INVENTORY OF PARASITIC COPEPODS AND THEIR HOSTS IN THE WESTERN WADDEN SEA IN 1968 AND 2010

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Cover illustration

The parasitic copepod *Lernaeenicus sprattae* (Sowerby, 1806) on its fish host, the sprat (*Sprattus sprattus*)

Contents

1. Summary

Ectoparasites, attaching mainly to the fins or gills, are a particularly conspicuous part of the parasite fauna of marine fishes. In particular the dominant copepods, have received much interest due to their effects on host populations. However, still little is known on the copepod fauna on fishes for many localities and their temporal stability as long-term observations are largely absent. The aim of this project was two-fold: 1) to deliver a current inventory of ectoparasitic copepods in fishes in the southern Wadden Sea around Texel and 2) to compare the current parasitic copepod fauna with the one from 1968 in the same area, using data published in an internal NIOZ report and additional unpublished original notes. In total, 47 parasite species have been recorded on 52 fish species in the southern Wadden Sea to date. The two copepod species, where quantitative comparisons between 1968 and 2010 were possible for their host, the European flounder (*Platichthys flesus*), showed different trends: Whereas *Acanthochondria cornuta* seems not to have altered its infection rate or per host abundance between years, *Lepeophtheirus pectoralis* has shifted towards infection of smaller hosts, as well as to a stronger increase of per-host abundance with increasing host length.

2. Introduction

Parasites are a ubiquitous but inconspicuous part of ecosystems, that have in the past often been largely overlooked. In recent years, their impact on not only the level of the individual host but subsequently on populations, communities and the dynamics of entire food webs has been increasingly recognized (SOUSA, 1991; MOURITSEN & POULIN, 2002; LAFFERTY *et al.*, 2008). This holds true also for the ectoparasitic copepods on marine fish, a clade of parasites with a diverse range of host species, life histories and impacts. In this respect, much attention has gone to the sea lice parasitic on farmed salmon, due to their particularly detrimental effects on these economically exploited stocks (TULLY & NOLAN, 2002) but also due to their dramatic effects on wild populations via a spill-over from aquaculture farms (KRKOŠEK *et al.*, 2007, 2011).

Aquaculture practices are just one example of how environmental changes can be reflected in changes in parasite dynamics. In general parasites are dependent on the abundances and interactions of their hosts. Trends in their abundances and diversity can thus be indicative of broader change due to environmental factors such as pollution, temperature, habitat loss and exploitation of stocks (WOOD *et al.*, 2010). When host species are affected by such factors, parasites will be affected accordingly. As fish available as hosts are generally smaller as a result of human exploitation, certain parasites are likely to decline when dependent on a host population of a certain average size (WOOD *et al.*, 2010). However, examples for such changes in parasitic copepods are, to the best of our knowledge, absent.

Most parasitic copepod species are well known and described, especially in the Northwest Atlantic Ocean (MÖLLER & ANDERS, 1986; KABATA, 1979, 2003), but quantitative data sets remain rare, and are often restricted to a limited time frame and number of species (e.g. CAUSEY, 1960; GROENEWOLD *et al.*, 1996; SCHMIDT *et al.*, 2003; KLEINERTZ *et al.*, 2011) and/or locality (e.g. BERE, 1936; HEEGAARD, 1962; PALM *et al.*, 1999; BOXSHALL, 2009).

In this study, we have two aims. First, we present the first inventory of parasitic copepods on fishes caught in the coastal waters around the island of Texel in the southern Wadden Sea, The Netherlands. Including North Sea waters as well as the westernmost part of the estuarine Wadden Sea, these shallow waters comprise an especially rich and dynamic ecosystem characterized by its mud flats emerging above sea water level at low tide. Its natural resources and situation in one of the most densely populated areas in the world have lead to a history of steadily increasing economic activities such as fisheries and recreation (TURNHOUT *et al.*, 2008). The presented data originates both from the archives of the Royal Netherlands Institute for Sea Research (NIOZ) and surveys undertaken in 1968 and 2010, all from the same localities, resulting in a combined overview of host-parasite relationships in this area. Our second aim is to investigate potential changes in the infection patterns of two copepod species (*Acanthochondria cornuta* (Müller, 1776) and *Lepeophtheirus pectoralis* (Müller, 1776)) on the same host species (*Platichthys flesus* (Linnaeus, 1758)), using data from surveys in 1968 and 2010.

