# EARLY LIFE HISTORY OF SAND LANCE (*AMMODYTES*), WITH EVIDENCE FOR SPAWNING OF *A. DUBIUS* IN FORTUNE BAY, NEWFOUNDLAND

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## ABSTRACT

Ichthyoplankton surveys in Fortune Bay, Newfoundland, indicate that sand lance (Ammodytes sp.) larvae occur annually in Fortune Bay from February, when recently hatched yolk-sac larvae occur, until July/August when, it is assumed, the larvae have grown to the size of metamorphosis and have taken up a demersal existence. Length-frequency data indicate the spawning season to extend from December to May-June, and this extended spawning season probably accounts for the consistent polymodality in length-frequency distribution of sand lance larvae from the Newfoundland area.

Meristic development is shown to be complete by the time a length of 35-40 mm is reached and analyses of meristic counts indicate that the large (>20 mm) sand lance larvae caught in Fortune Bay belonged to the offshore species *Ammodytes dubius*. Further, analyses of pre-anal melanophore counts and oceanographic features of the area indicate that yolk-sac larvae taken in Fortune Bay in February were also *A. dubius*. This is the first record of the occurrence and spawning of *A. dubius* in coastal Newfoundland waters. This finding is significant in view of the current confusion regarding the appropriate taxonomy of sand lance populations in the Northwest Atlantic.


Sand lance, *Ammodytes* sp., are widely distributed in the Northwest Atlantic from Greenland south to Cape Hatteras, NC (Liem and Scott 1966). Although presently commercially unimportant, they hold a strategic niche as a major food organism for numerous commercial fish species, and Winters (1981, 1983) listed sand lance as a prey of haddock, Atlantic cod, silver hake, yellowtail flounder, American plaice, and Atlantic salmon. They are also fed heavily upon by certain large marine mammals (Overholtz and Nicolas 1979), and it has been postulated (Winters 1983) that their importance as a prey species is enhanced during times of low capelin abundance.

Taxonomy of the Northwest Atlantic sand lance has received considerable attention (Richards et al. 1963; Richards 1982; Scott 1968, 1972; Winters 1970). Generally two species are recognized in the Northwest Atlantic, i.e., *Ammodytes americanus* (=*Ammodytes hexapterus*), which is the deep-bodied, inshore form, and *Ammodytes dubius*, the slender-bodied, offshore form. Their taxonomy, generally, is confused by the presence of two clines in their meristic character frequencies: one north to south cline, the other inshore to offshore cline, with frequent overlap in the ranges of meristic numbers (Reay 1970). The validity of the two species is also questioned due to correlations of meristic numbers with environmental conditions (Scott 1972). In the Newfoundland area, however, the two species exhibit quite distinct meristic counts (Winters 1970). For the purposes of this paper we use the species classification of Liem and Scott (1966).

Winters (1970) has described the meristics and morphometrics of both species from the Newfoundland area and described *A. dubius* in the offshore and *A. americanus* inshore. Winters (1981, 1983) has described aspects of the biology of *A. dubius* from the Newfoundland Grand Banks. Little information exists on their early life history in the Newfoundland area. Dannevig (1918) provided length and distribution information for 89 specimens of sand lance captured off southern Newfoundland in surface and vertical hauls in early summer 1915. He assigned the specimens to *A. tobianus* (Linnaeus), a European inshore species. Frost (1938) presented information on the distribution of sand lance larvae around Newfoundland from 1931 to 1935. No size information was provided, and she assigned all the specimens from both near shore and the edge of the Grand Banks to *A. americanus*. In spite of its importance as a forage fish to commercially important species, no other information exists for sand lance larvae from the Newfoundland area.

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Information in the literature supports the hypothesis that the two species are allopatric. Winters (1970) found, based on adult samples, that *A. dubius* occurred exclusively in offshore areas and *A. americanus* exclusively in inshore bays around Newfoundland. Reay (1970) pointed out that *A. dubius* is exclusively an offshore species although Richards (1982) indicated that there are offshore components to *A. americanus* in the New England area. This paper presents information on sand lance in Fortune Bay, Newfoundland, as a further test of the hypothesis that the two species are allopatric. Size and distribution (seasonal and diurnal) information on *Ammodytes* larvae both within and at the mouth of Fortune Bay is presented as well as length-frequency information for other parts of the Newfoundland-Labrador area. The development of the definitive number of meristic characteristics is examined to identify the Fortune Bay larvae and, in conjunction with this, aspects of the developmental biology of *Ammodytes* sp. in the area are also described.

## MATERIALS AND METHODS

Fortune Bay is a three still fjord located on the south coast of Newfoundland (Figs. 1, 2). Typically it has a two-layered structure with relatively warm (1.9°C) deep water in the outer portion in winter and cold (−0.25°-0.50°C) deep water in summer (de Young 1983). Annual surface temperatures typically range from 0.0°-1.0°C in February to 12°-16°C in August and September.

From June 1979 to February 1981, several ichthyoplankton surveys were carried out annually in Fortune Bay. The target species for the surveys was herring, *Clupea harengus*, but due to low numbers of herring larvae during the first three years the study was relocated, and during 1982-83 only one survey (July) was carried out in each year in Fortune Bay. Sand lance data examined here were collected during these surveys (1979-83).

