J. Northw. Atl. Fish. Sci., Vol. 9: 5-11

Life History Parameters of Sand Lances (*Ammodytes* spp.) from the Coastal Waters of Eastern Newfoundland

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Abstract

Estimates of various life history parameters of sympatric populations of *Ammodytes dubius* and *A. americanus* from coastal waters of Newfoundland are presented for the first time. Significant differences between the two species of sand lances were evident for length-weight and age-weight relationships. In addition, *A. americanus* tended to have a slightly earlier spawning season, and matured at a slightly earlier age than *A. dubius*. Similarities in these vital rates were noted between *A. americanus* populations in Newfoundland coastal waters and those in New England waters. Likewise, populations of *A. dubius* from coastal Newfoundland waters had similar vital rates as those published for *A. dubius* populations on the Grand Banks.

Introduction

Sand lances are small semi-pelagic fish which are widely distributed in the inshore and offshore areas of the Northwest Atlantic from Greenland southwards to Cape Hatteras, North Carolina (Leim and Scott, 1966). They belong exclusively to the genus *Ammodytes*, although there is considerable uncertainty as to the species distinctions. Historically, the genus was considered to be comprised of *A. dubius* and *A. americanus* in the Northwest Atlantic area (Leim and Scott, 1966; Richards, 1982). More recently, however, analyses of meristic data suggest that *A. americanus* is actually a polytypic form of *A. marinus* (Winters and Dalley, 1988) which was formerly considered to exist only in the Northeast Atlantic (Reay, 1970). In the absence of independent information which could confirm this conclusion, the provisional nomenclature of Leim and Scott (1966) for the species distinctions is adhered to in this paper.

There is a paucity of information on the biological characteristics of sand lance in coastal waters of Newfoundland. The earliest source of information is from Dannevig (1918), who provided length composition and distributional information for 89 specimens of juveniles taken from vertical plankton hauls off southern Newfoundland in the summer of 1915. Frost (1938) presented information on the distribution of larvae along the Newfoundland coast from 1931 to 1935. These larvae were all assumed to be *A. americanus*. Meristic analyses (Winters, 1970; Dalley and Winters, 1987; Winters and Dalley, 1988) demonstrated that co-occurrence is a common feature in the distribution of *A. dubius* and *A. americanus* in Newfoundland coastal waters. There is little other information on the biological characteristics of sand lances in the inshore areas of Newfoundland despite its importance as a prey species to a variety of commercially-important finfish species in the Northwest Atlantic (Winters, 1983).

This paper presents comparative information on various life history parameters of *A. dubius* and *A. americanus* populations in Newfoundland coastal waters. This information is compared with similar information of other coastal and offshore populations of sand lances in the Northwest Atlantic.

Materials and Methods

During the period 1970-85, samples were collected during June-July and October-November on an opportunistic basis from various coastal areas of eastern Newfoundland (Table 1, Fig. 1). These samples were obtained using a variety of gear, but with the same mesh size. Samples were examined in detail after preservation in frozen brine. Total lengths were measured to the nearest mm and conversion of thawed lengths to fresh equivalents was accomplished using a conversion factor of 1.03 (Winters, 1981). Separation of *A. dubius* and *A. americanus* in mixed samples were accomplished using vertebral counts in conjunction with bivariate discriminant function analyses. Here, specimens greater than 140 mm in length collected during the summer period and having vertebral counts in the overlapping range of vertebral distributions of *A. dubius* and *A. americanus* in the Northwest Atlantic

TABLE 1. Origin of samples of sand lance from Newfoundland coastal waters, 1970-85.

Sample	Area	Date	Gear type	Mesh size (mm)	Sample size	% Discrimated by species	Locality of catch
1	Quirpon, northern Newfoundland	20 Jul 1970	Cast net	18	40	93	on coastal beach
2	Westport, White Bay	22 Oct 1983	Beach seine	18	105	89	on coastal beach
3	Westport, White Bay	05 Nov 1983	Beach seine	18	97	93	on coastal beach
4	Westport, White Bay	01 Jul 1984	Beach seine	18	191	69	on coastal beach
5	Little Bay Head, Notre Dame Bay	25 Jun 1983	Purse seine	18	45	98	off Headland
6	off St. Brendan's, Bonavista Bay	26 Jun 1984	Purse seine	18	74	100	middle of bay
7	Long Beach, Trinity Bay	10 Jun 1983	Capelin trap	18	225	100	near coastal beach
8	Holyrood, Conception Bay	11 Oct 1985	Squid trap	18	50	100	near coastal beach

