Separation of Two Species of Sand Lances, *Ammodytes americanus* and *A. dubius*, in the Western North Atlantic

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Abstract.–Two species of sand lances are recognized in the western North Atlantic, the inshore *Ammodytes americanus* DeKay 1842 and the offshore *A. dubius* Reinhardt 1838. The best separation of the two species is achieved by using the number of plicae (oblique folds of skin on the lateral body surface) singly or in combination with the number of vertebrae. *Ammodytes americanus* has fewer meristic structures than *A. dubius*: number of lateral plicae 106–126, $\bar{x}$ 117.4 vs. 124–147, 132.1; total vertebrae 62–70, $\bar{x}$ 66.4 vs. 68–76, 70.8; dorsal fin rays 52–61, $\bar{x}$ 57.4 vs. 56–67, 61.8; anal fin rays 26–33, $\bar{x}$ 29.4 vs. 28–35, 31.1; pectoral fin rays 11–15, $\bar{x}$ 13.2 vs. 12–16, 14.0; gill rakers on first arch 21–28, $\bar{x}$ 24.3 vs. 23–31, 26.6. Meristic differences between species were summarized with principle component analysis. In addition to considerable variation within samples, there is geographic variation in numbers of vertebrae, plicae, and dorsal and anal fin rays, particularly in the offshore *A. dubius*. Specimens from the Scotian Shelf north have higher counts than do specimens from more southern populations. Based on specimens examined, *A. americanus* occurs from southern Delaware north to Labrador in shallow coastal waters as well as in protected bays and estuaries. *Ammodytes dubius* is found in deeper, open waters from North Carolina to Greenland.

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Members of the genus *Ammodytes*, or sand lances, are small elongate fishes abundant over shallow, sandy areas of the continental shelves of northern oceans. They are important prey items for several commercial fishes (e.g., American plaice, cod, haddock, silver hake, yellowtail flounder, and Atlantic salmon (Reay 1970, Meyer et al. 1979, Winters 1983) as well as fin and humpback whales (Overholtz and Nicolas 1979) and various kinds of seabirds (Reay 1970, Powers and Backus 1987). Additionally, in the North Sea and off Japan, sand lances are the basis for an important fish-meal industry (Macer 1966).

Western North Atlantic populations of sand lances have increased dramatically in recent years (Sherman et al. 1981, Winters 1983). This population explosion was correlated with a decline in stocks of herring *Clupea harengus* and mackerel *Scomber scombrus* along the eastern coast of the United States (Population Dynamics Branch, Conservation and Utilization Div., Northeast Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Woods Hole, MA 02543) (Fig. 1). The opportunistic sand lances seemed to have replaced these stocks. Concurrently, piscivorous fishes increased their consumption of sand lances. Peak abundance of sand lances in this region was reached in 1981, and numbers have since decreased (Nelson and Ross 1987). Again, the shift in sand lance abundance was correlated with mackerel numbers; mackerel populations have been steadily increasing since 1983 (Fig. 1). In view of the ecological importance and population dynamics of sand lances, it is important that the taxonomic status of these fishes be resolved.

Although the taxonomy of the majority of fish species in the western North Atlantic Ocean is known reasonably well, *Ammodytes* is a major exception despite the results of several detailed studies (e.g., Richards et al. 1963, Scott 1972, Winters and Dalley 1988). Recognition of two species of *Ammodytes* in the western North Atlantic dates back to at least Jordan and Evermann (1896). Since then, the majority of researchers have fundamentally accepted this finding (Bruun 1941, Backus 1957, Richards et al. 1963, Leim and Scott 1966, Winters 1970, Scott 1972, Winters and Dalley 1988, Scott and Scott 1988). However, final conclusions on species names, synonomies, and meristic and geographic ranges vary between studies. *Ammodytes americanus* DeKay 1842 and *A. dubius* Reinhardt 1838 are currently accepted as the appropriate names for these sand lances (Leim and Scott 1966, Reay 1970, Richards 1982, Winters and Dalley 1988), and until a worldwide systematic revision of the family is completed these names should be used.