Larvae collected in 1979-80 were taken by standard oblique plankton tows (Smith and Richardson 1977) using a 60 cm diameter bongo frame with 333 μm mesh netting on one side of the frame and 505 μm on the other. Tows were to a maximum depth of 200 m where possible. Nets were payed out at a speed of 0.77 m/second and retrieved at a speed of 0.38 m/second. After 1980 samples were caught in nets when both sides of the bongos were equipped with 333 μm netting.

In February 1981, collections were made using stepped oblique tows (5 minutes at each of 200, 150, 100, 50, 20, and 0 m) with a nonclosing N.I.O. rectangular midwater trawl (RMT-8) (Baker et al. 1973). During this survey all stations were fished during 6 hours of daylight with sets on the same stations being repeated after dark. A 10-min surface tow (3/4 m conical plankton net, 333 μm mesh) was carried out during each of the oblique tows with the RMT-8.

In June 1981, sand lance larvae were collected using bongo nets during the regular survey and also from special stations to investigate diurnal distribution. During each of these special stations, bongos were fished obliquely (to 200 m), and 3/4 m conical plankton nets (333 μm) were fished for 10 minutes at the surface during daylight hours and again (at the same positions) after dark of the same day.

Catches from all trips were preserved in a 5% formalin solution buffered with sodium borate. Fish larvae were later sorted, identified, counted, and measured. Total length was recorded to the nearest millimeter. A Macdonald and Pitcher (1979) mixture analysis was performed on the length-frequency distribution of the large sample from June 1979 to investigate the fit of the data to mixtures of normal distributions approximating the data.

Species designation was determined using meristic characters where possible (June 1979, June 1981), namely, vertebral, anal fin ray, and dorsal fin ray counts. Due to their small size, the specimens were stained for cartilage using Alcian blue and counterstained with alizarin red (Dingerkus and Uhler 1977). Counts were then done under a dissecting microscope (20-40× magnification) with the aid of the camera lucida.

Additional sand lance length-frequency data are presented, which have been on file at the Science Branch, Northwest Atlantic Fisheries Center in St. John's. These sand lance were collected incidentally during tows for other target species around Newfoundland using fishing and plankton gear (see Figures 1 and 4).

## RESULTS

### Seasonal and Diurnal Distribution

Table 1 lists the cruises in Fortune Bay from 1979 to 1983.

Sand lance larvae were encountered during 9 of the 17 cruises in Fortune Bay from 1979 to 1983

