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# On the Stock Identity of Short-finned Squid (*Illex illecebrosus*) in the Northwest Atlantic*

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## Abstract

The problem of stock discrimination in short-finned squid is addressed by reviewing size and maturity data, tagging experiments, distribution of young stages, and incidence of certain parasites. Although not conclusive, available evidence indicates that all short-finned squid comprise a single stock which spawns at least as far south as Cape Hatteras. A broad range of sizes during any season and the existence of larval stages during all seasons indicate that spawning occurs throughout most of the year. Modes of length distributions reflect several broods which result from relatively intense seasonal periods of spawning, with the winter brood being the most prominent. Spawning occurs in close proximity to the Gulf Stream, which serves as the mechanism for dispersal of young stages. The continuity of spawning and common medium for dispersal of young stages imply that temporal or geographical isolation of discrete spawning stocks is improbable. Parasites which commonly infest short-finned squid do not serve well as biological tags and are of little value in studies of stock discrimination for that species.

## Introduction

The short-finned squid (*Illex illecebrosus*) is a highly migratory species. It occurs in the western North Atlantic approximately from Cape Kennedy, Florida, to Labrador (Lu, MS 1973; Lu and Roper, 1979). Its exact northern limit of distribution is variable and poorly defined, because it is not exploited north of insular Newfoundland.

The stock composition of *I. illecebrosus* remains uncertain, because some important aspects of the life history of the species are unknown, especially its life span and the time and area of spawning. Stock discrimination is further complicated by the existence of a sympatric species (*Illex oxygonius*) in the southern part of its range of distribution, southward from New Jersey (Roper and Lu, 1978). Where both species exist, identification of larvae and small juveniles to the species level is not currently possible (Roper *et al*., 1969). Use of meristic characters is not applicable in stock discrimination studies of squids. Furthermore, tagging studies are of limited value in this respect, because *I. illecebrosus* is believed to be short-lived, with estimates of longevity varying from 1 year (Squires, 1967; Hurley and Beck, 1979) to 18 months (Mesnil, 1977).

This paper addresses the problem of stock discrimination in short-finned squid through an examination of basic biological data which were collected from certain regions within the range of distribution of the species (Fig. 1) and by reviewing relevant data

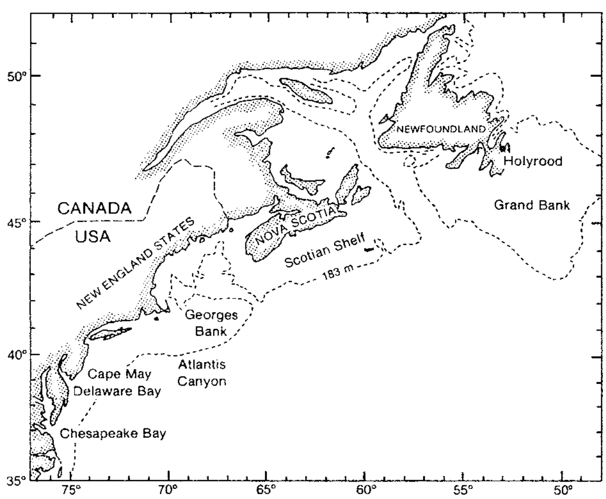


Fig. 1. Map of the Northwest Atlantic region showing the place names mentioned in the text.

reported by other researchers. Size and maturity data are examined as well as the distribution and mechanisms of transport of young stages. Also, the results of tagging studies and the incidence of certain parasites are considered.

## Materials and Methods

Data on the size and maturity of short-finned squid and on the incidence of certain parasites were collected during research vessel trawling in various

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regions of the continental shelf from the Grand Bank to Chesapeake Bay (NAFO Subareas 3-6) during 1966-72 (Table 1). A small sample was obtained with mechanized jigger at Holyrood, Newfoundland, on 2 November 1966. Detailed examination of the samples included measurement of dorsal mantle length (ML) to the nearest 0.5 cm, sex determination, and classification of the maturity condition of males according to the stages described by Mercer (MS 1973). Presence or absence of the cestode pleroceroids *Dinobothrium* and *Phyllobothrium* was also noted.

*Anisakis* larvae from short-finned squid and several fish hosts were cultured *in vitro* to determine specific identity of the nematodes from the adult stage. During May-November 1979, Atlantic salmon (*Salmo salar*), Atlantic herring (*Clupea harengus*), Atlantic mackerel (*Scomber scombrus*), and short-finned squid were obtained from various locations in Newfoundland coastal waters and examined for anisakine larvae. From early June to mid-August, 2,300 squid were necropsied and yielded 12 *Anisakis* larvae. From mid-September to mid-October, 230 squid were examined and 100 larvae were found.

Nematodes from the various host species were cultured *in vitro* and samples were either fixed in glacial acetic acid and stored in glycerine alcohol or deep-frozen at -20°C for further analysis. The culture method, described by Threlfall (1982), was a slight modification of the Van Banning (1971) method. Samples of nematodes of varying age, from the day on which culturing began, were preserved for morphological study. Specimens of larval and adult *Anisakis* from each host species were examined with a scanning electron microscope.

## Results and Discussion

### Population structure

The length distribution of male short-finned squid in samples from the Grand Bank and the Scotian Shelf at approximately the same time of year were generally unimodal and exhibited similar growth (Fig. 2). The range of modal lengths from May to early August was 13–18 cm in the Grand Bank samples and 10–19 cm in those from the Scotian Shelf. The males were classified as immature during spring and summer, but they were considerably larger by November and some had achieved advanced stages of maturity. The modal length of the November 1966 sample from Holyrood (23 cm) was similar to that of the Scotian Shelf sample (22 cm), but maturity was less advanced in the Holyrood specimens due possibly to the small size of the sample. Male squid from inshore Newfoundland waters in November are usually in more advanced stages of maturity than those described here (Mercer, MS 1975; Collins and Ennis, MS 1978).

