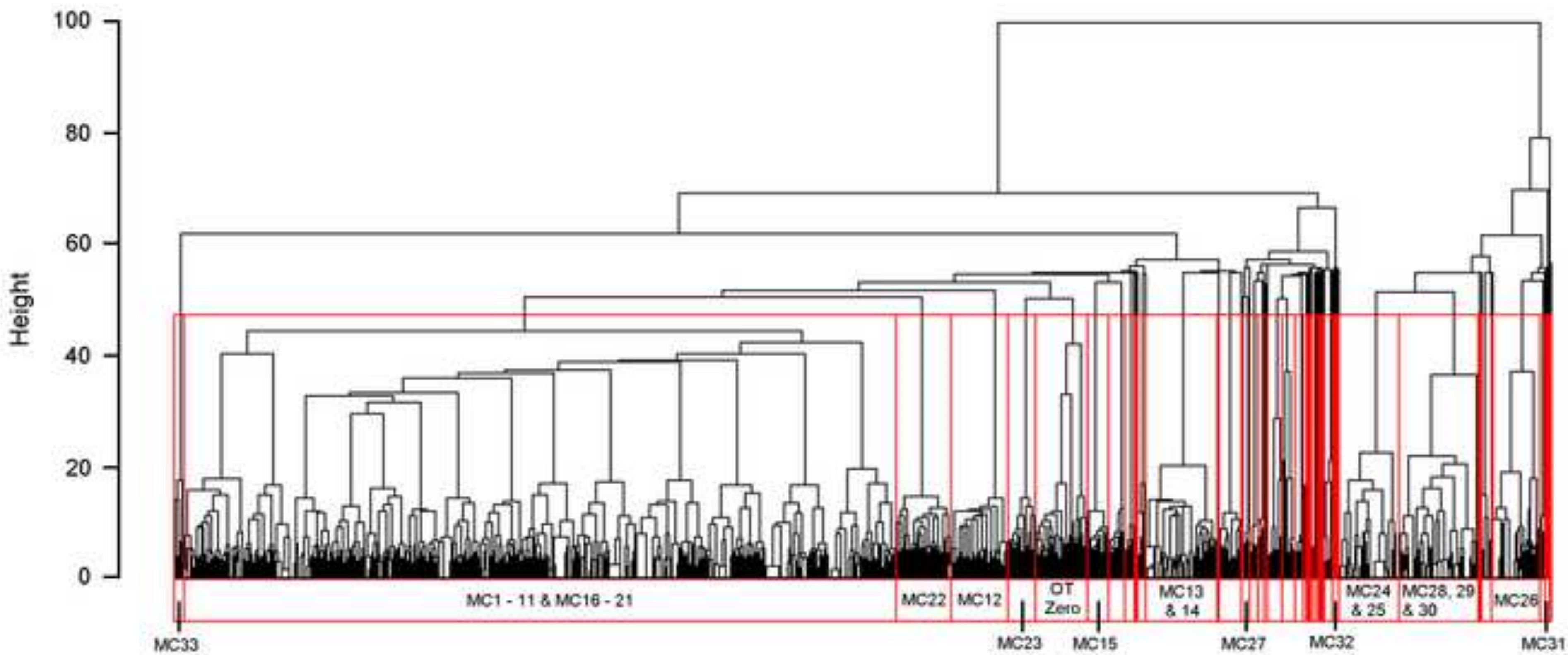

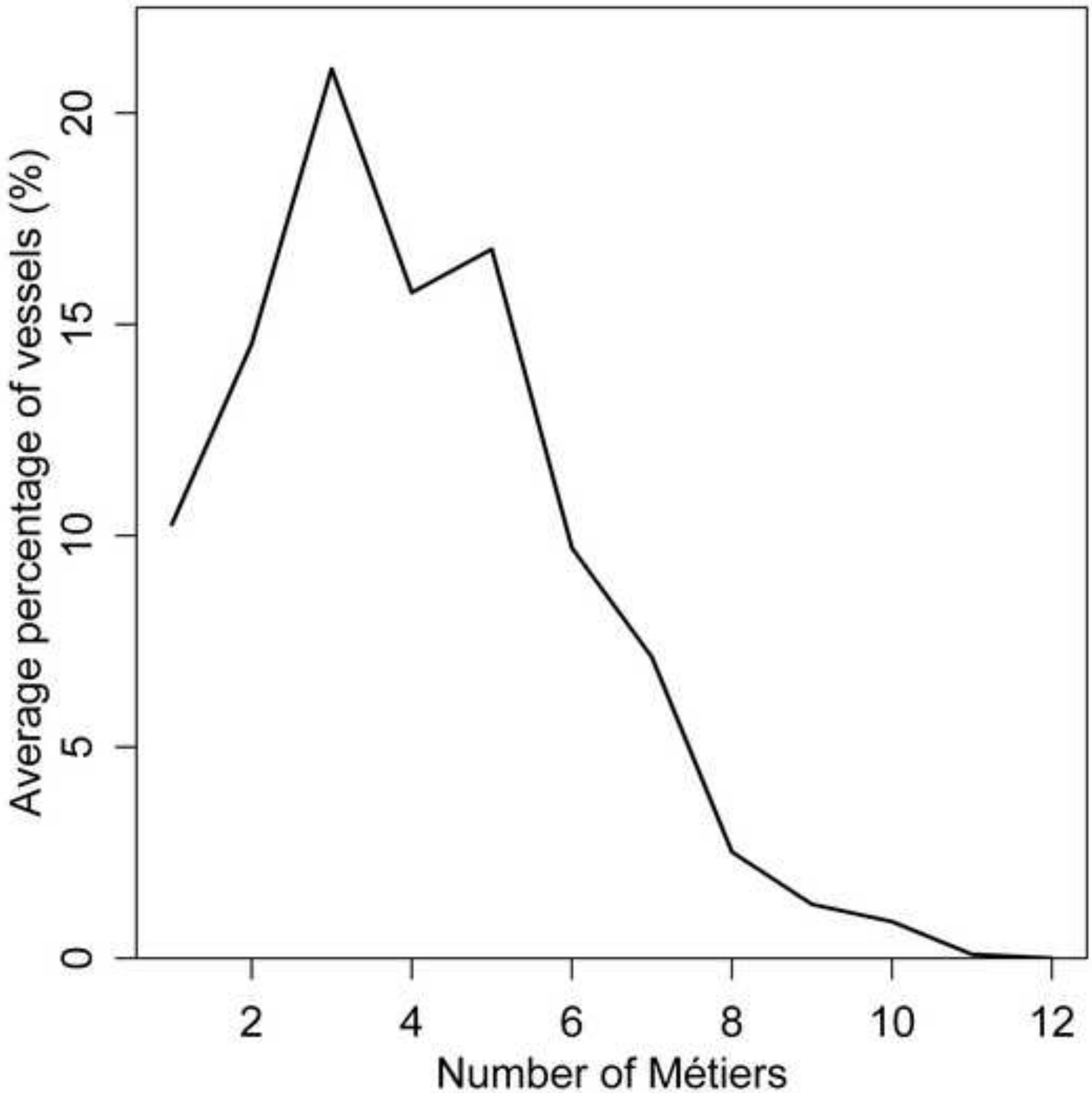
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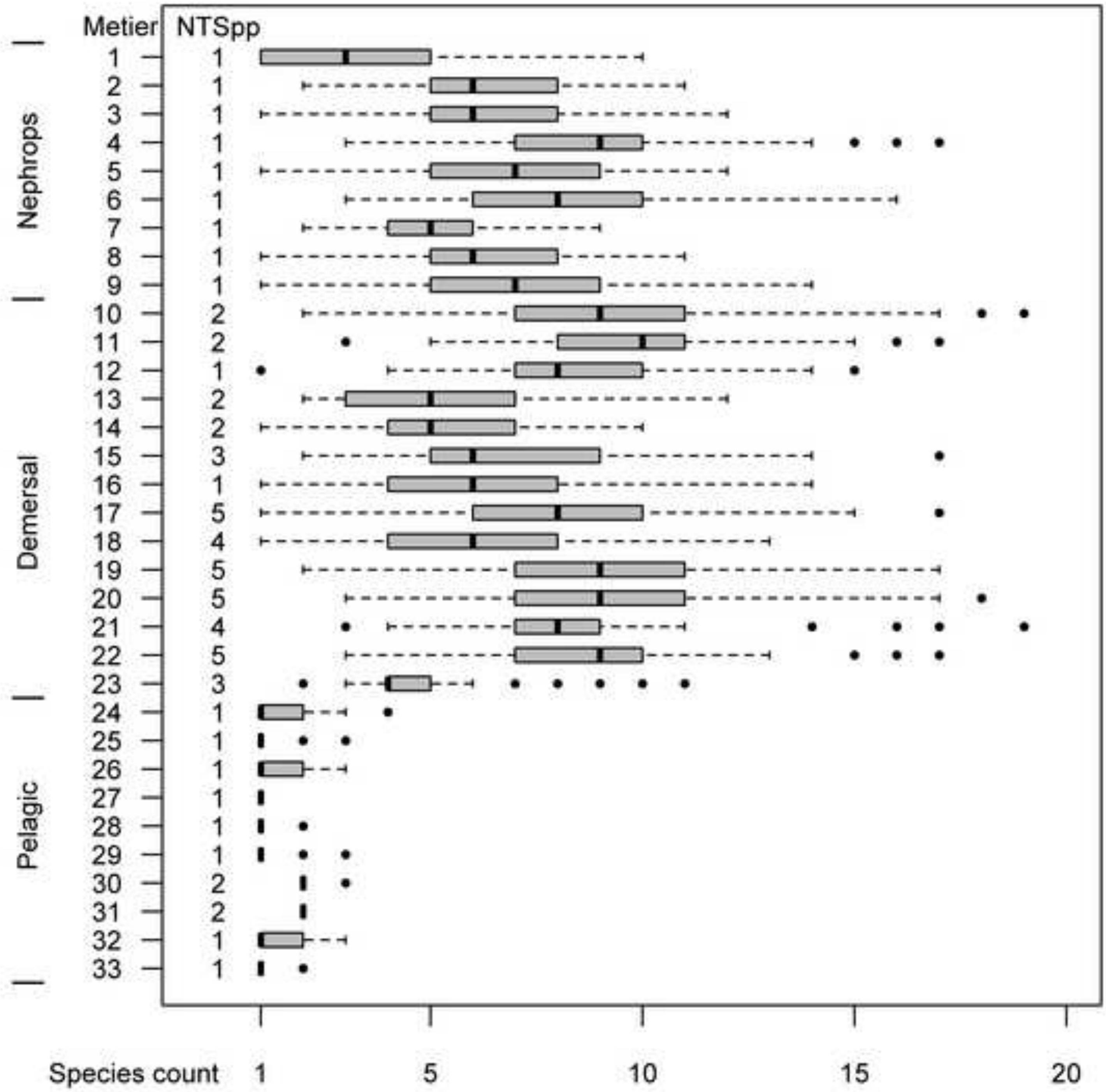
5
10
15
20
2
4
6
8
10
12
Number of Métiers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NTSpp
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