3. Methods

Host-parasite relationship observations were retrieved from three sources: 1) archival data from the NIOZ Royal Netherlands Institute for Sea Research where host-parasite relationships are merely mentioned without reporting a date or sampling effort, based on occasional observations during general research activities, 2) an unpublished survey from 1968 including sampling effort and dates, and 3) a survey undertaken in May-June 2010. In both surveys, fish were collected from several separate bottom- and pelagic trawls in the Wadden Sea and North Sea in the area south of the island of Texel, The Netherlands. In addition, fish caught in a fyke located in that same area, near 't Horntje on Texel, were added to the sample population. Caught fish were identified, measured and checked for ectoparasites. In order to find parasites, the skin and fins of the host were examined, after which the skin connected to the gill flaps was incised to allow an inspection of the gill arches. All ectoparasites found were collected, counted and subsequently stored on alcohol in a separate vial per host. Whenever fish could not be examined within 15 minutes after catching, they were stored at 4° Celsius. Fish that could not be examined the same day were stored individually in sealed plastic bags at -20° Celsius. Stored parasites were reviewed under magnification and identified to a species level using KABATA (2003). Since classification differed in 1968, when DOGIEL *et al.* (1953) and SCOTT & SCOTT (1912) were used for copepod identification, those parasite species were reassessed to comply with the classification and nomenclature described in KABATA (2003) (see Appendix A).

The 1968 data contained particularly detailed information on the intensity (number of copepods per host) of *Acanthochondria cornuta* (Müller, 1776) and *Lepeophtheirus pectoralis* (Müller, 1776) on different sizes of European flounder (*Platichthys flesus*). Similar data for both these parasites were available for European flounders caught in 2010, allowing for a comparison between these years. Correlations between the numbers of *A. cornuta* and *L. pectoralis* and host

length were tested using GLM, and an ANCOVA approach was used to test for significant temporal changes in the slopes of the intensity-length relationships. All statistical analyses were executed using R for Ubuntu Linux.

4. Results

4.1 Inventory

In total, 52 fish species from the waters around Texel belonging to 16 orders were inspected for parasitic copepods (see Appendix B). Most of the fish species were only infected by a single copepod species. However, some host species acquired up to 5 copepod species. There was a significant correlation (linear model, $P < 0.001$, $R^2 = 0.43$) between the number of individual fish of a species examined and the number of parasites species found to occur on them, indicating that higher sampling effort increases the number of parasite species found, and that the current sampling effort is not so high as to result in an exhaustive list. In total, 47 parasite species were found in the waters of the southern Wadden Sea (see Appendix C). The dominant families were the Caligidae, Chondracanthidae, Lernaeopodidae and Pennellidae. Most occurred only on a single host species, but some parasite species were found on as many as 6 different host species.

4.2 Temporal changes in infection patterns

The two copepod species *Acanthochondria cornuta* and *Lepeophtheirus pectoralis* infecting the European flounder (*Platichthys flesus*) showed different changes in infection patterns between the two sampling periods. In 1968, 101 European flounders out of 147 (69%) were infected with *A. cornuta*. Infected individuals had an average size of 235 (± SD 55.9) mm, and were host to an average of 6.28 *A. cornuta*. This amounted to a significant positive correlation between host size and number of parasites (GLM, $P < 0.001$, $R^2 = 0.16$). In 2010 this correlation was maintained (GLM, $P < 0.001$, $R^2 = 0.47$). Fish sampled in 2010 were smaller, containing proportionally fewer *A. cornuta*; 18 out of 40 (45%) European flounders were infected, infected individuals had an average size of 182 (± SD 41.2) mm and hosted an average of 3.17 *A. cornuta*. Analysis of these regressions reveals that the relationship between host size and *A. cornuta* infection has remained the same; slope (ANCOVA, $P = 0.20$, $F_{1,186} = 1.65$) nor intercept (ANCOVA, $P = 0.92$, $F_{1,186} = 0.01$) differed significantly between 1968 and 2010 (see Fig. 1).