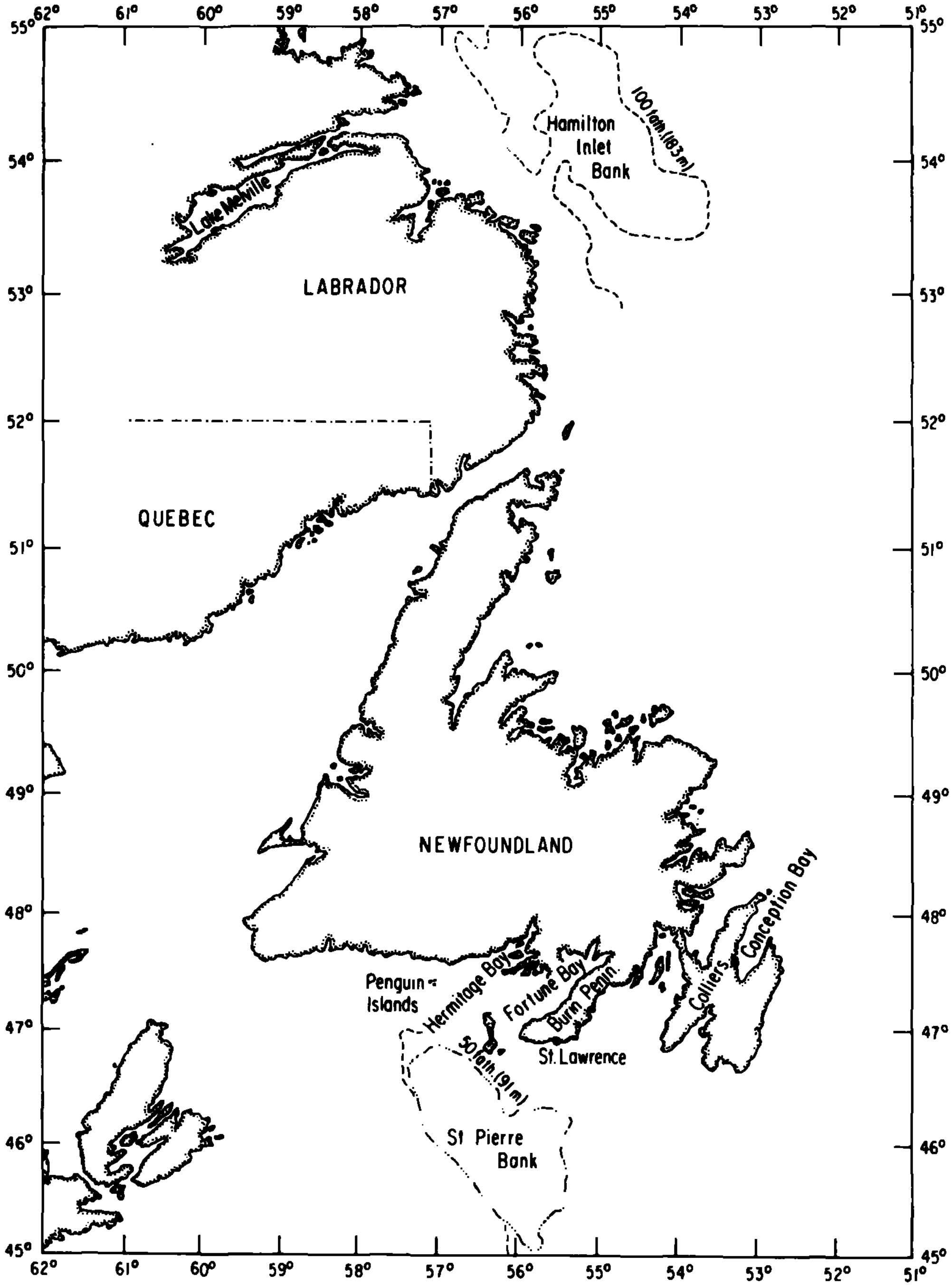


FIGURE 1.—Map of Newfoundland indicating places referred to in the text.

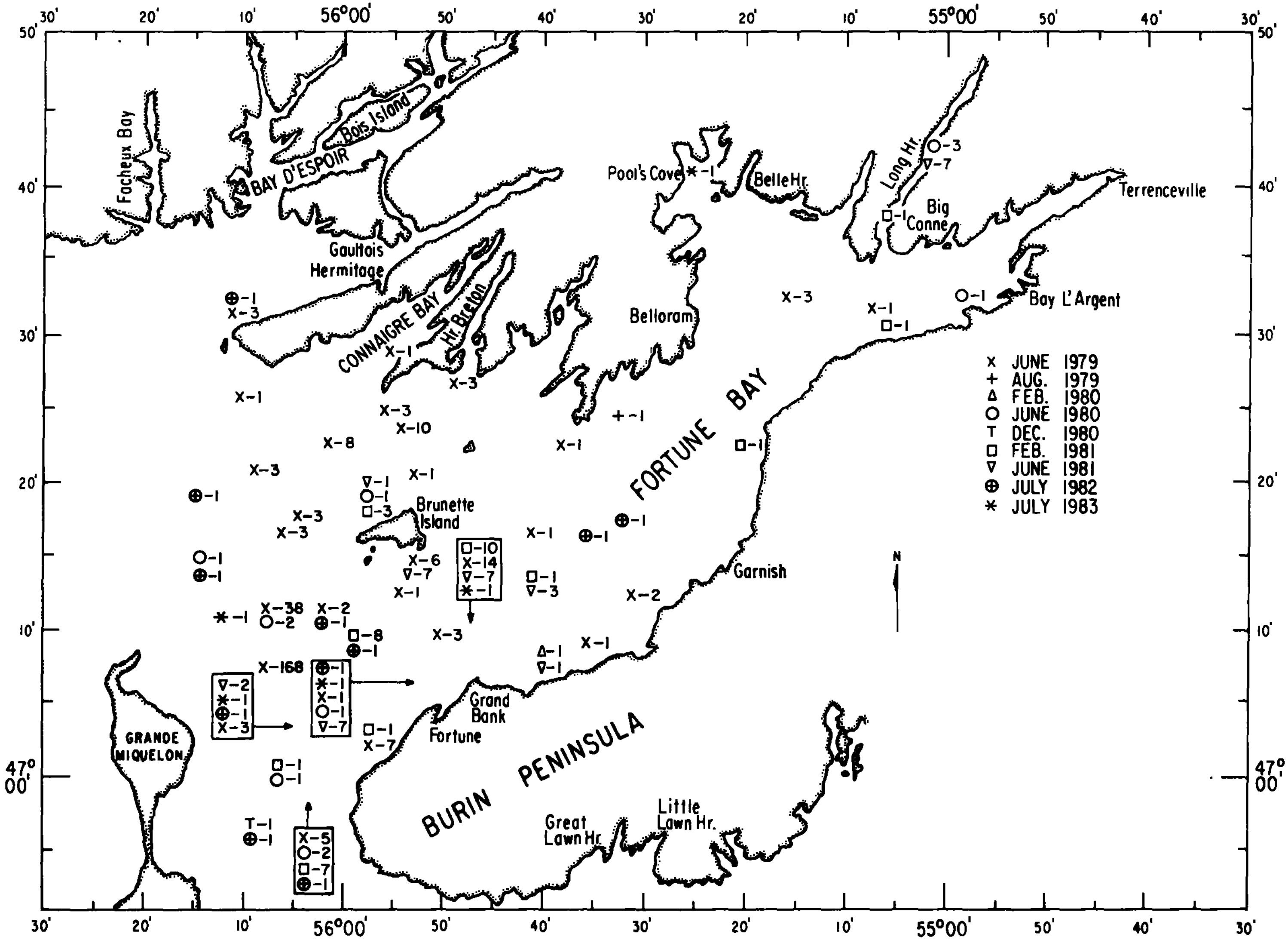


FIGURE 2.—Distribution and catch of *Ammodytes* larvae collected during ichthyoplankton surveys in Fortune Bay from 1979 to 1983.