TABLE 1. Time, method of capture, and location of short-finned squid samples, 1966–72.

| Year | Survey dates | Vessel/gear | Region* | Survey limits[a] North | Survey limits[a] South | Number of specimens Male | Number of specimens Female | Number of specimens Parasites |
|---|---|---|---|---|---|---|---|---|
| 1966 | 2 Nov | Inshore: mechanical jigger | Holyrood, Nfld | 47°24'N 53°07'W | — | 25 | 47 | 73 |
| | 7 Nov-6 Dec | *A. T. Cameron* Otter trawl | Scotian Shelf | 44°11'N 58°12'W | 42°58'N 65°18'W | 127 | 172 | 229 |
| 1968 | 15 Aug-3 Sep | *A. T. Cameron* Otter trawl | Atlantis Canyon to Cape May | 40°36'N 72°18'W | 38°58'N 72°50'W | 514 | 723 | 1,234 |
| | | | Delware Bay to Chesapeake Bay | 38°46'N 73°33'W | 37°22'N 72°28'W | 223 | 174 | 397 |
| 1970 | 21 May-3 Jun | *A. T. Cameron* Otter trawl | Grand Bank | 45°19'N 58°20'W | 43°07'N 51°05'W | 193 | 216 | 416 |
| | | | Scotian Shelf | 44°19'N 57°49'W | 42°58'N 63°44'W | 290 | 321 | 427 |
| 1970 | 22 Jul-4 Aug | *E. E. Prince* Otter trawl | Grand Bank | 45°19'N 56°25'W | 43°15'N 51°00'W | 263 | 313 | 577 |
| | | | Scotian Shelf | 44°19'N 57°48'W | 42°25'N 64°54'W | 313 | 375 | 688 |
| 1971 | 11-22 Jul | *E. E. Prince* Otter trawl | Grand Bank | 45°11'N 56°29'W | 43°13'N 51°12'W | 123 | 158 | 273 |
| | | | Scotian Shelf | 44°20'N 57°48'W | 42°24'N 64°55'W | 164 | 207 | 371 |
| 1972 | 21 Jun-3 Jul | *E. E. Prince* Otter trawl | Grand Bank | 45°17'N 56°19'W | 43°19'N 51°08'W | 226 | 256 | 482 |
| | | | Scotian Shelf | 44°20'N 57°47'W | 42°33'N 64°49'W | 235 | 303 | 537 |

[a] Range of positions delineate the distribution of sampling along the slope of the continental shelf.

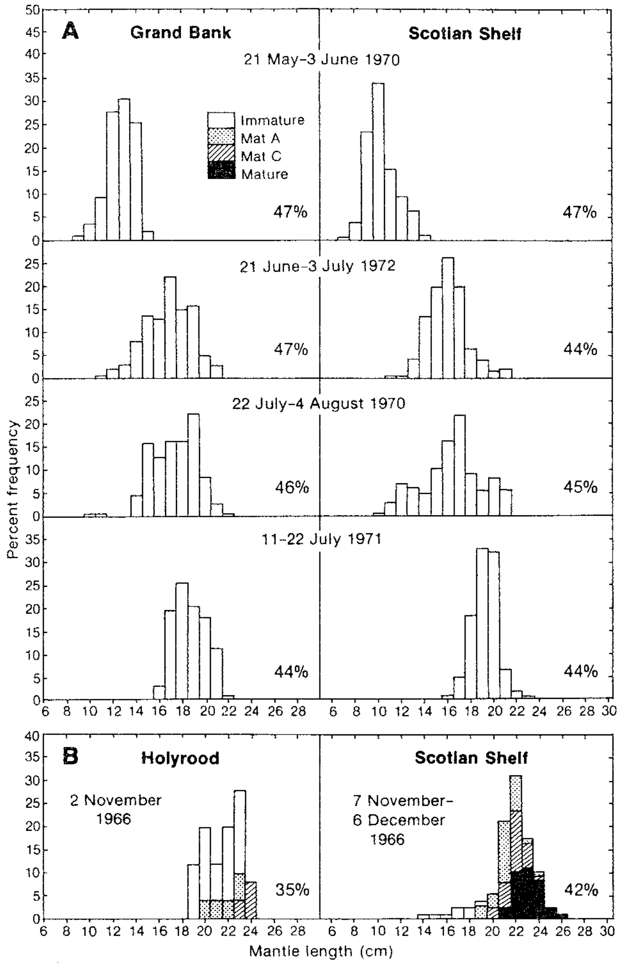


Fig. 2. Comparative length distributions of male short-finned squid from (**A**) Grand Bank and Scotian Shelf during May-July 1970-72 and (**B**) Holyrood and Scotian Shelf in November 1966. (Percentages indicate proportions of males in samples.)

