

NAMMCO Scientific Publications - Volume 3

SEALWORMS IN THE NORTH ATLANTIC: ECOLOGY AND POPULATION DYNAMICS

ABSTRACTS

Review of experimental and natural invertebrate hosts of sealworm (*Pseudoterranova decipiens*) and its distribution and abundance in macroinvertebrates in eastern Canada

Marcogliese, D. J. 2001. Review of experimental and natural invertebrate hosts of sealworm (*Pseudoterranova decipiens*) and its distribution and abundance in macroinvertebrates in eastern Canada. *NAMMCO Sci. Publ.* 3:27-37.

Experimental and natural invertebrate intermediate hosts of sealworm (*Pseudoterranova decipiens*) as well as transmission experiments of sealworm from invertebrates to fish are reviewed and summarized. Experimental hosts include copepods, mysids, cumaceans, isopods, amphipods, decapods, annelids, and molluscs. Invertebrates collected from eastern Canada between 1989 and 1995 were checked for nematode infections by microscopic examination of dissected animals or enzymatic digestion of bulk samples. Third-stage larval sealworm were found in mysids (*Neomysis americana*, *Mysis stenolepis*) from Passamaquoddy Bay, the Bras d'Or Lakes, inshore Cape Breton, Sable Island and Sable Island Bank. Infected amphipods (*Amphiporeia virginiana*, *Americorchestia megalophthalma*, *Gammarus* spp.) were found only on Sable Island. Typical infection rates in macroinvertebrates were 1-4/1000. No sealworm infections were found in approximately 18,000 amphipods examined from Sable Island Bank, the site of the most heavily infected fishes in eastern Canada. In Wallace Lake, a brackish pond on Sable Island, infection rates were much higher in mysids than in amphipods. Estimates of rates of transmission of sealworm from invertebrates to fish were derived from infection levels in Wallace Lake and feeding experiments involving sticklebacks and invertebrate prey. It is concluded that mysids may be much more important than amphipods in transmitting sealworm to fish hosts.

A note on the variation in sealworm (*Pseudoterranova decipiens*) infection in shorthorn sculpin (*Myoxocephalus scorpius*) with host age and size at two locations in Norwegian inshore waters

Andersen, K. 2001. A note on the variation in sealworm (*Pseudoterranova decipiens*) infection in shorthorn sculpin (*Myoxocephalus scorpius*) with host age and size at two locations in Norwegian inshore waters. *NAMMCO Sci. Publ.* 3:39-46.

A total of 540 shorthorn sculpins were collected between 1991 and 1996 from Hvaler and Vega in Norway. The sculpins were caught in traps or by gillnets near seal haul-out sites in both areas. Size, age and intensity of *P. decipiens* infection were recorded for most fish

sampled. Stomach contents of a subsample from each area were examined and the frequencies of occurrence of prey items were determined. Sealworm abundance (mean number of worms in all fish examined) increased significantly with host age and length within given age groups of sculpins from both areas. Sealworm abundance and mean intensity (mean number of worms per infected fish) in sculpins from Vega were lower than those found in the more rapidly growing fish from Hvaler. Abundance of sealworm peaked in 6 year old fish from Vega and in 4 year old fish from Hvaler. Fish and amphipods were the prey items found most frequently in the stomach of fish from Hvaler, while fish and decapods were found most frequently at Vega.

Sealworm (*Pseudoterranova decipiens*) infection in the benthic cottid (*Taurulus bubalis*) in relation to population increase of harbour seal (*Phoca vitulina*) in Skagerrak, Sweden

Lunneryd, S-G, Ugland, K.I. and Aspholm, P.E. 2001. Sealworm (*Pseudoterranova decipiens*) infection in the benthic cottid (*Taurulus bubalis*) in relation to population increase of harbour seal (*Phoca vitulina*) in Skagerrak, Sweden. *NAMMCO Sci. Publ.* 3:47-55.

In Koster archipelago (northern Skagerrak, Sweden) the harbour seal population increased from approximately 350 to more than 1000 individuals between 1988 and 1998. During the same period, sealworm (*Pseudoterranova decipiens*) abundance in the most heavily infected fish species, bullrout (*Myoxocephalus scorpius*) and sea scorpion (*Taurulus bubalis*), did not increase. Since harbour seals do not normally feed on those cottids an infection route via cod (*Gadus morhua*), which consume cottids, is proposed. The abundance of sealworm in the final host is therefore related to the probability of cod preying on infected cottids prior to being preyed upon by seals. Our model predicts that the abundance of larval sealworm in benthic fishes is not related to the number of seals when the colony is over a specific threshold size.