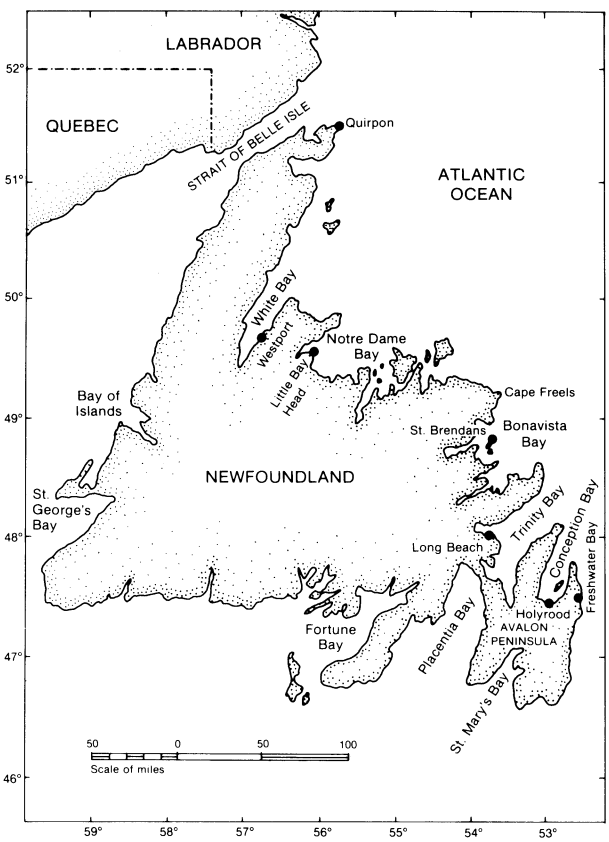

Fig. 1. Areas and place names mentioned in the text.

were separated based on discriminant function analysis utilizing length-weight parameters (Winters and Dalley, 1988). Otherwise, specimens were assigned to a particular species when their vertebral counts were outside the overlapping range.

Age determinations were based on otolith interpretations according to the methodology of Macer (1966) and Scott (1968, 1973). Age determinations were truncated at age 9+ due to difficulty in interpreting annual growth zones beyond that age.

Specimens were assigned to the following gonad development and maturity stages according to gonad condition and appearance as described by Macer (1966): 0 = immature; 1 = maturing; 2 = ripe; 3 = running; 4 = spent; and 5 = recovering.

Age and length data were analyzed using the von Bertalanffy (1938) growth model:

$$L_t = L_\infty [1 - e^{-k(t-t_o)}]$$

where L_t is mean length at age t years, L_∞ is the asymptotic length, k is a constant determining the rate of change in length increments and t_o is the theoretical length at zero age.

Age and weight data were analyzed using the Gompertz growth model:

$$W_t = W_o \exp\{-\exp[-B(t-m)]\}$$

where W_t is mean weight at age t years, W_o is the asymptotic weight, B is the instantaneous growth rate and m is the inflexion point. The model was fitted using the maximum likelihood program of the Numerical Algorithms Group (1987).

Results

Length and age composition

Length composition data (Fig. 2) show that *A. dubius* and *A. americanus* have similar length ranges, which in the present samples extend from 85 mm to 280 mm for the former and from 65 mm to 265 mm for the latter. In addition, for both species, there was a consistent difference in the length composition in samples which were taken directly on beaches when compared with samples taken either away from the beaches in open water by purse seine, or in coastal areas by squid trap or capelin trap. Samples from the beaches were predominantly juveniles less than 150 mm in length, whereas samples taken in open water were predominantly larger, up to 280 mm in length. Richards (1982) noted a similar disparity in the length composition of *A. americanus* between inshroe and offshore samples taken in the New England area. Since the various gears had the same mesh size (Table 1), it is probable that these length differences represent real differences in the distribution of juvenile *versus* adult.