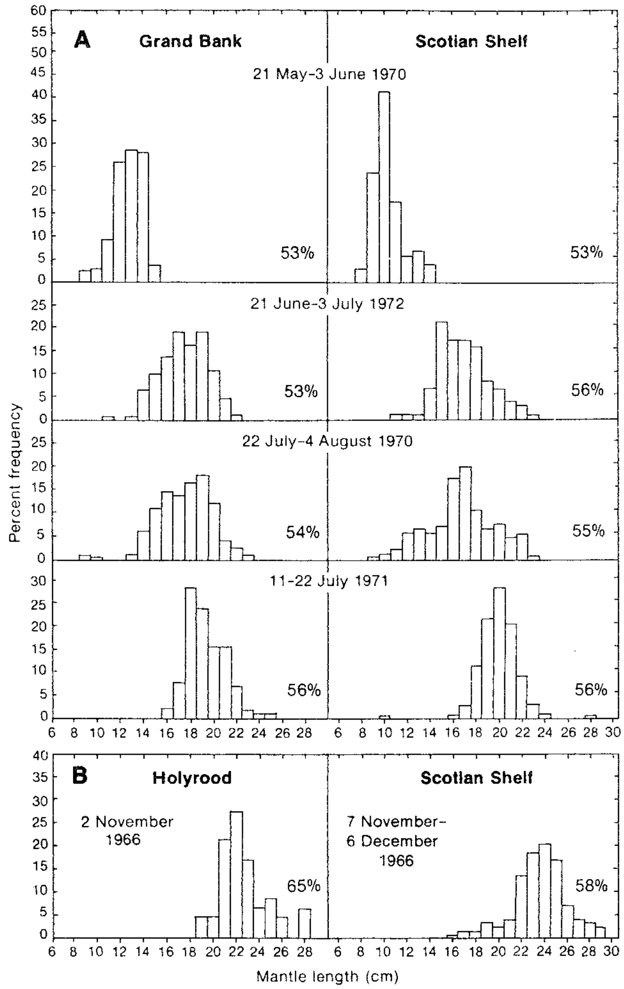


Fig. 3. Comparative length distributions of female short-finned squid from (**A**) Grand Bank and Scotian Shelf during May-July 1970-72 and (**B**) Holyrood and Scotian Shelf in November 1966. (Percentages indicate proportions of females in samples.)

Female short-finned squid from the Newfoundland area and the Scotian Shelf were also similar in size (Fig. 3). The length distributions were generally unimodal, and the range of modal lengths from May to early August was 13-21 cm in the Grand Bank samples and 10-20 cm in those from the Scotian Shelf. The females increased substantially in size from August to November, with modal lengths of 22 and 24 cm in samples from Holyrood and the Scotian Shelf respectively. By late autumn, the females do not attain such advanced stages of maturity as males and are generally larger when they disappear from inshore areas and the continental shelf.

From the unimodality of the size distributions and the regularity of seasonal growth, it is believed that *I. illecebrosus* is a short-lived species, with a life span of 1 year (Squires, 1967) or 18 months (Mesnil, 1977). Spawning probably occurs in winter, as inferred from the advanced state of maturity in males during late autumn. The similarity in sizes of squid sampled in the Newfoundland and Scotian Shelf areas indicate that they were spawned at approximately the same time, probably January-February as proposed by Squires (1967).

Insight into the spawning period for short-finned squid in areas off the United States coast may be gained by examining length and maturity data for samples from the continental shelf as far south as Virginia (Fig. 4). Samples from the region between Atlantis Canyon and Delaware Bay in August 1968 exhibited bimodality which was more pronounced for both sexes in the southern part of the region. For the more abundant group of males, modal lengths (20 and 21 cm) were similar to those in samples from inshore Newfoundland waters in August, the range being 19-22 for most localities, according to Collins and Ennis (MS 1978) and Beck *et al.* (MS 1982). The degree of sexual maturity in males was similar to that described by Collins and Ennis (MS 1978) for Holyrood samples in August 1966

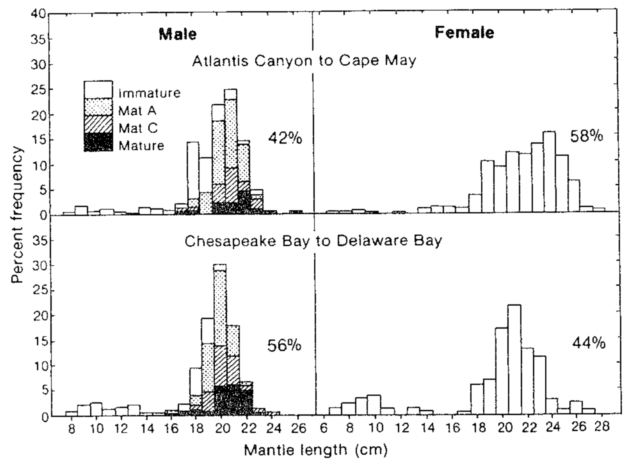


Fig. 4. Length distributions of male and female short-finned squid, with maturity stages for males, from the northern and southern areas of the continental slope, Atlantis Canyon to Chesapeake Bay, surveyed during 15 August-3 September, 1968.

but somewhat more advanced than is usual in August samples from Newfoundland waters in most years (Mercer, MS 1975; Collins and Ennis, MS 1978; Beck *et al.*, MS 1982). For comparable lengths, however, maturity of males was considerably more advanced in the samples taken off the United States coast (Fig. 2). Maturation of males at smaller sizes in the more southerly areas was previously noted by Lu (MS 1973), and Mercer (MS 1975) observed that this phenomenon is due probably to the accelerating effect of higher water temperature on the maturation process. The length distributions of the dominant group of females, with modal length of 21 and 24 cm (Fig. 4), were also similar to those in August of most years at Newfoundland with modal lengths of 20-23 cm (Mercer, MS 1975; Collins and Ennis, MS 1978; Beck *et al.*, MS 1982). Similarly, the dominant group in samples collected in the region from Georges Bank to Virginia during July-August 1973-79 had modal lengths (sexes combined) in the range of 18-21 cm (Lange and Sissenwine, MS 1981). It is most likely that these squid were destined to mature during the autumn of the years in which they were caught and to spawn during the ensuing winters.