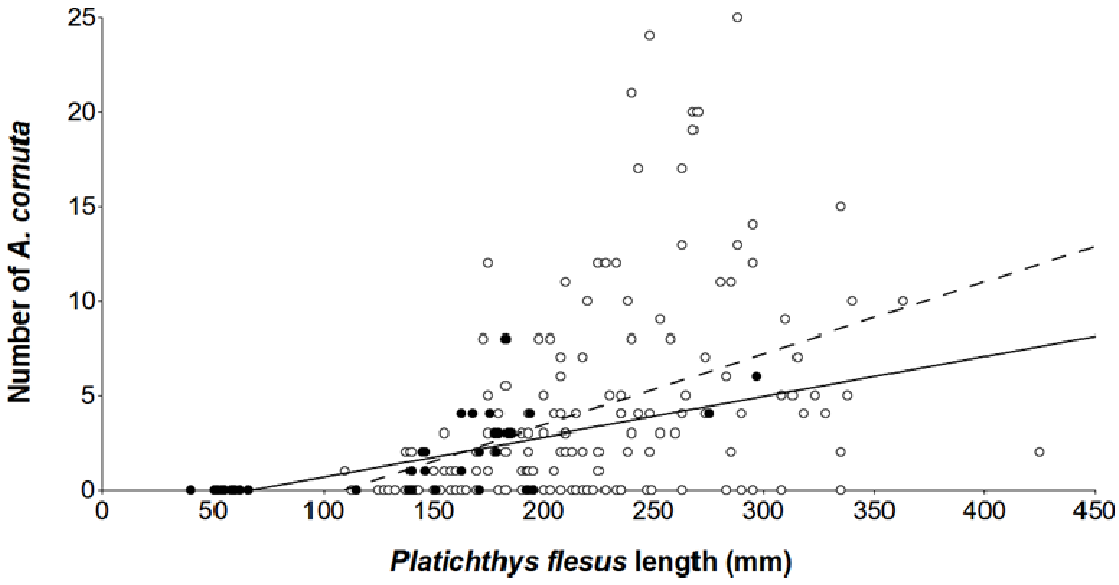

Fig. 1: Number of *Acanthochondria cornuta* on *Platichthys flesus* versus host fork length (mm). Open dots and dashed trend line represent 1968 data, filled dots and solid trend line represent data from 2010.

The infection with *L. pectoralis*, in contrast, shows a different temporal pattern. In 1968, 115 European flounders out of 152 (76%) were infected with *L. pectoralis*, infected individuals measured on average 230 (± SD 55.0) mm, and were host to an average of 6.22 *L. pectoralis*. As with *A. cornuta*, host size shows a significant positive correlation with the number of parasites per host (GLM, $P < 0.001$, $R^2 = 0.19$). In 2010, host size was only 149 (± SD 58.2) mm on average. Still, 34 out of 40 (85%) European flounder were infected with *L. pectoralis*, and at a higher per-host abundance; on average 10.26. There was a significant positive correlation between host size and number of *L. pectoralis* in 2010 (GLM, $P < 0.001$, $R^2 = 0.55$), and the slope of the regression was significantly higher than in 1968 (ANCOVA, $P < 0.001$, $F_{1,191} = 21.51$), (see Fig. 2). This means that in 2010 *L. pectoralis* infected smaller hosts, and with higher infectivity at a given host size than in 1968.