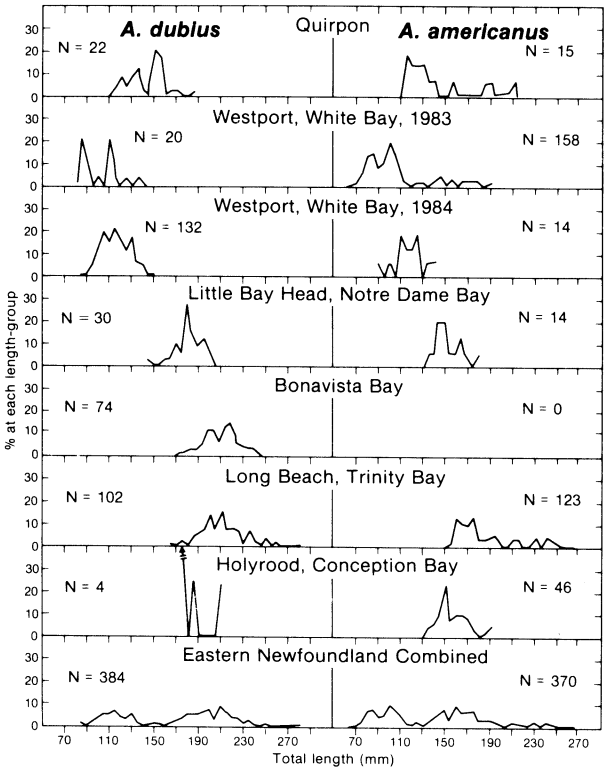

Fig. 2. Length frequency distributions of samples of *A. dubius* and *A. americanus* from Newfoundland coastal waters.

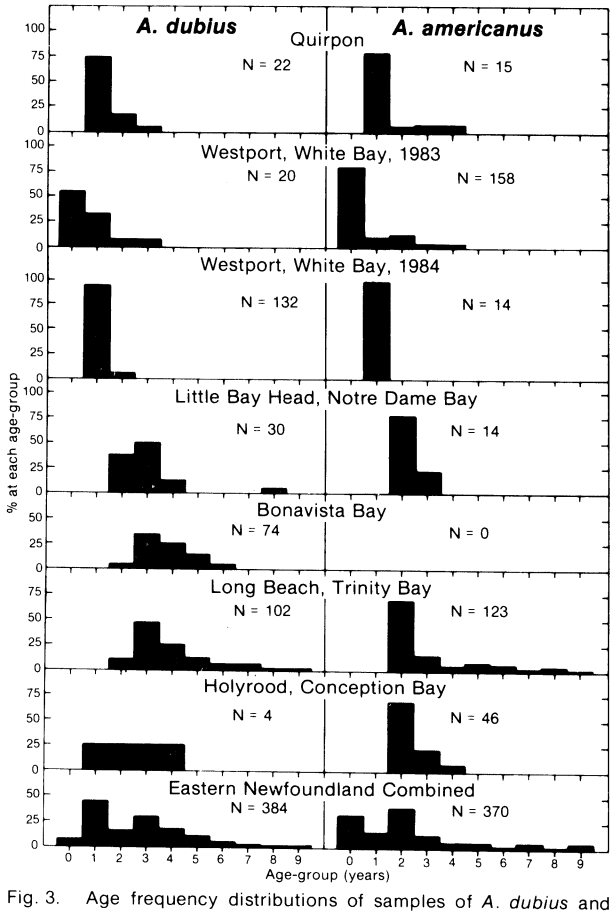

Fig. 3. Age frequency distributions of samples of *A. dubius* and *A. americanus* taken from eastern Newfoundland coastal waters.

Age composition data (Fig. 3) indicate that there was very little difference in the age ranges of *A. dubius* and *A. americanus*. The longevity of *A. dubius* from the coastal samples (age 9+) was also very similar to that recorded for *A. dubius* from the Newfoundland Grand Banks (age 10+) (Winters, 1983). Consistent with the length composition observations, samples taken on the beaches were mainly juveniles belonging to 0-group and 1-group.

Growth parameters

There was a consistent difference in the length-weight relationship of *A. dubius* compared with *A. americanus*, regardless of the season of the year (Fig. 4). This difference reflects differences in the morphometry of the two species (Richards *et al.*, 1963; Scott, 1968; Winters, 1970; Richards, 1982), i.e. *A. dubius* is slender-bodied whereas *A. americanus* is deep-bodied. The seasonal difference in the length-weight relationships of both species is consistent with the improvement in body condition which occurs over the summer feeding period.