Small short-finned squid, of sizes caught in August 1968 with modal length of about 10 cm (Fig. 4), are not usually encountered during summer in Newfoundland waters. They probably are not part of the spawning population from which the dominant group of larger squid was derived. Lange and Sissenwine (MS 1981) described the presence of groups of small squid, with modal lengths of 9 and 10 cm, in the southern extreme of their survey area (New Jersey to Virginia) during July-August of 1977 and 1979. Considering the available information on growth of *I. illecebrosus*, which has been estimated to vary from 1.1 to 2.5 cm/month (Lange and Sissenwine, MS 1981; Squires, 1967), it seems likely that these small squid were hatched sometime during the preceding spring. A group of small squid, with modal length of about 8 cm, was found on the Scotian Shelf in August-September 1981 (Dupouy, MS 1982: Dupouy and Minet, MS 1982), and these may also have been spawned in the spring.

The presence of more than one size-group of short-finned squid in the length distributions is more pronounced in autumn than in summer samples off the northeastern United States. Groups of small squid, with modal lengths from 6 to 11 cm, have been found in autumn samples (Mesnil *et al.*, MS 1976; Mesnil, MS 1977, Lange and Sissenwine, MS 1981), and the last-named authors noted that these small squid were likely to have been spawned during the summer. In fact, the great variation in relative proportions of small and large squid caught during the autumn surveys off the United States led Lange and Sissenwine (MS 1981) to suggest that summer spawning may be more significant than winter spawning in some years, especially in the southern part of the survey area (New Jersey to Virginia). The presence of mature males during spring and summer further supports the hypothesis of summer and possibly autumn spawning in the area. Also, the existence of several periods of relatively intense spawning is indicated by the occurrence of a small group of medium-sized squid off the northeastern United States and on the Scotian Shelf during autumn of some years (Mesnil *et al.*, MS 1976; Mesnil, MS 1977; Dupouy and Minet, MS 1982). This group has been observed occasionally in coastal areas of southern Newfoundland where 14-25 cm squid have been captured occasionally in late autumn (Squires, 1957).

The predominance of the group of large squid with modal lengths of 21-27 cm and the prevalence of mature males in the late autumn samples, especially in the northern part of the distributional range (Squires, 1957; Mercer, MS 1975; Mesnil, MS 1977; Collins and Ennis, MS 1978; Lange and Sissenwine, MS 1981; Beck *et al.*, MS 1982), indicate that spawning is more prevalent in winter than at other times of the year. The summer brood apparently does not become as broadly dispersed toward the northern part of the range as the winter brood. The persistent prominance of winter spawning indicates that *I. illecebrosus* usually lives for 1 year and dies after spawning, in contrast to Mesnil's hypothesis of an 18-month life-span with generations spawning alternately in winter and summer.

The distribution of larval and juvenile short-finned squid within the Gulf Stream system during winter and spring provides further insight about the time and area of spawning. Captures of larval *Illex* sp. have been reported at different times of the year (Roper and Lu, 1978; Vecchione, 1978; Lu and Roper, 1979; Hatanaka *et al.*, MS 1982; Dawe and Beck, 1984), indicating that spawning occurs to some degree throughout the year. This is supported by the broad range of sizes of juveniles (0.6-11.5 cm) found within the Gulf Stream system during February 1982 as far east as 58°W in the region seaward of the Scotian Shelf (Hatanaka *et al.*, MS 1982). It is not surprising, therefore, that length frequencies of squid from the continental shelf later in the year are comprised of two or more modal size-groups. In the Japanese common squid (*Todarodes pacificus*), which is closely related to *I. illecebrosus* with a similar life cycle, three seasonal broods are produced from peak spawning in winter, summer and autumn (Araya, 1967; Kasahara, 1978). Spawning evidently occurs throughout most of the year because larvae are caught from September to May, although the highest concentrations are found in January. The larvae are transported from the spawning area northeastward by the Tsushima and Kuroshio Currents (Okutani and Watanabe, 1983).

The short-finned squid, which are exploited in Canadian waters during summer and autumn, probably move southward to spawn off the United States, as indicated by the continuous distribution of small juveniles along the axis of the Gulf Stream flow in January-March (Fedulov and Froerman, MS 1980; Hatanaka *et al.*, MS 1982). These juveniles were most abundant along the northern boundary of the Gulf Stream, which transported them northeastward possibly from a spawning area south of Cape Hatteras. Trites (1983) used a shear dispersion model to simulate the transport of a substance released in the northern edge of the Gulf Stram off Cape Hatteras and concluded that, if the larvae and small juveniles are neutrally buoyant and drift passively with the current, they would be transported rapidly (100 km/day) northeastward toward the Grand Bank. The absence of newly-hatched larvae in plankton samples containing *Illex* larvae and juveniles from the Slope Water and Gulf Stream region south of the Grand Bank in February-March 1981 and 1982 indicates that spawning occurs farther southwestward (Dawe and Beck, 1984). In fact, newly-hatched larvae have been collected only to the south of Cape Hatteras. The rapid migration of *I. illecebrosus* southwestward from Newfoundland waters in late autumn is indicated by the recapture off Maryland in December of a squid tagged in Notre Dame Bay, Newfoundland, in September of the same year (Dawe *et al.*, 1981).

Seasonal peaks of spawning activity cannot be considered as indicative of separate stocks. Because spawning is fairly continuous throughout the year, seasonal broods are not temporally segregated such that they could be considered as discrete stocks. Geographic isolation of separate spawning groups is also unlikely. All short-finned squid of the western North Atlantic apparently spawn in close proximity to the Gulf Stream at least as far south as Cape Hatteras. Because the water masses of the Gulf Stream system are relatively homogenous in physical properties along the axis of flow, distinctly separate spawning sites are unlikely. It is more likely that a single stock exists and that spawning occurs over an extensive area.