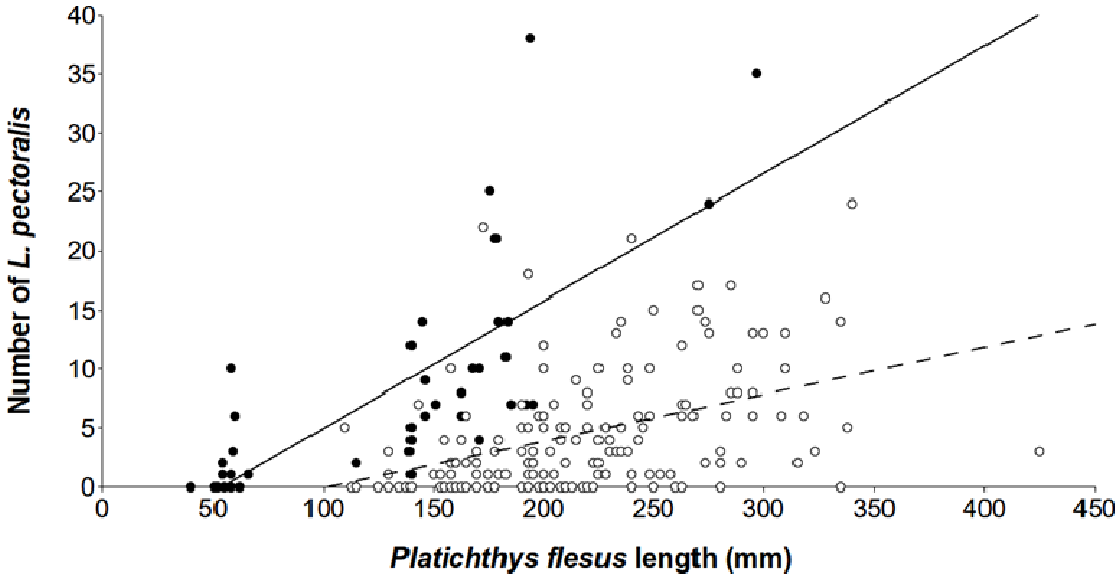

Fig. 2: Number of *Lepeophtheirus pectoralis* on *Platichthys flesus* versus host fork length (mm). Open dots and dashed trend line represent 1968 data, filled dots and solid trend line represent data from 2010.

5. Discussion

This first inventory of parasitic copepods of fishes in the Wadden Sea to date revealed a rich parasite fauna, with about 47 parasite species on 52 examined fish species. The observations in this study expand our knowledge from previous surveys in the North Sea (GROENEWOLD *et al.*, 1996; PALM *et al.*, 1999; SCHMIDT *et al.*, 2003; BOXSHALL, 2009). A total of 37 host species were present in these earlier reports that were not examined here, among which the order of Syngnathiformes (5 species, all without copepods) and 15 species from the order Perciformes (only few with copepods). These earlier studies furthermore report 19 copepod species not found in this survey, including the Ergasilidae and Eudactylinidae (with 3 species reported from each of these families). More than half (24 out of 47) of the copepod species found in our survey were not present in these previous reports, including all findings of Cecropidae (3 species) and Sphyriidae (2 species). Of the 24 additions, 12 were found on one of the 8 host species not examined in the earlier reports, although none of these host species are particular to the Wadden Sea. So, while there is considerable overlap with the earlier North Sea studies, many of the copepod species found are new findings that can be ascribed to both the inclusion of other host species, and the parasite diversity of the Wadden Sea. The number of copepod species found is similar to abundances found in surveys from other regions (CAUSEY, 1960). Large studies, sampling a larger array of fish species, have found higher numbers of parasite species especially when a large percentage of examined hosts are nectonic and pelagic species, migratory and gregarious (RAIBAUT & COMBES, 1998). The observation that the sum of parasites found in a region is a multitude of those found in any singular survey (CAUSEY, 1960) further demonstrates that even the most extensive study is likely to find only a subset of parasite fauna present, as is likely to be the case here.

The parasites examined in most detail here, *Acanthochondria cornuta* and *Lepeophtheirus pectoralis* on European flounder (*Platichthys flesus*) exhibit an interesting difference when comparing 1968 and 2010. Whereas *A. cornuta* seems not to have altered its infection rate or

per host abundance between years, *L. pectoralis* has shifted towards infection of smaller hosts, as well as to a stronger increase of per-host abundance with increasing host length. A likely explanation is to be found in the combination of the properties of the parasites themselves, and a shift in population composition of the host species. *Acanthochondria cornuta* is a parasite of the gill cavity, attaching to the gill arches, whereas *L. pectoralis* dwells on the skin of the host, mobile but usually in close proximity to the fins (KABATA, 2003). Seen in light of the reported trend that many commercially harvested fish species are less abundant, the fact that the largest specimens are being selectively fished out of the population (WOOD *et al.*, 2010), and the resulting adaptive response where fish tend to stay smaller (LAW, 2000), it is reasonable to assume that these parasites face different challenges. Both are confronted with a declining host density, and the available hosts are on average smaller than in 1968. As gill cavities are a much confined space containing a fixed number of gill arches, *A. cornuta* may not be able to infect individuals at a higher per-host abundance, nor infect individuals below a certain size, preventing it from compensating for the overall decline of host numbers. *Lepeophtheirus pectoralis*, in contrast, does not face such intrinsic limitations, and can potentially compensate for dwindling host abundance by infecting smaller fish, as well as by increasing its per-fish abundance. These changes in infection patterns may thus reflect the effects of environmental changes. However, while parasite trends can be indicative of broader changes, e.g. the host fish size trend described here, various environmental parameters such as temperature, pollutants, hunting- and fishing regulations, invasive species and recreational activity are known to change as well and may be alternative explanatory variables (WOOD *et al.*, 2010). Nevertheless, the particularly strong and rapid trend in host fish size (JØRGENSEN *et al.*, 2007) provides a probable and eminent explanatory mechanism for the observed change in infection patterns of *L. pectoralis* on *P. flesus*.