The exponent in the length-weight regression of *A. dubius* in the June–July period is very close to the value (2.93) obtained for the same species and approximately the same season (April–June) from samples collected on the Grand Bank (Winters, 1981).

Age-at-length data of *A. dubius* and *A. americanus* for the June–July period based on samples collected from northeastern Newfoundland (north of Cape Freels (Fig. 1)) and southeastern Newfoundland (south of Cape Freels) are shown in Table 2. The age specific sizes of both species from southeastern Newfoundland area were consistently larger than for specimens of the same age from northeastern Newfoundland. This difference in growth may merely reflect differences in sampling locations since all of the Northeast Newfoundland samples were taken directly on coastal beaches whereas the Southeast Newfoundland samples were caught in open water. However, the differences in growth from northeastern to southeastern Newfoundland is consistent with the growth pattern observed for several other species such as capelin (Winters, 1982), herring (Pinhorn, 1976), and cod (May *et al.*, 1965).

Comparison of von Bertalanffy growth curves derived from aggregated samples of each species (Fig. 5) indicates that growth rates of the two species are very similar. Further, the von Bertalanffy growth parameters for *A. dubius* from eastern Newfoundland

TABLE 2. Length-at-age data for sand lance collected in the June-July period from southeastern and northeastern Newfoundland.

Age-group (years)	*A. dubius*						*A. americanus*					
	Southeastern Newfoundland		Northeastern Newfoundland		Combined		Southeastern Newfoundland		Northeastern Newfoundland		Combined	
	No.	Length (mm)	No.	Length (mm)	No.	Length (mm)	No.	Length (mm)	No.	Length (mm)	No.	Length (mm)
1	—	—	149	119	149	119	—	—	26	120	26	120
2	13	190	17	168	30	178	85	172	12	152	97	170
3	74	202	16	186	90	199	15	204	4	173	19	197
4	47	210	2	188	49	209	4	221	1	203	5	217
5	26	225	—	—	26	225	7	234			7	234
6	9	232	—	—	9	232	4	240			4	240
7	5	238	—	—	5	238	2	243			2	243
8	1	261	—	—	1	261	2	247			2	247
9+	1	281			1	281	3	254			3	254

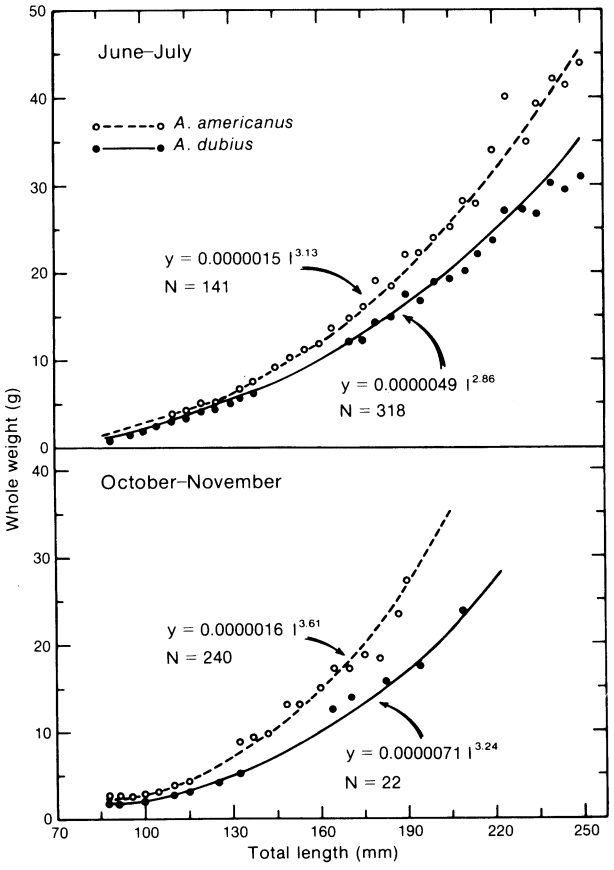

Fig. 4. Length-weight relationships of *A. dubius* and *A. americanus* for the June-July and October-November periods of the year.