**Parasite incidence**

**Cestodes**. The most common parasites of *I. illecebrosus* are plerocercoids of the tetraphyllidean cestodes *Phyllobothrium* sp. and *Dinobothrium* sp. (Squires, 1957; Mercer, MS 1965; Brown and Threlfall, 1968a, 1968b), which frequently infest the caecum. *Dinobothrium*, which has been identified from squid in Newfoundland waters as *D. plicitum* by Brown and Threlfall (1968a), is usually found encysted on the spiral part of the caecum, whereas *Phyllobothrium* may be found on other internal organs as well as on the caecum (Squires, 1957). For both parasites, crustaceans probably serve as primary intermediate hosts (Squires, 1957), and elasmobranchs are likely the definitive hosts (Brown and Threlfall, 1968a).

Percent infestation of *I. illecebrosus* with *Dinobothrium* relative to size of the host (sexes combined) from various regions of the Northwest Atlantic (Fig. 5) indicates little infestation until the squid reach a size of about 14 cm. Brown and Threlfall (1968b) reported that squid from inshore Newfoundland in 1966 and 1967 were not infested with this parasite at sizes less than 16 and 18 cm respectively. The infestation rate, being lowest in May-June, increased as the squid grew in size during the period of their occurrence on the continental shelf, as found by other investigators (Squires, 1957; Mercer, MS 1965; Brown and Threlfall, 1968b). However, there was no consistent variation in the degree of infestation by geographic area. According to Gaevskaya and Nigmatullin (1975), *Dinobothrium* is a common parasite of a great variety of intermediate hosts including many species of bony fishes and is found throughout the distributional range of *I. illecebrosus*. These authors noted that helminths found in ommastrephids show wide host specificity and are typical "fish" forms, and that *Dinobothrium* is a member of the coastal environment. This parasite is not acquired during the early part of the life cycle of *I. illecebrosus* but rather after the squid migrate to the continental shelf and consume crustaceans which are infested with procercoids of the parasite (Squires, 1957; Mercer, MS 1965).

Infestation of *I. illecebrosus* with *Phyllobothrium* in various regions of the Northwest Atlantic occurred in juveniles as small as 7 cm (Fig. 6), and the incidence of this parasite was much higher than that of *Dinobothrium*, especially during May-July on the Grand Bank and Scotian Shelf. *Phyllobothrium* is found not only in the coastal environment but also in the oceanic coenosis (Gaevskaya and Nigmatullin, 1975), and it may be acquired initially by juvenile *I. illecebrosus* during the oceanic phase of their life cycle. An increase in percent infestation with size of squid was evident in the May-July samples from the Grand Bank and Scotian Shelf (Fig. 6), in agreement with the observations of Mercer (MS 1965). However, Squires (1957) and Brown and Threlfall (1968b) found higher incidence of infestation

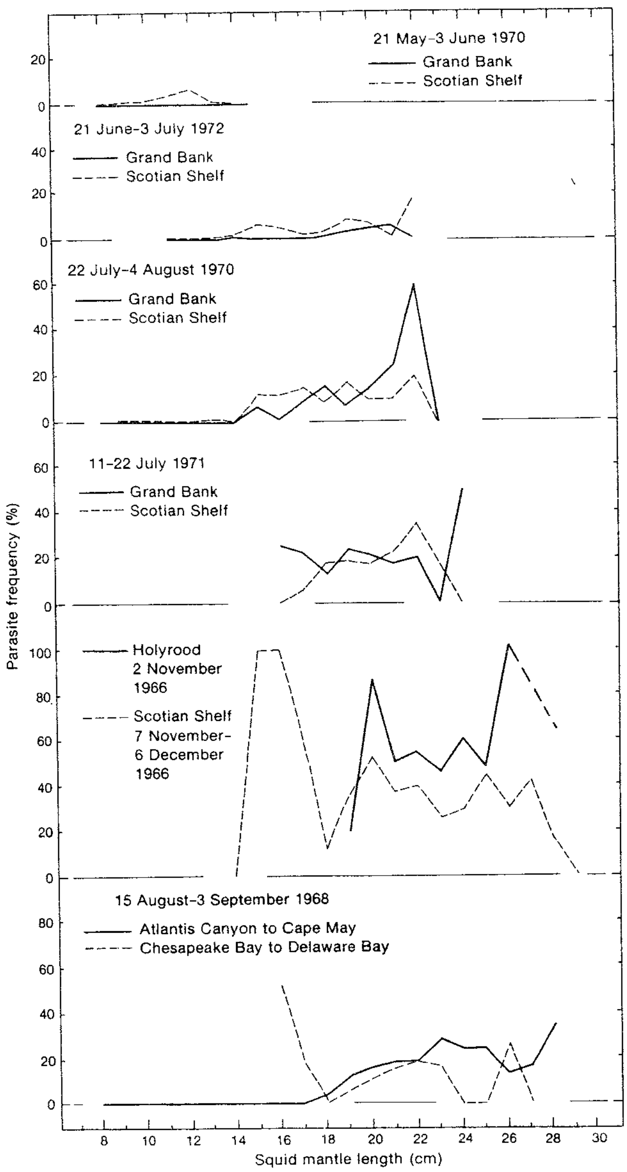


Fig. 5. Percentage infestation of short-finned squid with *Dinobothrium* sp. by size of host, in samples from various regions of the Northwest Atlantic, 1966-71.