Taxonomic confusion results mainly from the morphological similarity and large variability in characters traditionally used to separate and identify the different species of *Ammodytes*. Generally, distinguishing characters have been limited to meristic ones, especially numbers of vertebrae and dorsal and anal fin rays. Meristic overlap and variability are further complicated by the trend for more northerly populations of both species to have higher counts. Meristic characters show clinal variation, increasing both with latitude and distance offshore (Richards et al. 1963, Scott 1972, Richards 1982). Body depth and maximum total length have also been used to separate species (Richards et al. 1963, Winters and Dalley 1988), although this character combination has been shown to vary greatly with stage of maturity and age. In fact, intraspecific variation is greater than interspecific variation in some cases (Scott 1972). Additionally, the phase of the reproductive cycle and the amount of food present in the digestive tract also affect body depth in these fish.

With numerous hypotheses and species names circulating in the literature (see Richards et al. 1963 and Winters and Dalley 1988 for additional reviews), a need to alleviate some of the confusion associated with this genus is obvious. The western North Atlantic sand lances were studied in detail to determine appropriate species definitions, delimit geographic distributions, and describe meristic variation.

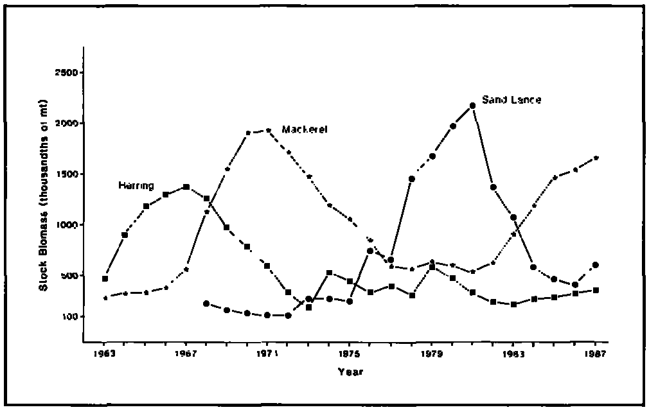

Figure 1
Abundance (10^6 metric tons) of mackerel *Scomber scombrus*, herring *Clupea harengus*, and sand lance *Ammodytes dubius* populations, 1963–87, in the western North Atlantic (Northeast Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Woods Hole, MA).

Historical background

Systematic problems involving *Ammodytes* are prevalent at all levels of taxonomic complexity. Researchers still are not sure of the phylogenetic relationships between genera of sand lances and the systematic placement of the Ammodytidae among perciforms. Pietsch and Zabetian (1990), however, believe ammodytids to be trachinoids with the family Ammodytidae the sister group of the Trachinidae plus Uranoscopidae.

At the alpha taxonomy level, 23 nominal species of the genus *Ammodytes* have been described. However, only the following six species have been consistently recognized in the literature: *A. americanus* DeKay 1842 and *A. dubius* Reinhardt 1838 in the western North Atlantic, *A. marinus* Raitt 1934 and *A. tobianus* Linnaeus 1758 in the eastern North Atlantic, and *A. hexapterus* Pallas 1811 and *A. personatus* Girard 1857 in the North Pacific (Reay 1970). However, Reay's (1970) synopsis of valid species names and delimitations of geographic ranges has not always been accepted; synonymies and geographical range adjustments are abundant. For instance, several workers including Andriashev (1954), Walters (1955), McAllister (1960), and Richards et al. (1963) have proposed that *A. hexapterus* is circumpolar and synonymous with *A. americanus* and/or *A. marinus*. Regarding the sand lances that occur in the extreme northern oceans (particularly Greenland), some investigators suggest that the low-count inshore form should be regarded as *A. americanus* (Reay 1970). Winters and Dalley (1988) proposed that these northern populations were *A. marinus*. Thus, these two nominal species may be conspecific, but researchers disagree on which name to use for the species in the western North Atlantic. *Ammodytes dubius* also occurs off the coast of Greenland but generally is considered to be a distinct species (e.g., Backus 1957, Reay 1970, Winters and Dalley 1988). Additionally, Jensen (1941, 1944) suggested that the broad overlap in characters used to separate *Ammodytes* species is so great that there may be only one extremely variable, polymorphic Atlantic species of sand lance.

Furthermore, clinal variation adds to the taxonomic confusion since some investigators recognize this variation as worthy of species designation while others propose the use of subspecies or only recognize isolated populations. Richards et al. (1963) suggested that clinal variation may be due to effects of environmental factors such as temperature, a phenomenon that has been documented in many other marine fishes. These trends have been reported in all species of *Ammodytes*, again leading to the suggestion of a single heterogeneous species with meristic and morphological differences attributable to environmental variables related to distribution.