(Table 1), and the spatial distribution of these catches is shown in Figure 2. Sand lance larvae have a fairly wide distribution within and at the mouth of Fortune Bay; however, the incidence of positive catches and the size of the catches were greatest in the area between Miquelon and Fortune, north to Brunette Island.

The highest and most consistent catches of sand lance larvae were made in June and July, and only two specimens were caught in the August-November period. Yolk-sac larvae were taken only in surveys carried out in February, but larger larvae apparently remained in the water column until July-August at which time it is assumed that metamorphosis is complete, and the postlarvae take on a demersal existence. Macer (1966) gave the length of metamorphosis as 30-40 mm. Surveys in August of 3 consecutive years caught only one larva (43 mm), and surveys later than August caught only a single 82 mm postlarva in December 1980.

Catches of sand lance larvae from two periods in 1981 illustrate day-night variability in catches, especially at the surface (Table 2). During February, 44 stations were fished twice the same day, once during daylight and once after dark using stepped-oblique tows with the RMT-8 and surface tows with conical nets. Thirty-two larvae (94%) (mean length of 7.7 mm) were taken in night sets: 2 in oblique tows and 30 in surface tows. Of the two caught during daylight hours, one was in the surface tow and one in the oblique.

In June, 12 stations were fished using standard oblique tows with bongo nets and horizontal surface tows with conical nets during daylight and darkness of the same day. Twenty-five larvae

TABLE 1.—List of ichthyoplankton surveys carried out in Fortune Bay, Newfoundland, 1979-83, indicating gear fished, number of stations, numbers, and length information of *Ammodytes* sp. caught.

| Cruise | Date | Gear[1] | No. stations fished during survey | No. positive sets | No. larvae caught | No. extra sets | No. positive catches (extra sets) | No. larvae in extra sets | Length range (mm) (all larvae) | Mean and SD of total length (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| Marinus 15 | June 1979 | B | 71 | 28 | 302 | | | | 10-43 | 22.9 (15.7) |
| Shamook 51 | Aug. 1979 | B | 60 | 1 | 1 | | | | | 43.0 |
| Marinus 21 | Nov.-Dec. 1979 | B | 53 | | | | | | | |
| Shamook 57 | Feb. 1980 | B, R | 25, 25 | 1 | 1 | | | | 8.0 | |
| Marinus 25 | June 1980 | B | 52 | 8 | 12 | | | | 8-40 | 18.3 (9.5) |
| Marinus 28 | Aug. 1980 | B | 42 | | | | | | | |
| Shamook 64 | Sept. 1980 | R | 50 | | | | | | | |
| Shamook 67 | Nov. 1980 | B | 48 | | | | | | | |
| Shamook 69 | Dec. 1980 | B | 52 | 1 | 1 | [2]28B,28S | | | | 82.0 |
| Shamook 71 | Feb. 1981 | R, S | 44, 44 | 12 | 34 | | | | 6-12 | 7.7 (1.0) |
| Shamook 76 | June 1981 | B | 52 | 4 | 8 | [2]24B,24S | 8 | 27 | 12-61 | 38.4 (14.2) |
| Marinus 39 | Aug. 1981 | B | 52 | | | [2]22B,20R | | | | |
| Shamook 79 | Oct. 1981 | B | 52 | | | | | | | |
| Shamook 81 | Dec. 1981 | R | 35 | | | | | | | |
| Shamook 82 | Feb. 1981 | R | 29 | | | | | | | |
| Shamook 88(2) | July 1982 | B | 52 | 11 | 11 | | | | 14-46 | 22.1 (10.4) |
| Shamook 98(2) | July 1983 | B | 52 | 5 | 5 | | | | 11-22 | 14.8 (4.2) |

[1]B = BONGO, R = RMT-8, S = Surface net.
[2]Half of sets with each gear type during daylight; half at same station during darkness of same day.

TABLE 2.—Numbers of sand lance larvae caught in oblique[1] and surface tows during investigations into day-night catch variability, February-June 1981.

| Type of tow | Day | | | | Night | | | |
|---|---|---|---|---|---|---|---|---|
| | February | | June | | February | | June | |
| | Oblique | Surface | Oblique | Surface | Oblique | Surface | Oblique | Surface |
| No. of sets | 44 | 44 | 12 | 12 | 44 | 44 | 12 | 12 |
| No. of positive catches | 1 | 1 | 1 | 0 | 2 | 8 | 3 | 4 |
| No. of Ammodytes larvae caught | 1 | 1 | 2 | 0 | 2 | 30 | 9 | 16 |

[1]Oblique tow with RMT-8 in February, bongo in June.
[2]Includes 1 set at dusk in which 6 larvae were captured.

(93%) of 27 were taken in night sets: 16 at the surface and 9 in oblique tows. Two were caught in the oblique tows, and none, at the surface during daylight.