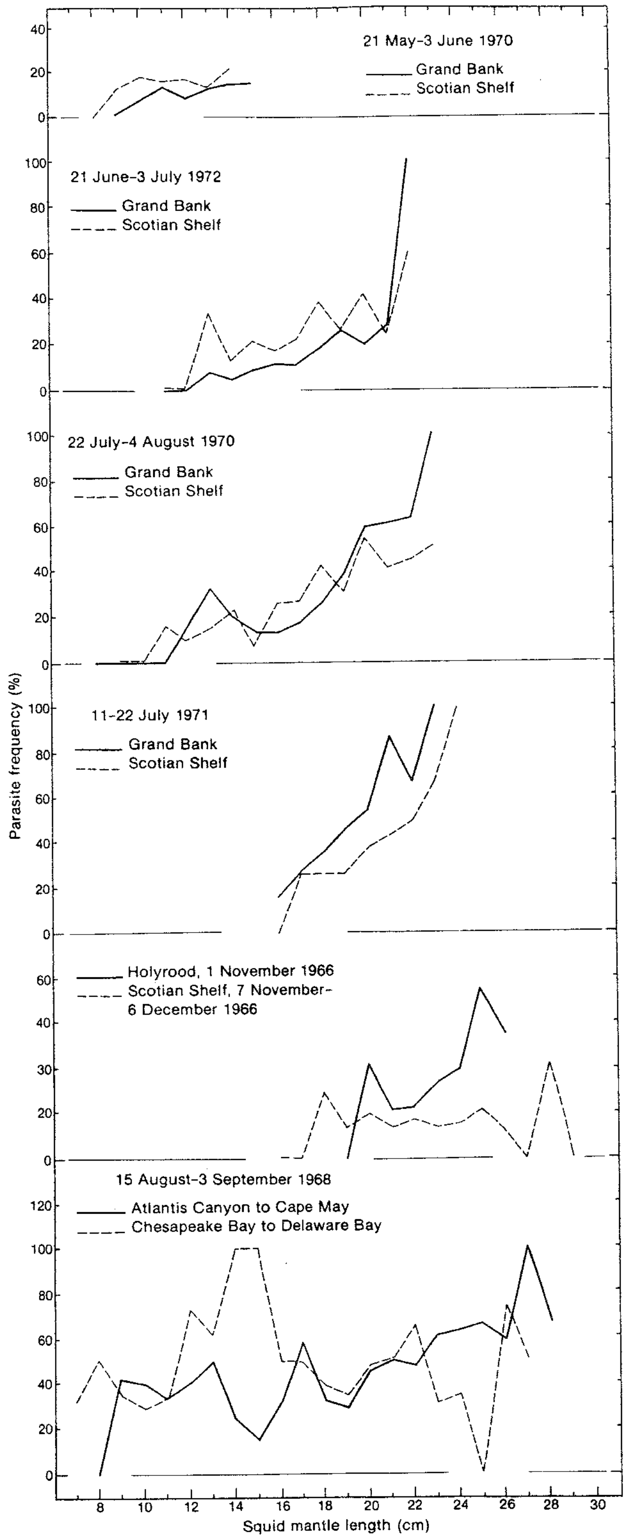


Fig. 6. Percentage infestation of short-finned squid with *Phyllobothrium* sp. by size of host, in samples from various regions of the Northwest Atlantic, 1966-71.

in smaller squid from Newfoundland inshore waters. The rapid increase in infestation of squid greater than 14-16 cm mantle length was probably due to increased consumption of crustaceans containing procercoids after the squid had migrated to the continental shelf. Trends in the incidence of *Phyllobothrium* infestation of squid from the Grand Bank and Scotian Shelf during May-July were quite similar (Fig. 6). However, juveniles less than about 18 cm from the continental shelf off the United States in late August 1968 had a considerably higher incidence of infestation than those of similar sizes from the Grand Bank and Scotian Shelf. Also, the small squid from the southern part of the survey area (south of Cape May) had a higher level of infestation than those from the northern part of the area (Cape May to Atlantis Canyon). These differences may have been due to variation in the seasonal and geographic distribution of the parasite in organisms on which the juvenile squid feed, noting also that juveniles taken off the United States in late August were probably derived from later spawning than those from the Grand Bank and Scotian Shelf in May–July.

Neither of the two genera of cestodes serves well as a biological tag for *I. illecebrosus*, according to the conditions outlined by Kabata (1963) and Sindermann (1983). Although *Phyllobothrium* tends to be acquired at an earlier age than *Dinobothrium*, both parasites become prevalent in squid mainly after they migrate to the continental shelf. Furthermore, both parasites are distributed broadly throughout the geographic range of short-finned squid and have a wide host specificity.

**Nematodes**. Larvae of *Anisakis* sp. are found in short-finned squid and many fish species of the Northwest Atlantic. Although larval *Anisakis* of the Northwest Atlantic have not been cultured *in vitro* to the adult stage, it is believed that *A. simplex* is a species found in Atlantic herring and Atlantic salmon (Beverley-Burton *et al.*, 1977; Beverley-Burton and Pippy, 1977). A second species of the genus (*A. typica*) reportedly occurs in its adult form in cetacean hosts between 36° S and 40° N in the Atlantic (Davey, 1971). Therefore, if the species of *Anisakis* in short-finned squid from the Newfoundland area was found to be *A. typica*, it could be assumed that the squid spend part of their life cycle in waters south of 40° N.

*Anisakis* larvae from Atlantic herring, Atlantic salmon, Atlantic mackerel and short-finned squid were cultured during 1979 in an effort to determine the specific identity of the adult form. Although maturation of larvae to adult form did not occur, preadults cultured from the three fish species were designated as *A. simplex*, on the basis of spicule size in males and lip-conformation in both sexes (Davey, 1971). From morphometric measurements (Table 1), *Anisakis* larvae from squid were recognizably different from those of the fishes. Mean length of larvae from squid after culturing for 37 days (22.5 mm) was considerably less than those of larvae from the fish hosts (31-36 mm). Some larger larvae appeared in squid later in the season, but the mean width of these (0.6 mm) was less than mean widths of preadults cultured from Atlantic salmon (1.5 mm) and Atlantic herring (1.3 mm).