Methods

Approximately 1500 specimens from a range of locations (North Carolina to Greenland) along the western North Atlantic coast were examined in this study (Fig. 2; Appendix 1). Total number of gill rakers were counted on the first arch on the right side; pectoral fin rays were counted on the left. Dorsal and anal ray counts were obtained from radiographs. The anterior 1–3 pterygiophores of the dorsal fin may have no associated fin ray; therefore, dorsal fin counts began at the first visible ray. Several cleared and stained specimens were examined to verify counts obtained from radiographs. Precaudal, caudal, and total vertebral counts were also taken from radiographs. The first caudal vertebra was defined as the centrum bearing the first elongate hemal spine. Total vertebral counts exclude the hypural plate following the practice of most recent workers on the genus.

Sand lances possess distinctive rows of oblique folds of skin or plicae which occur on the lateral body surfaces and are lined on the undersides by cycloid scales. The rows of plicae characteristically extend from an area above the pectoral fin base to the caudal peduncle. Plicae length and the angle of direction at which plicae run are highly variable near the head and tail (Fig. 3). Total plicae counts proved difficult to make and were not repeatable. Therefore, we modified plicae counts to begin with the first plica posterior to the first

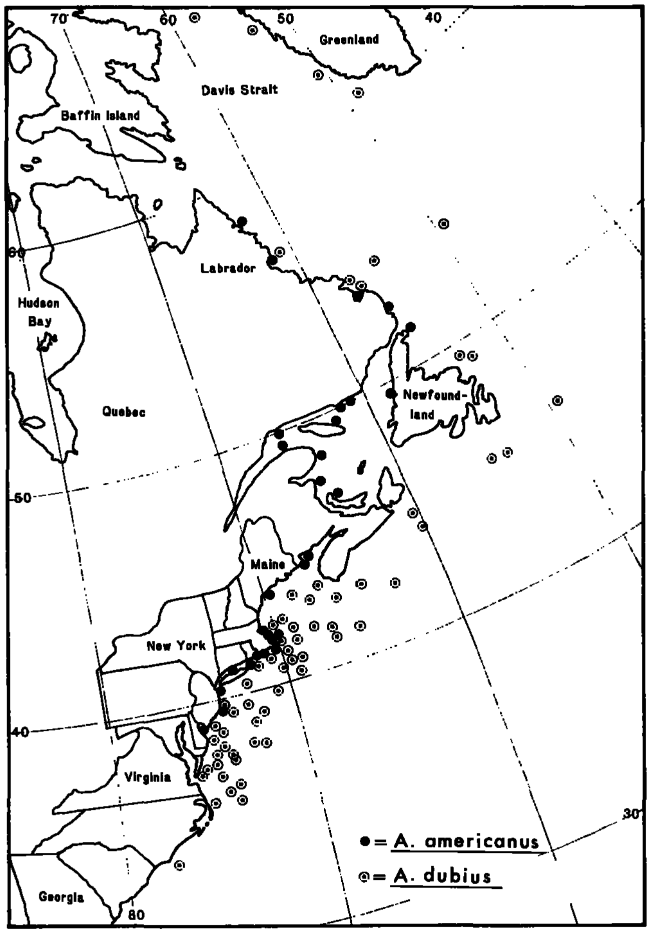

Figure 2
Distribution of *Ammodytes americanus* and *A. dubius* in western North Atlantic based on specimens examined for this study.