## Size and Length-Frequency Distributions

Mean length data (Table 1) illustrate the annual variation in mean size during the late June-July period. In 1979, 1980, and 1982, the mean lengths of sand lance were 22.9 mm, 18.3 mm, and 22.1 mm, repectively. The 34 larvae caught in June 1981 were larger with a mean length of 38.4 mm, and the 5 caught in early July 1983 were smaller with a mean length of 14.8 mm.

Length-frequency distribution of the largest samples from Fortune Bay are shown in Figure 3. The distributions from June of each year indicate a wide range of lengths, and although samples from June of 1980 and 1981 are not large, the extended range in both suggests that the distribution is not unimodal and that there is more than one spawning cohort present. This extended length range may also result from delayed hatching or a combination of both these processes. In June 1979 there is a distinct mode at 23 mm with others probable at 14-15 mm and another at 29 mm. The length frequency of the June 1979 sample was subjected to modal analysis as described by MacDonald and Pitcher (1979). Three modes were interpreted from the length-frequency histogram. The results of the analysis indicated normal distributions with means at 13.4, 22.2, and 28.8 mm with standard deviations of 1.76, 3.02, and 4.36 mm, respectively (Table 3). The June 1981 sample of 33 larvae has a distinct mode at 45 mm, which is widely separated from a group of fish ranging in length from 12 to 17 mm. The wide range and polymodality in the length distributions of the June samples is good evidence of multiple spawning cohorts although differential hatching rates of the same cohort cannot be ruled out (S. Richards[2]). Given that sand lance larvae take 3-5 months (Reay 1970) to attain metamorphic sizes (30-40 mm, Macer 1966), the above observations suggest a spawning season extending from December through to April. In addition, the occurrence of larvae as small as 11 mm in July and 8 mm in June 1980 (Table 1) suggests that spawning may occur as late as May or June in certain years.

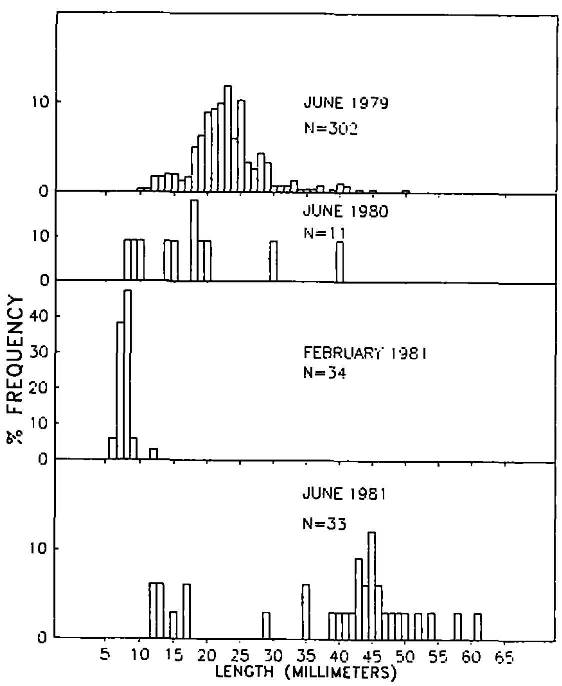


FIGURE 3.—Length-frequency distributions from Fortune Bay sand lance samples.

TABLE 3.—Results of the MacDonald and Pitcher (1979) method of analyzing length distribution mixtures of sand lance, June 1979, assuming a mixture of three (spawning) components. Results assuming only one component are also shown.

| | Component | Percent of total population in component (SE) | Mean length (SE) | Standard deviation (SE) |
|---|---|---|---|---|
| $K = 3$ | 1 | 8.2 (2.9) | 13.4 (0.77) | 1.76 (0.52) |
| $\chi^2 = 25.32$ | 2 | 78.1 (28.2) | 22.2 (0.65) | 3.02 (0.53) |
| df 19 | | | | |
| $P = 0.1504$ | 3 | 13.7 (27.1) | 28.8 (9.2) | 4.36 (3.46) |
| $K = 1$ | | | | |
| $\chi^2 = 49.55$ | 1 | 100 | 22.4 (0.27) | 4.65 (0.19) |
| df 25 | | | | |
| $P = 0.0024$ | | | | |

This tendency for protracted length ranges is also evident in the historical samples collected around Newfoundland (Fig. 4). Samples are small, but the two from Labrador range in length from 22 to 55 mm with a break between the larger and smaller groups. The 14 fish from Colliers Bay, Conception Bay exhibit a protracted length range from 28 to 65 mm. The two samples collected off southern Newfoundland (Penguin Is-

[2]Sarah W. Richards, Little Harbor Laboratory, Inc., 69 Andrews Road, Guilford, CT 06437, pers. commun. October 1986.