Larval *Anisakis*, extracted from squid and cultured for 0–2 days, were 6.8–19.1 mm in total length and 0.3–0.6 mm in width. These sizes compare with length range of 16–22 mm and width range of 0.3–0.6 mm for larval *Anisakis* in *Ommastrephes pteropus* and *O. bartrami* from the tropical Atlantic (Gaevskaya, 1974).

Examination of *Anisakis* larvae, preadults and adults with a scanning electron microscope indicated that *Anisakis* from short-finned squid (Fig. 7) appeared to have a larger number of teeth per lip than did an adult *A. simplex* from a beluga (*Delphinapterus leucas*) (Fig. 8). Thus, it seems likely that *Anisakis* larvae in *I. illecebrosus* represent a different species from those found in other hosts. Culture of these larvae to the

TABLE 2. Linear measurements (mm) of *Aniskakis* sp. larvae cultured from short-finned squid and three common fish species of the Newfoundland area in 1979.

| Days after culture | Total length | | | Maximum width | | | Oesophagus length | | | Ventricle length | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Mean | Range | No. | Mean | Range | No. | Mean | Range | No. | Mean | Range |
| **Short-finned squid (*Illex illecebrosus*)** | | | | | | | | | | | | |
| 0 | 3 | 16.9 | 15.0–19.1 | 3 | 0.4 | 0.4–0.6 | 3 | 1.6 | 1.4–1.8 | 3 | 0.7 | 0.6–0.8 |
| 1–2 | 33 | 12.6 | 6.8–18.3 | 33 | 0.4 | 0.3–0.5 | 31 | 1.2 | 0.6–1.3 | 31 | 0.6 | 0.4–0.7 |
| 11 | 2 | 15.3 | 13.4–17.1 | 2 | 0.3 | 0.1–0.4 | 1 | 1.1 | — | 1 | 0.6 | — |
| 25–27 | 5 | 20.1 | 13.7–28.5 | 5 | 0.6 | 0.4–0.9 | 1 | 2.3 | — | 1 | 0.7 | — |
| 37 | 3 | 22.5 | 21.3–24.5 | — | — | — | — | — | — | — | — | — |
| **Atlantic herring (*Clupea harengus*)** | | | | | | | | | | | | |
| 0 | 24 | 26.2 | 21.9–29.7 | 24 | 0.4 | 0.3–0.6 | 24 | 2.1 | 1.9–2.9 | 24 | 1.1 | 0.8–1.3 |
| 1–10 | 4 | 18.9 | 13.9–25.0 | 4 | 0.4 | 0.3–0.4 | 1 | 2.1 | — | 1 | 0.9 | — |
| 11–20 | 6 | 23.8 | 15.6–35.3 | 6 | 0.6 | 0.3–0.7 | 3 | 2.4 | 1.9–2.8 | 1 | 0.7 | — |
| 21–30 | 17 | 24.2 | 14.0–42.3 | 15 | 0.7 | 0.4–1.0 | 3 | 1.9 | 1.8–2.3 | 3 | 0.6 | 0.5–0.7 |
| 31–40 | 4 | 31.0 | 24.3–37.3 | 4 | 1.0 | 0.8–1.3 | — | — | — | — | — | — |
| **Atlantic mackerel (*Scomber scombrus*)** | | | | | | | | | | | | |
| 0 | 10 | 25.6 | 18.7–31.3 | 10 | 0.5 | 0.4–0.7 | 10 | 1.8 | 1.3–2.0 | 10 | 0.9 | 0.6–1.2 |
| 35 | 1 | 41.6 | — | 1 | 1.0 | — | — | — | — | — | — | — |
| 45 | 1 | 29.0 | — | 1 | 0.8 | — | 1 | 2.8 | — | 1 | 0.9 | — |
| **Atlantic salmon (*Salmo salar*)** | | | | | | | | | | | | |
| 1 | 5 | 21.4 | 17.7–23.3 | 5 | 0.6 | 0.5–0.7 | 4 | 2.2 | 1.8–2.4 | 3 | 0.9 | 0.8–1.0 |
| 21–30 | 5 | 28.5 | 20.9–41.9 | 5 | 0.9 | 0.8–1.4 | 4 | 2.5 | 1.6–3.2 | 4 | 0.7 | 0.7–0.7 |
| 31–40 | 4 | 36.0 | 21.9–41.8 | 4 | 1.1 | 0.8–1.2 | 1 | 3.5 | — | 1 | 1.2 | — |
| 41–50 | 9 | 46.7 | 26.7–67.9 | 9 | 1.5 | 1.0–1.9 | — | — | — | — | — | — |