The trends observed in parasitic copepod abundances in the coastal area around Texel are striking and deemed to reflect real changes in parts of the parasite community, indicative of broader changes in the area. In monitoring and identifying trends, a continuous data series would be desirable, and this survey is likely to be incomplete but valuable nonetheless, as it is the first within these localities. The lower sample size in 2010 induces a possible bias towards underestimation of the true increase in parasite abundance and intensity (MARQUES & CABRAL, 2007), strengthening the validity of the observations described here. Besides the need for extended surveying in the waters investigated here, there are many areas as of yet devoid of such data, and where data is available it is often of such an age that a new survey could provide further insights in parasite communities. An increase in spatial and temporal resolution of parasite patterns could serve as a valuable tool in monitoring trends in these inconspicuous yet diverse and dynamic worlds.

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8. Appendices

Appendix A: Parasite nomenclature conversions

1968 name	Updated name
Acanthochondria depressa	*Acanthochondria cornuta*
Acanthochondria flurae	*Acanthochondria cornuta*
Bomolochus onosi	*Taeniacanthus onosi*
Brachiella ovalis	*Neobrachiella bispinosa*
Caligus rapax	*Caligus elongatus*
Medesicaste triglarum	*Lernentoma asellina*

Appendix B: Hosts and their observed ectoparasites

List of host species by order, and the parasites found on them in 1968 and/or 2010. Numbers in square brackets indicate the host sample size in 1968 and 2010, respectively. Question marks in the 1968 data set occur where species were mentioned without quantitative information, referring to the NIOZ archive as the source. A dash is presented in cases were that particular classification of host species was not applied in that year. The distinction between the common goby and the sand goby was not made in 1968, so goby sp. is included to provide a combined 1968 sample size. Host names are in concordance with www.fishbase,org, parasite names follow Kabata (2003).

BELONIFORMES

Garfish (*Belone belone*) [?, 1]: *Caligus belones*.

CARCHARHINIFORMES

Tope shark (*Galeorhinus galeus*) [?, 0]: *Echthrogaleus coleoptratus*, *Lernaeopoda bidiscalis*, *Lernaeopoda galei* and *Pandarus bicolor*.

Smooth-hound (*Mustelus mustelus*) [?, 0]: *Lernaeopoda bidiscalis*, *Lernaeopoda galei*, *Pandarus bicolor* and *Tripaphylus musteli*.

Small-spotted catshark (*Scyliorhinus canicula*) [?, 0]: *Lernaeopoda galei*.

CLUPEIFORMES

Twaite shad (*Alosa fallax*) [3, 0]: *Clavellisa emarginata*.

Atlantic herring (*Clupea harengus*) [2627, 6]: *Caligus elongatus*, *Lepeophtheirus salmonis* and *Lernaeenicus sprattae*.

European sprat (*Sprattus sprattus*) [2903, 55]: *Lepeophtheirus salmonis*, *Lernaeenicus encrasicoli* and *Lernaeenicus sprattae*.

GADIFORMES

Fivebeard rockling (*Ciliata mustela*) [3, 1]: none.

Fourbeard rockling (*Enchelyopus cimbrius*) [?, 0]: *Taeniacanthus onosi*.

Atlantic cod (*Gadus morhua*) [15, 0]: *Caligus curtus*, *Caligus elongatus* and *Lernaeocera branchialis*.