Surveys of larval sealworm (*Pseudoterranova decipiens*) infection in various fish species sampled from Nova Scotian waters between 1988 and 1996, with an assessment of examination procedures

McClelland, G. and Martell, D.J. 2001. Surveys of larval sealworm (*Pseudoterranova decipiens*) infection in various fish species sampled from Nova Scotian waters between 1988 and 1996, with an assessment of examination procedures. *NAMMCO Sci. Publ.* 3:57-76.

Between November 1988 and October 1996, >10,000 fish from the Breton Shelf, Sable Island Bank and the northeastern Gulf of Maine were examined for larval anisakines. Larval sealworm, *Pseudoterranova decipiens*, occurred in 30 of 39 species surveyed, including 8 new host records, *Enchelyopus cimbrius*, *Lycodes reticulatus*, *Eumesogrammus praecisus*, *Lumpenus lumpretaeformis*, *Lumpenus maculatus*, *Cryptacanthodes maculatus*, *Artediellus atlanticus* and *Triglops murrayi*. The parasite was most prevalent and abundant in mature demersal piscivores and benthic consumers.

Sealworm densities (nr kg⁻¹ host wt.), however, were greatest in small benthophagous fish including mature *E. cimbrius*, *A. atlanticus*, *T. murrayi* and *Aspidophoroides monopterygius*, and juvenile *Hippoglossoides platessoides*. ANOVA revealed that geographical disparities in sealworm prevalence and abundance were highly significant in 14 of 20 species tested, although significant disparities between samples from each of the three areas were evident only in *H. platessoides*. Almost invariably, infection parameters were greatest in fish from Sable Island Bank. ANOVA also indicated that sealworm prevalence and/or abundance increased significantly in Sable Island Bank populations of *Gadus morhua*, *H. platessoides*, and seven other species between 1985-1986 and 1989-1990. Routine examinations, in which host flesh was sliced and candled, proved as efficacious as digestion in warm (35° C) pepsin-HCl for detection of larval sealworm in the flesh of large frozen fish. Procedures employing fresh (iced) samples, digestion at ambient temperature and microscopy are recommended, however, for surveys of small benthic consumers. Many of the sealworm infecting the latter hosts are tiny (2 to 10 mm in length) nematodes, which escape detection by routine inspection, and may not survive in warm pepsin-HCl solution.

Spatial and temporal distributions of larval sealworm, *Pseudoterranova decipiens* (Nematoda: Anisakinae), in *Hippoglossoides platessoides* (Pleuronectidae) in the Canadian Maritime Region from 1993 to 1999

McClelland, G. and Martell, D.J. 2001. Spatial and temporal distributions of larval sealworm, *Pseudoterranova decipiens* (Nematoda: Anisakinae), in *Hippoglossoides platessoides* (Pleuronectidae) in the Canadian Maritime Region from 1993 to 1999. *NAMMCO Sci. Publ.* 3:77-94.

Spatial and temporal trends of larval sealworm (*Pseudoterranova decipiens*) infection in eastern Canadian groundfish were monitored in an indicator host, Canadian plaice (*Hippoglossoides platessoides*), in the 31 to 40 cm length range. Between February 1993 and September 1999, a total of 8,482 plaice were collected from 33 locations in Canadian Maritime waters (NAFO Subdivisions 4TVWX-5ZE), and their fillets and napes were examined for sealworm. Prevalence (P) and abundance (A) of the parasite were greatest (P, ranging from 95 to 100%, A, from 7.48 to 15.60) in fish collected from the central Scotian shelf (4VSW) near Sable Island, site of the largest grey seal (*Halichoerus grypus*) colony in the northwest Atlantic, and from Jordan Basin in the northeastern Gulf of Maine (4X). The infection of greatest intensity (I=158) occurred in a fish from "The Gully" slopewaters of Banquereau (4VS), a few kilometres northeast of Sable Island. By 1995-99, sealworm prevalence and/or abundance had increased significantly in plaice from most locations where stable or declining infection parameters were observed from 1989 to '93, but abundance of the parasite continued to decline in the Sable Island area. While spatial and temporal distributions of larval sealworm in plaice seemed largely related to the distribution and growth of grey seal populations, the influence of definitive hosts was probably mitigated by other factors such as changes in environmental temperature and parasite density limiting effects in the indicator host.

A review of the ecology of sealworm, *Pseudoterranova sp (p)* (Nematoda: Ascaridoidea) in Icelandic waters.

Ólafsdóttir D. 2001. Review of the ecology of sealworm, *Pseudoterranova sp (p)* (Nematoda: Ascaridoidea) in Icelandic waters. *NAMMCO Sci. Publ.* 3:95-111.