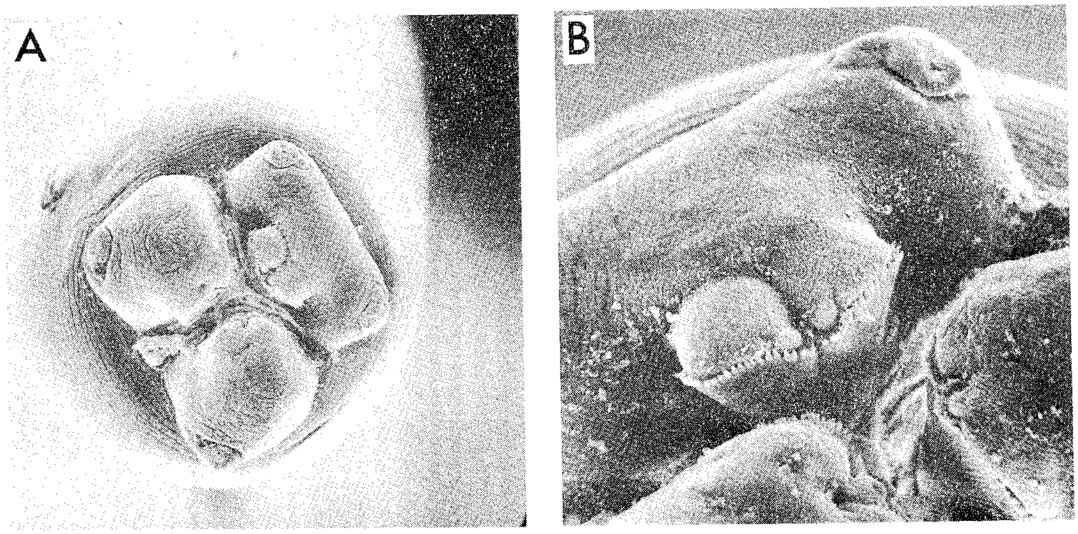


Fig. 7. Frontal view (**A**) and dentigerous ridge of the lip (**B**) of a cultured "large variety" *Anisakis* sp. larva from a short-finned squid (*Illex illecebrosus*).

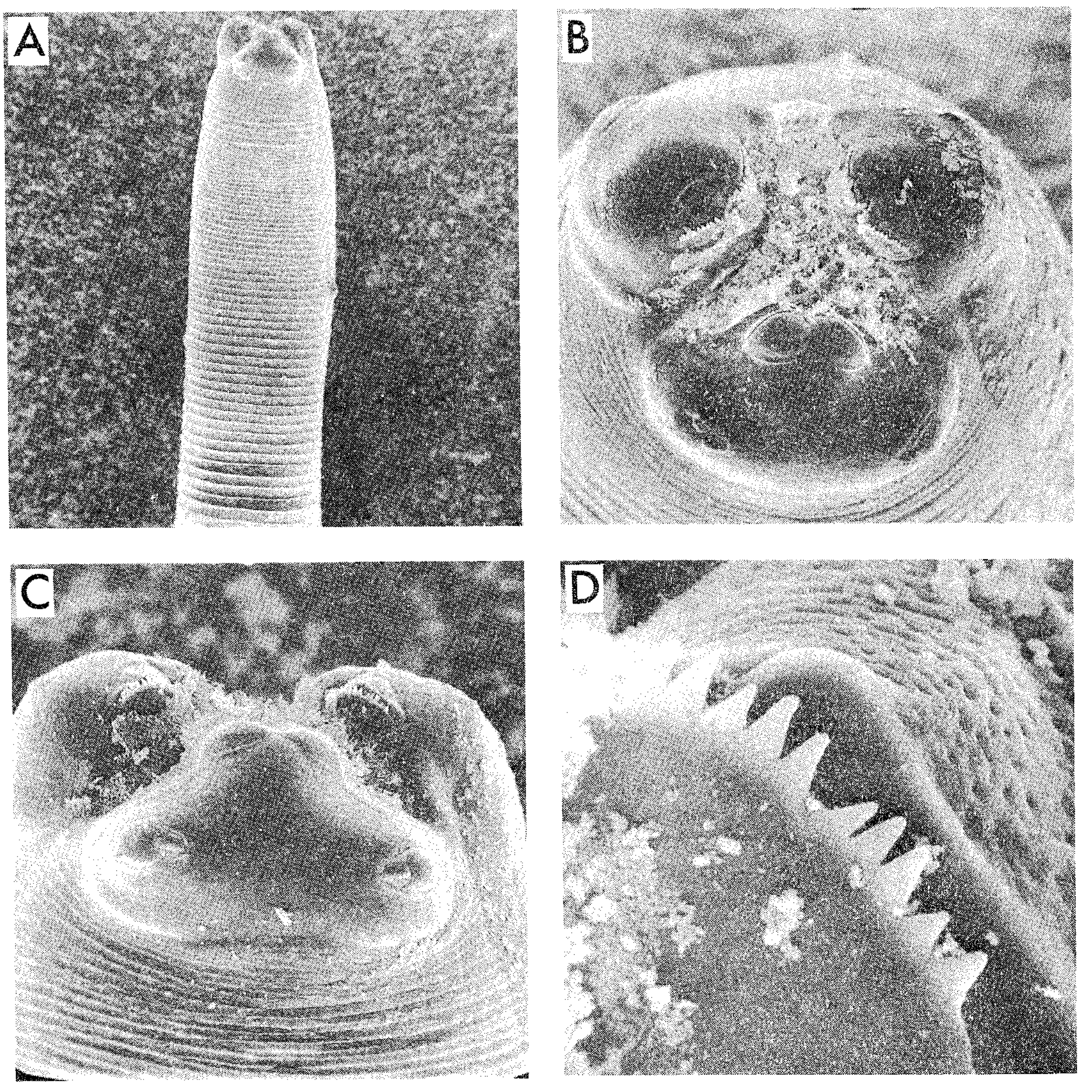


Fig. 8. Anterior section (**A**), frontal view (**B**), lateral view of lips (**C**), and part of dentigerous ridge (**D**) of an adult *Anisakis simplex* from a beluga (*Delphinapterus leucas*).

adult stage will be necessary to establish species identity.

## Summary

Although many factors confound studies of stock discrimination of *I. illecebrosus*, inferences are drawn from what is known of the distribution patterns and biology of the species. It is concluded that all short-finned squid in the western North Atlantic likely constitute a single stock. Several seasonal broods exist, resulting from relatively intense periods of spawning. However, the existence of temporally or geographically isolated spawning groups is improbable. Spawning, which is continuous throughout most of the year, likely occurs over an extensive area to the south of Cape Hatteras.

The incidence of parasites proved of little value as a method of stock discrimination for this species. Cestode plerocercoids are not suitable as biological tags due to their broad geographic distribution and wide host specificity. Studies of the nematode *Anisakis* sp. in short-finned squid may be of some value but its specific indentity must first be established.

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