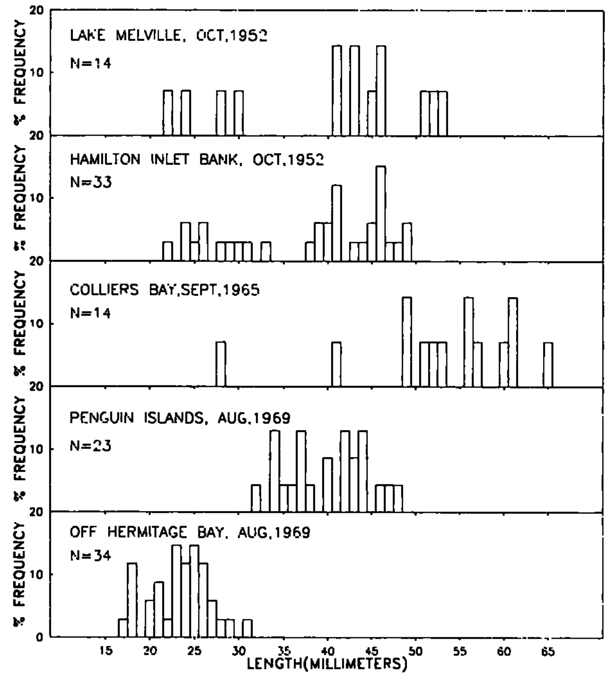


FIGURE 4.—Length-frequency distributions of historical sand lance samples from the Newfoundland area.

lands and Hermitage Bay) (Fig. 1) are interesting because although they were collected approximately 30 miles apart on successive days, the two samples have completely distinct length-frequency distributions. The sample collected on August 20 ranges in length from 32 to 48 mm, and the one collected on August 21 ranges from 17 to 31 mm. The distribution of both of these samples indicates that there may be more than one mode in each of the smaller and larger groups. These two completely different distributions may reflect multiple spawning cohorts or different spawning seasons in the case that they are comprised of different species.

## Meristic Development

The staining procedure resulted in cartilaginous tissue being stained blue and ossified tissues red. Very few of the larvae had vertebral columns that stained for both cartilage and bone. The procedure resulted in three categories of vertebral columns. In the first category, the whole column stained blue, and this sometimes made counts difficult because parts of the notochord had not been replaced by individual vertebrae. The second category contained larvae in which part of the vertebral column was stained blue and part was stained red. These were few and had varying portions of red and blue stain. Neither the anterior nor the posterior portion of the vertebral column consistently ossified first. The third category contained those larvae in which all of the vertebral columns were ossified and stained red. Most larvae fell into this category. The observation that larvae in the second category did not show a consistent sequence of ossification may be an artifact of the preservation. Fixation of any protein or its amino acid derivatives will be followed by a drop in pH wherever formaldehyde is employed (Steedman 1976). Low pH causes decalcification or solubility of small deposits of calcium carbonate (Steedman and Omari 1976) and could therefore bias the interpretation of the normal developmental sequence of ossification. Moser (1972), Fritzsche and Johnson (1980), and Matarese et al. (1980) found that ossification of the vertebral column proceeded posteriorly in rockfish, white perch, striped bass, and Pacific tomcod, respectively. The sequence of development and ossification of fin rays was from anterior to posterior and from proximal to distal portions of the rays.

Table 4 and Figure 5 show the vertebral, dorsal fin ray, and anal fin ray counts for the length classes within the samples. The counts include both cartilageous and ossified fin rays. The full complement of dorsal fin rays is not developed until the larvae have attained a size of approximately 40 mm. The full complement of anal fin rays were developed by a size of 35-40 mm total length. Richards (1982) stated that fin ray development varied greatly in 21 specimens of both species but first appeared at 12-13 mm and was completely developed in 23 mm larvae of *A. americanus*. Fin rays first appeared at 14-15 mm in *A. dubius*, but the full complement was not present until after the larvae were greater than 25 mm total length. Scott (1972) found that the definitive number of anal fin rays were attained at a later stage in growth than 30 mm and that the definitive number of dorsal fin rays was attained at about 30 mm for Scotian Shelf *A. dubius*.

Figure 5 indicates that the definitive number of vertebrae is achieved by a total length of approximately 20 mm. As mentioned above, at sizes smaller than this, the notochord had not been replaced by vertebrae. This resulted in clear regions along the column. It was not possible to count myomeres because the staining process resulted in the fleshy parts of the body being cleared.

Matarese et al. (1980) pointed out that considerable variation occurs in the development of meristic structures of Pacific tomcod, *Microgadus proximus*, because the size at which bone ossifies varies from specimen to specimen. Figure 5 illustrates this variation in the mean counts of dorsal and anal fin rays at the smaller length classes.

TABLE 4.—Results of vertebral, dorsal fin ray, and anal fin ray counts for the length classes of sand lance.