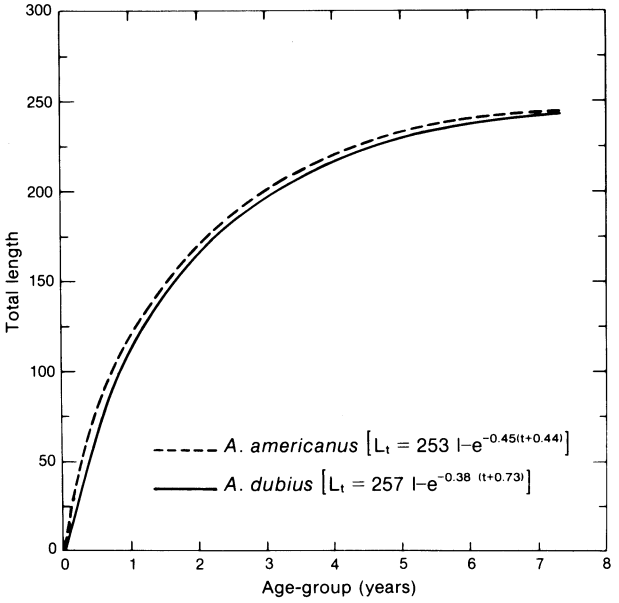

Fig. 5. Von Bertalanffy growth curves for *A. dubius* and *A. americanus* for samples collected from eastern Newfoundland in the June-July period.

(Table 2) were very similar to those reported for *A. dubius* from the Grand Banks (Winters, 1981).

Length frequencies of 0-group *A. dubius* and *A. americanus* taken in October-November (Fig. 6) indicate that these two species attain the same length at the end of their first year of life. This observation is consistent with length-at-age comparisons for the 1-group specimens in the June-July period (Table 2).

Age-weight curves (Fig. 7) confirm the inference from the length-weight and age-length data that *A. americanus* is much heavier than *A. dubius* for specimens of the same age. Also, the age-weight relationship of *A. dubius* from these inshore samples is very similar to the age-weight relationship of *A. dubius* from the Grand Banks (Winters, 1983).

Reproductive parameters

Maturity stage data (Fig. 8) indicate that both *A. dubius* and *A. americanus* spawning is completed by June. The occurrence of specimens with gonads in the running stage (Stage 3) in October and the presence of spent gonads in November indicate that spawning of *A. americanus* in inshore waters begins as early as October. The absence of maturity stages 3 to 5 in the October-November samples of *A. dubius* suggests that

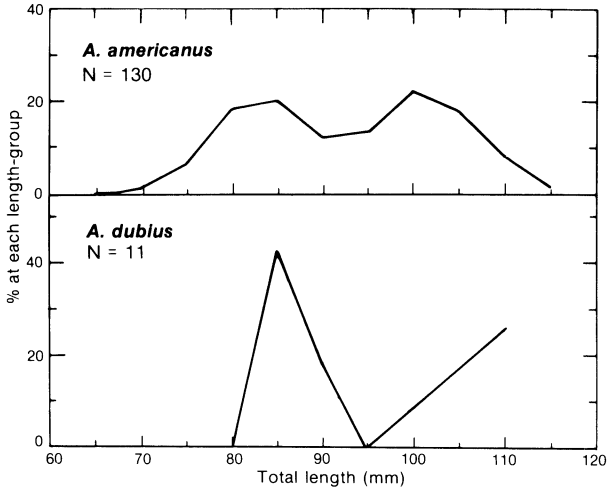

Fig. 6. Length distribution of 0-group *A. dubius* and *A. americanus* from samples taken from eastern Newfoundland during the October-November period.