The early life cycle of sealworm in Icelandic waters is not known. Various fish serve as transport hosts but benthic coastal fish, especially bull rout (*Myoxocephalus scorpius*), probably have a major role in transmission of larvae to the final hosts, seals. Grey seals (*Halichoerus grypus*) are more heavily infected with sealworm than common seals (*Phoca vitulina*) and the grey seal population, estimated at 6,000 probably plays a larger role in the dynamics of the worm than the estimated 15,000 common seals. Other seals seem to play a small or insignificant role in sealworm dynamics in the area. Sealworm abundances in fish and final hosts are higher off the west coast than in other areas in Iceland. A combination of shallow, temperate waters, large numbers of small islands inhabited by numerous seals and grey seals' consumption of heavily infected bull rout during the breeding season in autumn are important factors responsible for maintaining an abundance of sealworm in this area. Future research on sealworm in Iceland should focus on long term monitoring of worm abundance in all potential hosts in order to observe, interpret and predict possible changes, the dynamics of infections in fish frequently consumed by seals and on seasonal and spatial variations in worm fecundity.

Distribution and abundance of sealworm (*Pseudoterranova decipiens*) and other anisakid nematodes in fish and seals in the Gulf of St. Lawrence: potential importance of climatic conditions

Marcogliese, D.J. 2001. Distribution and abundance of sealworm (*Pseudoterranova decipiens*) and other anisakid nematodes in fish and seals in the Gulf of St. Lawrence: potential importance of climatic conditions. *NAMMCO Sci. Publ.* 3: 113-128.

Prevalence and abundance of sealworm (*Pseudoterranova decipiens*) and other anisakid nematodes were determined in a variety of fishes from the Gulf of St. Lawrence in 1990 and 1992. Sealworm abundance and prevalence were also determined in three species of seals in the Gulf between 1988 and 1992. Atlantic cod (*Gadus morhua*) and shorthorn (*Myoxocephalus scorpius*) and longhorn sculpin (*M. octodecemspinosus*) were the fishes most heavily infected with sealworm. Grey seals (*Halichoerus grypus*) proved to be the most important definitive hosts for sealworm in the Gulf. Abundance of sealworm increased, whereas that of *Anisakis simplex* and contraecaecine nematodes decreased, from north to south in the Gulf. Abundance of sealworm increased compared to earlier surveys in most areas of the Gulf, but decreased in both cod and grey seals during the course of this study. In contrast, abundance of *Contraecaecum osculatum* and *Phocascaris* spp. in grey seals and cod continued to increase during the study period. Observed increases of nematodes are attributed to growing populations of grey seals (for sealworm) and harp seals (for Contraecaecinea). Levels of *A. simplex* remained relatively constant between 1988 and 1992 in both grey seals and cod. There is no evidence suggesting that observed patterns in nematode abundance were due to changes in grey seal diet. Nor was there any

evidence of competition between *P. decipiens* and *C. osculatum* in grey seals affecting either sealworm abundance or fecundity. The trends detected herein are attributed to climatic events in the Gulf of St. Lawrence, where water temperatures in the cold intermediate layer consistently decreased between 1986 and 1994. It is suggested that low temperatures inhibited development and hatching of sealworm eggs, but not those of *C. osculatum*.

Sealworm (*Pseudoterranova decipiens*) dynamics in Sable Island grey seals (*Halichoerus grypus*): seasonal fluctuations and other changes in worm infections during the 1980s.

Stobo, W.T. and Fowler, G.M. 2001. Sealworm (*Pseudoterranova decipiens*) dynamics in Sable Island grey seals (*Halichoerus grypus*): seasonal fluctuations and other changes in worm infections during the 1980s. *NAMMCO Sci. Publ.* 3:129-147.

The abundance of *P. decipiens* sampled from the stomachs of 553 grey seals (aged 0-48 years) collected during 14 field trips to Sable Island in 1983 and 1989 did not change significantly between years, even though the seal population has been increasing at over 12% annually and there has been a substantial decline in the fish biomass upon which they depend. The proportion of mature worms in the seals' stomachs has decreased, however. Seal growth, expressed in terms of either age or length, showed the strongest correlation with total worm abundance. These infections were not completely eliminated at any time during the year, but a seasonal pattern in worm abundance was apparent. Among the youngest seals an inverse relationship was demonstrated between the abundance of *P. decipiens* and another parasitic nematode, *Contracaecum osculatum*. Sexually mature *P. decipiens* were found in pups within 3 to 4 months of the commencement of independent feeding, and the abundance of *P. decipiens* progressively increased throughout the first year of life. Male pups contracted more worms than female pups of the same age. *P. decipiens* abundances in juvenile seals were primarily associated with seasonal pattern and age, with *C. osculatum* abundance still influencing the abundance of *P. decipiens*, but to a much lesser extent than seen with pups. Length of seals was the main predictor of total worm abundance in adult seals, with a seasonal pattern being next in order of importance. Age was also significant, possibly representing a component of growth not accounted for by length alone. No relationship between the abundances of *P. decipiens* and *C. osculatum* was apparent for adult seals. The seasonal pattern in total worm abundance of juvenile and adult seals was characterized by declines during the winter and mid-summer. We suggest these declines are due, respectively, to the breeding season fast and one or both of 1) a change in seal diet from primarily highly infected fish species to less infected ones, and 2) a partial fast during the annual moult. The proportion of mature worms increased during reductions in worm abundance throughout most of the year, but during the breeding fast both total abundance and the proportion mature declined.