| Length class | *N* | Range | Standard deviation | Mean |
|---|---|---|---|---|
| *Vertebrae* | | | | |
| 22.5 | 49 | 72-76 | 0.90 | 73.98 |
| 27.5 | 75 | 71-76 | 1.14 | 73.95 |
| 32.5 | 19 | 73-77 | 1.10 | 74.11 |
| 37.5 | 8 | 73-75 | 0.76 | 74.00 |
| 42.5 | 13 | 72-75 | 1.09 | 73.77 |
| 47.5 | 5 | 73-77 | 1.67 | 74.40 |
| 52.5 | 4 | 72-75 | 1.26 | 73.75 |
| >22.5 | 173 | 71-77 | 1.66 | 73.98 |
| *Dorsal fin rays* | | | | |
| 22.5 | 69 | 22-45 | 3.66 | 30.04 |
| 27.5 | 69 | 28-47 | 3.93 | 35.72 |
| 32.5 | 16 | 39-65 | 9.27 | 49.31 |
| 37.5 | 5 | 44-66 | 9.63 | 61.20 |
| 42.5 | 10 | 64-68 | 1.27 | 65.50 |
| 47.5 | 5 | 65-67 | 1.10 | 65.80 |
| 52.5 | 4 | 64-67 | 1.26 | 65.25 |
| >42.5 | 19 | 64-68 | 1.17 | 65.53 |
| *Anal fin rays* | | | | |
| 22.5 | 67 | 25-33 | 1.79 | 30.66 |
| 27.5 | 72 | 27-35 | 1.20 | 32.17 |
| 32.5 | 18 | 31-35 | 1.13 | 32.89 |
| 37.5 | 6 | 33-36 | 1.17 | 34.17 |
| 42.5 | 8 | 33-36 | 1.06 | 34.38 |
| 47.5 | 4 | 33-35 | 0.96 | 34.25 |
| 52.5 | 4 | 32-34 | 0.96 | 33.25 |
| >37.5 | 22 | 32-36 | 1.06 | 34.09 |

## Species Identification

Sand lance larvae collected in Fortune Bay in June 1979 had a mean vertebral count of 73.98 (SD = 1.66) (Table 4, Fig. 5). From Figure 5 and Table 4, the definitive number of dorsal fin rays varies from 64 to 68 with a mean of 65.53, and similarly the definitive number of anal fin rays varies from 32 to 36 with a mean of 34.09 (Table

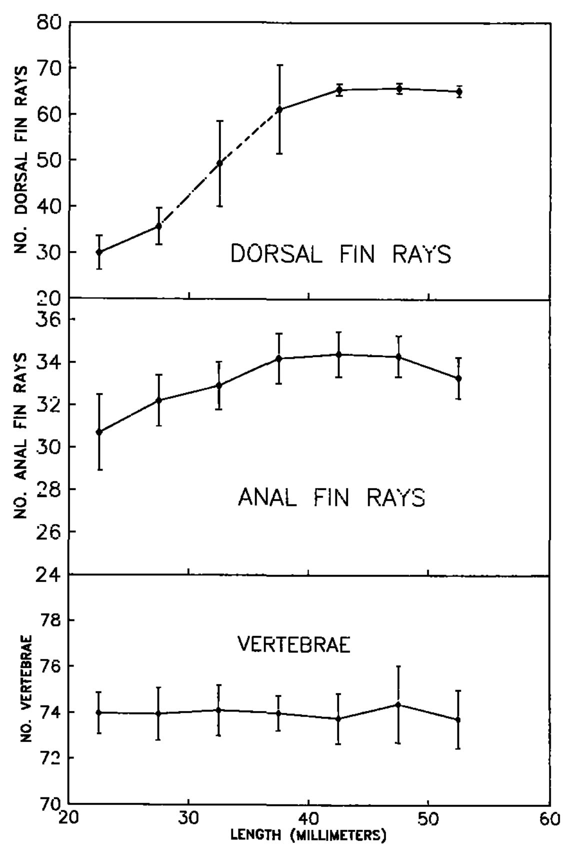


FIGURE 5.—Development of definitive number of dorsal fin rays, anal fin rays, and vertebrae with increasing size of sand lance, showing mean and standard deviation for each length class.

4). Winters (1970) gave mean vertebral counts of approximately 73.8-73.9, mean dorsal fin ray counts of 64.3-64.6, and mean anal fin ray counts of 33.2-33.6 for *A. dubius* from the Newfoundland Grand Banks. Comparable values for *A. americanus* from inshore areas of Newfoundland are 66.2-68.2, 55.7-57.8, and 27.8-30.6. We conclude, therefore, that the larger larvae collected in Fortune Bay in June 1979 belong to the offshore form, *A. dubius*.

The small larvae from February 1981 (lengths 6-12 mm) were examined for the presence of lateral or pre-anal melanophores. Counts of other melanophores (e.g., pectoral and subdorsal) were not possible, due either to the early stage of development of the larvae or to bleaching by the preservative. According to Richards (1982), counts of pre-anal melanophores can be used to distinguish between the larvae of *A. dubius* and *A. americanus*. From 6.0 to 8.9 mm in length, *A. americanus* has 0-16 pre-anal melanophores, and *A. dubius* has 10-21. Full or partial counts were possible for 11 of the larvae. Ten were 6-7 mm in length. Of these, two had 15 pre-anal melanophores, four had 16, one had 17, one had 18, and two had 20. One 9 mm larva had 15 pre-anal melanophores. According to Richards' (1982) criteria, four larvae are definately *A. dubius* because the counts are out of range for *A. americanus*. The other seven are in the upper extreme of the overlap range for the two species suggesting that these too are *A. dubius*. Thus, not only do larger larvae of the offshore species occupy Fortune Bay, but yolk-sac larvae are also present. This suggests that spawning of the offshore species occurs within the bay.