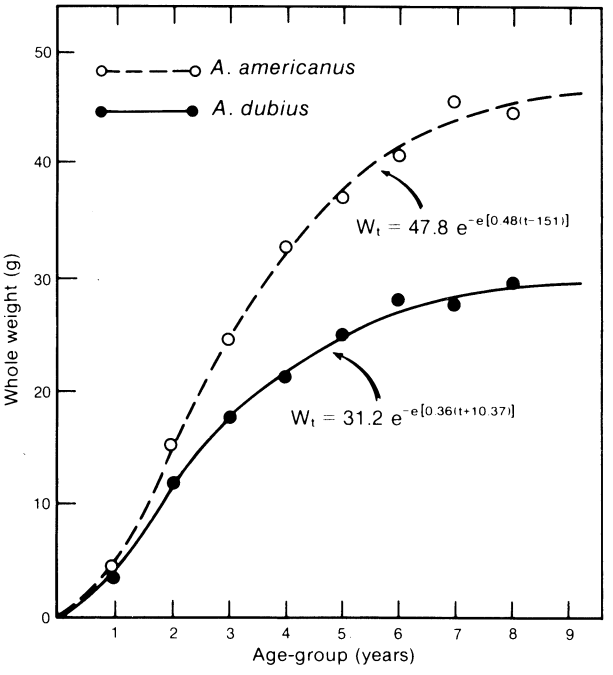

Fig. 7. Age-weight relationships of *A. dubius* and *A. americanus* from samples collected from eastern Newfoundland during the June-July period. The curves have been fitted using the Gompertz growth model.

its spawning season may be somewhat later than that of *A. americanus*, although sample sizes are limited. In general, however, the spawning season of *A. dubius* and *A. americanus*, as inferred from maturity stage data, is similar to that described by Winters (1983) for *A. dubius* in offshore areas and by Richards (1982) for inshore populations of *A. americanus* i.e. that main spawning season occurs in the late autumn-early winter period.

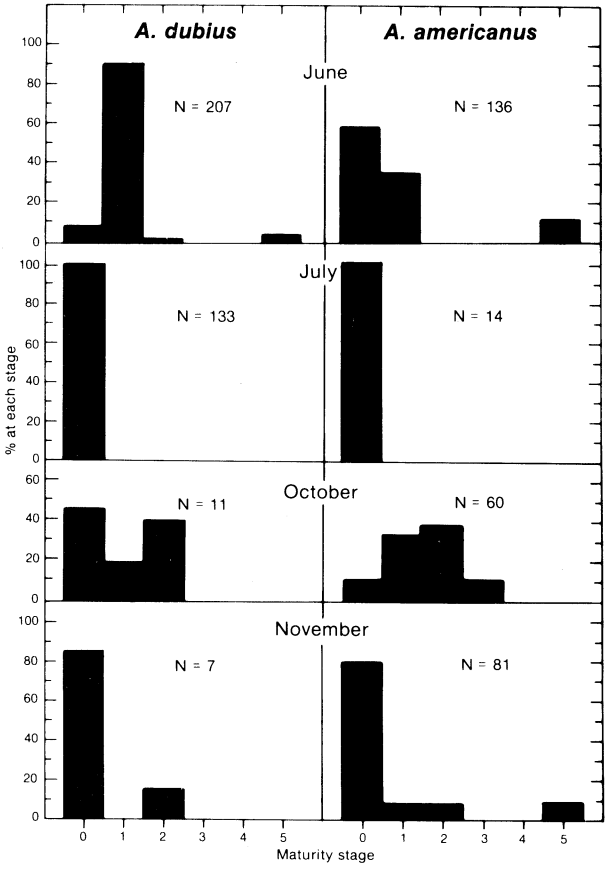

Fig. 8. Maturity stage composition of *A. dubius* and *A. americanus* from samples collected from eastern Newfoundland during the June-November period.

Length-dependent maturity ogives of *A. dubius* and *A. americanus* from samples taken in June (Fig. 9) give a mean length of maturity of 175-180 mm for both species. Samples of *A. americanus* taken in October--November, however, give a much smaller mean length of maturity of about 140 mm. Since specimens maturing for the first time would still be considered immature in June, the maturity ogives derived for June are actually the length dependent maturation rates of individuals who had spawned during the previous spawning season, including the interim growth increment. The maturity ogive obtained for the October-November period includes both first and repeat spawners and therefore is a more appropriate estimate of the length-dependent maturation rate of *A. americanus*. This interpretation can also be applied to the *A. dubius* maturation data.

A similar interpretation can be used to explain the differences in the age-dependent maturation rates of *A. dubius* and *A. americanus* from June to the October-November period (Table 3). Assuming that the June-July samples are mostly post spawners, a significant proportion of both species mature at the end of their

TABLE 3. Age-dependent maturation rates of *A. dubius* and *A. americanus* for the June-July and October-November sampling periods.