Haddock (*Melanogrammus aeglefinus*) [3, 0]: *Caligus curtus*.

Whiting (*Merlangius merlangus*) [564, 3]: *Caligus curtus*, *Caligus elongatus*, *Clavella adunca*, *Lepeophtheirus salmonis* and *Lernaeocera branchialis*.

European hake (*Merluccius merluccius*) [?, 0]: *Chondracanthus merluccii* and *Clavella stellata*.

Pollack (*Pollachius pollachius*) [14, 0]: *Lernaeocera branchialis*.

Saithe (*Pollachius virens*) [140, 3]: *Lepeophtheirus pollachius* and *Lernaeocera branchialis*.

Pouting (*Trisopterus luscus*) [102, 30]: *Lernaeocera lusci*.

Poor cod (*Trisopterus minutus*) [17, 0]: *Lernaeocera lusci*.

LAMNIFORMES

Porbeagle (*Lamna nasus*) [?, 0]: *Anthosoma crassum* and *Dinemoura producta*.

LOPHIIFORMES

Angler (*Lophius piscatorius*) [?, 0]: *Caligus curtus* and *Chondracanthus lophii*.

MUGILIFORMES

Thicklip grey mullet (*Chelon labrosus*) [0, 4]: none.

OSMERIFORMES

European smelt (*Osmerus eperlanus*) [153, 17]: *Lernaeocera sp.* (juv) and *Lernaeocera sp.* (larvae).

PERCIFORMES

Small sandeel (*Ammodytes tobianus*) [28, 32]: none.

Transparent goby (*Aphia minuta*) [1, 2]: *Lernaeocera sp.* (juv).

Meagre (*Argyrosomus regius*) [?, 0]: *Brachiella thynni* and *Lernanthropus gisleri*.

Dragonet (*Callionymus lyra*) [85, 1]: *Lernaeocera lusci*.

European seabass (*Dicentrarchus labrax*) [0, 1]: none.

Rock gunnel (*Pholis gunnellus*) [5, 6]: *Haemobaphes cyclopterina* and *Philorthagoriscus serratus*.

Sand goby (*Pomatoschistus minutus*) [-, 9]: *Lernaeocera minuta*.

Goby sp. (*Pomatoschistus sp.*) [448, -]: *Lernaeocera minuta*.

Atlantic horse mackerel (*Trachurus trachurus*) [39, 0]: *Caligus pelamydis*.

Eelpout (*Zoarces viviparus*) [151, 6]: *Lernaeocera sp.* (juv) and *Lernaeocera sp.* (larvae).

PLEURONECTIFORMES

Witch flounder (*Glyptocephalus cynoglossus*) [?, 0]: *Acanthochondria cornuta*.

American plaice (*Hippoglossoides platessoides*) [?, 0]: *Acanthochondria cornuta* and *Pandarus cranchii*.

Common dab (*Limanda limanda*) [546, 2]: *Acanthochondria limandae*, *Lepeophtheirus pectoralis* and *Lernaeocera sp.* (larvae).

Lemon sole (*Microstomus kitt*) [?, 9]: *Acanthochondria clavata* and *Lernaeocera sp.* (larvae).

European flounder (*Platichthys flesus*) [213, 40]: *Acanthochondria cornuta*, *Lepeophtheirus pectoralis* and *Lernaeocera sp.* (larvae).

European plaice (*Pleuronectes platessa*) [614, 36]: *Acanthochondria cornuta*, *Acanthochondria sp.*, *Lepeophtheirus pectoralis* and *Lernaeocera sp.* (larvae).

Turbot (*Scophthalmus maximus*) [?, 0]: *Lepeophtheirus pectoralis* and *Lepeophtheirus thompsoni*.

Brill (*Scophthalmus rhombus*) [3, 1]: *Lepeophtheirus pectoralis*, *Lepeophtheirus thompsoni* and *Lernaeocera sp.* (larvae).

Common sole (*Solea solea*) [177, 16]: *Acanthochondria soleae*, *Bomolochus soleae*, *Lernaeocera lusci*, *Lernaeocera sp.* (juv) and *Lernaeocera sp.* (larvae).

RAJIFORMES

Blue skate (*Dipturus batis*) [?, 0]: *Trebius caudatus*.