Because *A. dubius* is present on St. Pierre Bank (Winters 1970), we have considered the possibility that the yolk-sac larvae collected from Fortune Bay in February 1981 were transported from St. Pierre Bank. Smigielski et al. (1984) gave times for yolk-sac absorption from 5 to 14 days, depending on temperature. Using minimum and maximum speeds (0.05-0.20 $ms^{-1}$) of the Labrador Current along the south coast of Newfoundland (Petrie and Anderson 1983), it would take yolk-sac larvae 9-36 days to be carried from St. Pierre Bank to inner stations in Fortune Bay where they were collected. De Young (1983), however, described a seasonal cycle of water exchange for Fortune Bay in which the flow of Labrador Current water over St. Pierre sill (between Miquelon and the tip of the Burin Peninsula (Fig. 2)) is minimal in winter months and predominates in the summer. Under normal current conditions, it appears unlikely that these yolk-sac larvae were transported over St. Pierre Bank into Fortune Bay with the Labrador Current during the winter period. A persistent wind event from the south could transport larvae in the surface layers at a much faster rate than would the inshore branch of the Labrador Current. However, the prevailing wind direction at St. Lawrence on the southern part of the Burin Peninsula for January and February 1981 was from the west with wind from the south only 1% of the time in January and 6% in February 1981 (Anonymous 1981). A peak wind event from the SSE on February 9 did not persist into the next day when winds were again from the west. We conclude, therefore, that it is unlikely that the yolk-sac larvae found within Fortune Bay in February 1981 were transported from St. Pierre Bank. More likely, these larvae were spawned in Fortune Bay. Such spawning is consistent with evidence from hydrographic charts that indicate many areas of gravel and sand mixtures in Fortune Bay. According to Reay (1970), this is the preferred spawning substrate for sand launce.

### Yolk-Sac Absorption

Sixty-two percent of the larvae collected in February 1981 contained yolk sacs. The mean length of those in which the absorption of yolk-sac (+ oil globule) was complete was 8.1 mm while those with absorption incomplete had a mean length of 7.4 mm. This is consistent with published records. Smigielski et al. (1984) gave yolk-sac absorption lengths of 7.2-7.41 for laboratory reared *A. americanus*, and Richards (1965) found that oil globule absorption was complete between 5 and 7.5 mm.

## DISCUSSION AND CONCLUSIONS

The conclusion from the data collected during the day-night investigations is that smaller yolk-sac larvae in February and larger larvae in June are more abundant or more available to the gear at night. It is difficult to discern a particular pattern of diurnal and vertical migratory behavior for sand lance larvae from the literature because documentation on the subject has not been consistent. The observation that larger larvae in June are more abundant at night is not unusual and may be attributable to net avoidance (Norcross et al. 1961; Richards and Kendall 1973; Potter and Lough 1986). The observation that yolk-sac larvae are more abundant in surface night sets appears unusual since Richards and Kendall (1973) found that in winter larvae 8-17 mm were more abundant in deep tows at night and surface tows during the day. Avoidance behavior does not appear to develop until a size of greater than 10 mm (Norcross et al. 1961; Potter and Lough in press). Assuming the same for larvae in Fortune Bay, it is not likely that yolk-sac larvae were avoiding the gear during the day. Although it is not possible to make a definite conclusion on vertical migration with the relatively small number of larvae, the data suggest that yolk-sac larvae in February are also capable of vertical migration.

Our analyses of sand lance larvae from Fortune Bay have demonstrated for the first time the occurrence and probable spawning of the slender-bodied *A. dubius* in coastal waters in Newfoundland. Previous studies by Winters (1970) have indicated the occurrence of only the deep-bodied form *A. americanus* in Newfoundland bays with *A. dubius* being found exclusively on the offshore banks. This finding is significant in light of the current confusion as to the appropriate taxonomy of the sand lance populations in the Northwest Atlantic. Both *A. americanus* and *A. dubius* appear to resemble *A. marinus* which is currently considered to occur only in European waters (Reay 1970), and the characteristics used to separate the two Northwest Atlantic types from each other and from *A. marinus* are sometimes tenuous particularly in southern parts of the range. In the Newfoundland area, however, *A. americanus* and *A. dubius* maintain distinct meristic counts. The occurrence and probable spawning of *A. dubius* in a coastal area, formerly considered to be inhabited exclusively by *A. americanus* (Winters 1970), indicates sympatry. This provides evidence that the two forms are reproductively isolated and therefore separate species. This is substantiated by the fact that the meristics described for *A. dubius* larvae in Fortune Bay and those offshore (Winters 1970) are identical.

We have also demonstrated that the spawning season of sand lance in Fortune Bay, Newfoundland, is protracted and probably extends from December to May or June. This spawning period is much longer than in southern areas of the Northwest Atlantic where the spawning season in inshore waters is from the period December to February (Richards 1982). It is possible that this extended spawning season is also a result of the mixture of the two species in Fortune Bay; however, the polymodality in the length frequency of large *A. dubius* (>20 mm) larvae in Fortune Bay suggests that an extended spawning season may be characteristic of this species in coastal Newfoundland waters.

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