Patterns of abundance and maturity among three species of parasitic nematodes (*Pseudoterranova decipiens*, *Contracaecum osculatum*, *Anisakis simplex*) co-existing in Sable Island grey seals (*Halichoerus grypus*).

Fowler, G.M. and Stobo, W.T. 2001. Patterns of abundance and maturity among three species of parasitic nematodes (*Pseudoterranova decipiens*, *Contracaecum osculatum*, *Anisakis simplex*) co-existing in Sable Island grey seals (*Halichoerus grypus*). *NAMMCO Sci. Publ.* 3: 149-160.

The abundance and maturity of three species of anisakine nematode (*Pseudoterranova decipiens*, *Contracaecum osculatum*, *Anisakis simplex*) that co-occurred in the stomachs of Sable Island grey seals were examined in relation to seal growth and seasonal considerations. Sealworm (*P. decipiens*), the predominant nematode in these seals, typically reached numbers of 400 to 2000 worms per stomach. *C. osculatum* and *A. simplex* were usually found in much smaller numbers of 40 to 100 and 20 to 60 worms, respectively, per stomach. All three species initially increased in abundance as the seals grew, but after most of a seals' growth had been attained *P. decipiens* abundance continued to increase with age, *A. simplex* numbers either continued to increase or were simply maintained, while *C. osculatum* abundance declined. Numbers of both *P. decipiens* and *A. simplex* declined during winter breeding/pupping and summer moulting fasts or partial fasts, and rose during the regular feeding periods between the fasts. Conversely, numbers of *C. osculatum* rose during the breeding period, and also during the moulting period in younger seals. We believe this could be attributed to some degree of feeding on prey species in the immediate vicinity of Sable Island that were not preferred during focused feeding periods, and that the inclination to feed during fasting periods decreased as seals grew. An inverse relationship between worm abundance and worm maturity, attributable to the seasonal changes in rates of ingestion of immature worms, was more pronounced for *C. osculatum* than *P. decipiens*. *C. osculatum* was usually represented by much higher proportions of mature worms than *P. decipiens*. This could be entirely related to the longer periods of time dedicated to feeding than spent breeding or moulting, but higher mortality rates of immature *C. osculatum* or greater longevity of mature *C. osculatum* could also have occurred. *A. simplex*, generally associated with cetacean species as final hosts, rarely matured in grey seals. We have doubts that the grey seal could be considered a final host for *A. simplex*.

Establishing the relative importance of sympatric definitive hosts in the transmission of the sealworm, *Pseudoterranova decipiens*: a host-community approach

Aznar, F.J., Balbuena, J.A., Fernández, M. and Raga, J.A. 2001. Establishing the relative importance of sympatric definitive hosts in the transmission of the sealworm, *Pseudoterranova decipiens*: a host-community approach. *NAMMCO Sci. Publ.* X:161-171.

The importance of a given host to a particular parasite can be determined according to three different criteria: host preference, host physiological suitability and host contribution to transmission. Most studies on the sealworm *Pseudoterranova decipiens* have focussed on the latter factor, but few attempts have been made to develop a

quantitative transmission model evaluating the relative importance of each host. The purpose of this study was to propose a flow-chart model to study sealworm transmission within a seal community. The model was applied to hypothetical data of four seal species acting as definitive hosts of *P. decipiens sensu stricto* in eastern Canada: harp seal *Phoca groenlandica*, harbour seal *P. vitulina*, grey seal *Halichoerus grypus* and hooded seal *Cystophora cristata*. The dynamics of the model was studied using population estimates from 1990 to 1996. To illustrate the interrelationship of the seal populations in the flow dynamics, the model's behaviour was explored by manipulation of the harp seal population size. The results showed that grey seals accounted by far for most transmission from and to the seals. The harbour seal population also sustained a biologically significant proportion of the flow, whereas the role of hooded and harp seals seemed negligible despite their large population sizes. The hypothetical removal of the harp seal population resulted in small increases in the relative flows to the other seals. These results conform to previous qualitative assessments on the relative importance of these seal species in sealworm transmission. The model provided some heuristic rules useful to understand transmission patterns. The data suggested that the harbour seal population should be about twice that of the grey seals to account for a larger share of transmission than grey seals. Although this is unlikely to occur at a large geographic scale, harbour seals outnumber grey seals in some areas and, therefore, the role of each host may change locally. To make this approach more realistic, further work should seek accurate estimates of parasite population parameters, better definition of the host community boundaries (at a local scale) and improved control of confounding variables.