Age-group	*A. dubius*				*A. americanus*			
	Immature	Mature	Total	% mature	Immature	Mature	Total	% mature
				Jun-Jul				
1	150	0	150	0	24	2	26	8
2	15	15	30	50	67	29	86	34
3	3	87	90	97	3	16	19	84
4	0	49	49	100	0	5	5	100
				Oct-Nov				
1	7	1	8	13	9	35	44	80
2	0	2	2	100	4	17	21	81
3	0	2	2	100	0	5	5	100
4	0	1	1	100	0	1	1	100

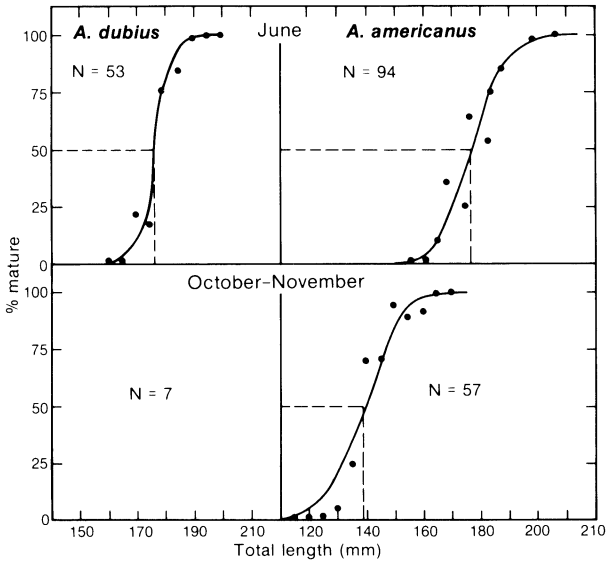

Fig. 9. Length dependent maturity ogives of *A. dubius* and *A. americanus* from samples collected from eastern Newfoundland during the June and October-November period. The ogives have been fitted by probit analyses.

second year of growth (i.e. age-group 1). Also, a small proportion of *A. americanus* mature at the end of their first year of growth (i.e. age-group 0). Although sample sizes are small, these conclusions are borne out by the October-November samples. These samples also support the observations that *A. americanus* matures at an earlier age than *A. dubius*. Early maturity, at the end of the first year of growth, was also noted by Richards (1982) for *A. americanus* along the inshore areas of the New England seaboard. A similar observation was made by Macer (1966) for the North Sea populations of *A. marinus* which Winters and Dalley (1988) consider to be conspecific with *A. americanus*. The age-dependent maturation rates observed for the inshore population of *A. dubius* from eastern Newfoundland during the June-July period is in general agreement with the maturation rate of *A. dubius* collected during the April-June period for the Grand Banks (Winters, 1983).

Discussion and Conclusions

This paper presents new information on the life history parameters of *A. dubius* and *A. americanus* from inshore areas of eastern Newfoundland. In general, the growth rate, maturation rate and spawning period of *A. dubius* in Newfoundland coastal waters are very similar to those described for offshore populations of the same species in the Grand Banks area (Winters, 1983). Differences between *A. americanus* and *A.* dubius in body morphometry (Richards *et al.*, 1963; Scott, 1968; Winters, 1970; Winters and Dalley, 1988) were consistently observed in length-weight and age-weight relationships in samples from the coastal waters. In addition, *A. americanus* tended to have a slightly earlier spawning season, and matured at a slightly earlier age than *A. dubius* in samples from Newfoundland coastal waters.

Comparison of the life history parameters of *A. americanus* in Newfoundland coastal waters with the New England area (Richards *et al.*, 1963) indicates that populations in both areas have similar growth rates, maturation rates, and spawning seasons. However, specimens from Newfoundland waters ranged upwards of 265 mm in length, compared to maximum lengths of less than 200 mm reported by Richards (1982) for *A. americanus* collected in the inshore New England area. It is however possible that this difference may be due to a sampling bias caused by the predominance of juveniles in the coastal beaches, which was the primary source of Richards' (1982) data.

Acknowledgements

The authors thank the staff of the Pelagic Station, Northwest Atlantic Fisheries Centre, St. John's, New-

foundland, for assistance in the collection and processing of the biological samples of sand lance. Mr D. Stansburg provided statistical services.

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