Thornback ray (*Raja clavata*) [?, 0]: *Lepeophtheirus pectoralis*.

SALMONIFORMES

Sea trout (*Salmo trutta*) [?, 1]: *Lepeophtheirus salmonis*.

SCORPAENIFORMES

Red gurnard (*Chelidonichthys cuculus*) [?, 0]: *Pandarus bicolor*.

Tub gurnard (*Chelidonichthys lucerna*) [28, 3]: *Caligus brevicaudatus*, *Caligus diaphanus* and *Lernentoma asellina*.

Gurnard sp. (*Chelidonichthys sp.*) [?, -]: *Caligus gurnardi*.

Lumpfish (*Cyclopterus lumpus*) [?, 0]: *Caligus elongatus*, *Lernaeocera sp.* (larvae) and *Sphyrion lumpi*.

Grey gurnard (*Eutrigla gurnardus*) [8, 0]: *Caligus diaphanus*, *Lernentoma asellina* and *Neobrachiella bispinosa*.

Striped seasnail (*Liparis liparis*) [5, 5]: none.

Shorthorn sculpin (*Myoxocephalus scorpius*) [69, 10]: none.

SQUALIFORMES

Picked dogfish (*Squalus acanthias*) [?, 0]: *Pandarus bicolor*.

TETRAODONTIFORMES

Ocean sunfish (*Mola mola*) [?, 0]: *Cecrops latreilli*, *Lepeophtheirus nordmanni*, *Orthagoriscicola muricatus* and *Philorthagoriscus serratus*.

ZEIFORMES

John dory (*Zeus faber*) [?, 0]: *Chondracanthus zei*.

Appendix C: Ectoparasites and their hosts

List of ectoparasites by family, and the hosts they have been found on in 1968 and/or 2010. Data based on Appendix B.

BOMOLOCHIDAE

Bomolochus soleae: Common sole (*Solea solea*).

CALIGIDAE

Caligus belones: Garfish (*Belone belone*).

Caligus brevicaudatus: Tub gurnard (*Trigla lucerna*).

Caligus curtus: Angler (*Lophius piscatorius*), Atlantic cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*) and Whiting (*Merlangius merlangus*).

Caligus diaphanus: Grey gurnard (*Eutrigla gurnardus*) and Tub gurnard (*Trigla lucerna*).

Caligus elongatus: Atlantic cod (*Gadus morhua*), Atlantic herring (*Clupea harengus*), Lumpfish (*Cyclopterus lumpus*) and Whiting (*Merlangius merlangus*).

Caligus gurnardi: Gurnard sp. (*Trigla sp.*).
Caligus pelamydis: Atlantic horse mackerel (*Trachurus trachurus*).
Lepeophtheirus nordmanni: Ocean sunfish (*Mola mola*).
Lepeophtheirus pectoralis: Brill (*Scophthalmus rhombus*), Common dab (*Limanda limanda*), European flounder (*Platichthys flesus*), European plaice (*Pleuronectes platessa*), Thornback ray (*Raja clavata*) and Turbot (*Scophthalmus maximus*).
Lepeophtheirus pollachius: Saithe (*Pollachius virens*).
Lepeophtheirus salmonis: Atlantic herring (*Clupea harengus*), European sprat (*Sprattus sprattus*), Sea trout (*Salmo trutta*) and Whiting (*Merlangius merlangus*).
Lepeophtheirus thompsoni: Brill (*Scophthalmus rhombus*) and Turbot (*Scophthalmus maximus*).

CERCROPIDAE

Cecrops latreilli: Ocean sunfish (*Mola mola*).
Orthagoriscicola muricatus: Ocean sunfish (*Mola mola*).
Philorthagoriscus serratus: Ocean sunfish (*Mola mola*) and Rock gunnel (*Pholis gunnellus*).

CHONDRACANTHIDAE

Acanthochondria clavata: Lemon sole (*Microstomus kitt*).
Acanthochondria cornuta: American plaice (*Hippoglossoides platessoides*), European flounder (*Platichthys flesus*), European plaice (*Pleuronectes platessa*) and Witch flounder (*Glyptocephalus cynoglossus*).
Acanthochondria limandae: Common dab (*Limanda limanda*).
Acanthochondria soleae: Common sole (*Solea solea*).
Acanthochondria sp.: European plaice (*Pleuronectes platessa*).
Chondracanthus lophii: Angler (*Lophius piscatorius*).
Chondracanthus merluccii: European hake (*Merluccius merluccius*).
Chondracanthus zei: John dory (*Zeus faber*).
Lernentoma asellina: Grey gurnard (*Eutrigla gurnardus*) and Tub gurnard (*Trigla lucerna*).

DICHELESTHIIDAE

Anthosoma crassum: Porbeagle (*Lamna nasus*).

LERNAEOPODIDAE

Brachiella thynni: Meagre (*Argyrosomus regius*).
Clavella adunca: Whiting (*Merlangius merlangus*).
Clavella stellata: European hake (*Merluccius merluccius*).
Clavellisa emarginata: Twaite shad (*Alosa fallax*).
Lernaeopoda bidiscalis: Smooth-hound (*Mustelus mustelus*) and Tope shark (*Galeorhinus galeus*).
Lernaeopoda galei: Small-spotted catshark (*Scyliorhinus canicula*), Smooth-hound (*Mustelus mustelus*) and Tope shark (*Galeorhinus galeus*).
Neobrachiella bispinosa: Grey gurnard (*Eutrigla gurnardus*).

LERNANTHROPIDAE

Lernanthropus gisleri: Meagre (*Argyrosomus regius*).

PANDARIDAE

Dinemoura producta: Porbeagle (*Lamna nasus*).
Echthrogaleus coleoptratus: Tope shark (*Galeorhinus galeus*).
Pandarus bicolor: Picked dogfish (*Squalus acanthias*), Red gurnard (*Chelidonichthys cuculus*), Smooth-hound (*Mustelus mustelus*) and Tope shark (*Galeorhinus galeus*).
Pandarus cranchii: American plaice (*Hippoglossoides platessoides*).

PENNELLIDAE

Haemobaphes cyclopterina: Rock gunnel (*Pholis gunnellus*).
Lernaeenicus encrasicoli: European sprat (*Sprattus sprattus*).
Lernaeenicus sprattae: Atlantic herring (*Clupea harengus*) and European sprat (*Sprattus sprattus*).
Lernaeocera branchialis: Atlantic cod (*Gadus morhua*), Pollack (*Pollachius pollachius*), Saithe (*Pollachius virens*) and Whiting (*Merlangius merlangus*).
Lernaeocera lusci: Common sole (*Solea solea*), Dragonet (*Callionymus lyra*), Poor cod (*Trisopterus minutus*) and Pouting (*Trisopterus luscus*).
Lernaeocera minuta: Sand goby (*Pomatoschistus minutus*) and Goby sp. (*Pomatoschistus sp.*).
***Lernaeocera sp.* (juv)**: Common sole (*Solea solea*), Eelpout (*Zoarces viviparus*), European smelt (*Osmerus eperlanus*) and Transparent goby (*Aphia minuta*).
***Lernaeocera sp.* (larvae)**: Brill (*Scophthalmus rhombus*), Common dab (*Limanda limanda*), Common sole (*Solea solea*), Eelpout (*Zoarces viviparus*), European flounder (*Platichthys flesus*), European plaice (*Pleuronectes platessa*), European smelt (*Osmerus eperlanus*), Lemon sole (*Microstomus kitt*) and Lumpfish (*Cyclopterus lumpus*).

SPHYRIIDAE

Sphyrion lumpi: Lumpfish (*Cyclopterus lumpus*).
Tripaphylus musteli: Smooth-hound (*Mustelus mustelus*).

TAENIACANTHIDAE

Taeniacanthus onosi: Fourbeard rockling (*Enchelyopus cimbrius*).

TREBIIDAE

Trebius caudatus: Blue skate (*Dipturus batis*).

Het NIOZ Koninklijk Nederlands Instituut voor Zeeonderzoek is een instituut van de Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO).

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NIOZ Rapport 2012-6

De missie van het NIOZ is het verkrijgen en communiceren van wetenschappelijke kennis van zeeën en oceanen voor een beter begrip en een duurzaam beheer van onze planeet, het beheren van de nationale faciliteiten voor zeeonderzoek en het ondersteunen van onderzoek en onderwijs in Nederland en in Europa.