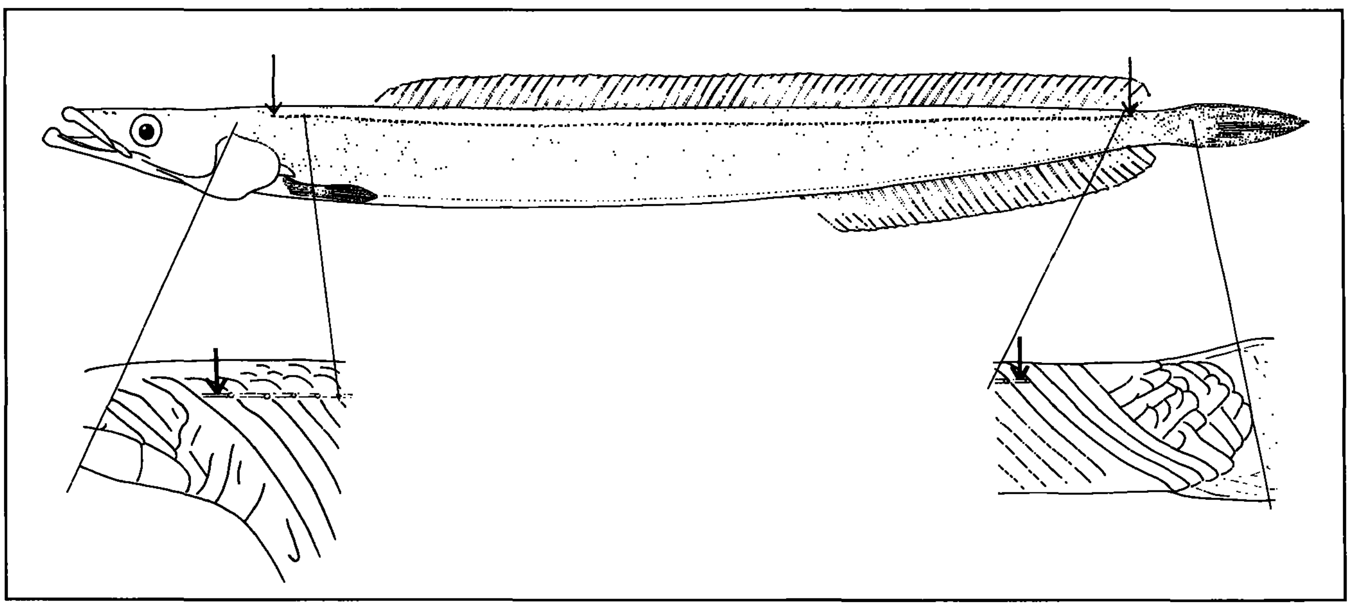

Figure 3
Drawing of *Ammodytes dubius* shows how plicae were counted (between arrows). The irregular plicae present anteriorly and posteriorly (see insets) were not counted.

pored lateral line scale and continuing posteriorly to the plica associated with the last pored scale (Fig. 3). Because plicae are much easier to count than scales, the folds themselves were counted between the two end points. If, however, the regular serial arrangement of plicae was interrupted (i.e., size and direction of slope of the plicae become irregular), the pored lateral line scales were counted in order to maintain consistency in counts between specimens. Plicae counts made in this manner are much more consistent.

Meristic data were divided into four geographic regions in order to describe and analyze geographic variation: Labrador, Quebec-Nova Scotia, Maine-Massachusetts, and New York-North Carolina. Since three species of *Ammodytes* may be present in Greenland waters, Greenland specimens were analyzed separately. Conclusions made with regard to the other geographic regions were applied to Greenland collections in an effort to determine which species are present in this region.

To determine if two species could be distinguished objectively, principle component analysis (PCA) was conducted on a covariance matrix for meristic characters (plicae, vertebrae, dorsal, anal, and pectoral fin rays, and gill rakers) for 332 individuals. These specimens, all with a complete complement of meristic values, were pooled from locations throughout the geographic range, exclusive of Greenland. An attempt was made to give equal representation to each area; however, there were not many offshore collections from Labrador available. Since the data set contained both individuals with low meristics and those with high counts, the assumption was made that both forms were present within the sample. An individual's score on the first component was determined by entering its values for meristic characters into an equation. Component scores were plotted and two groups are clearly present (Fig. 4). The point of least overlap was chosen as the boundary between the two species. Data points were then coded using earlier tentative identifications (based on observed meristic trends) to determine the effectiveness of the methodology. The equation and the value of the score at the boundary between the two species were cross-validated by testing an additional 54 specimens.

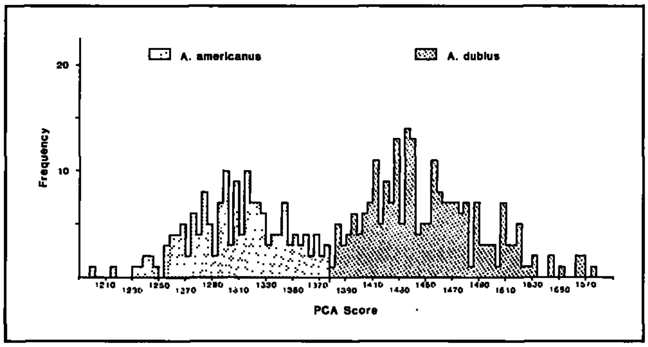

Figure 4
Histogram of principal component analysis (PCA) scores for six meristic characters of *Ammodytes*. Ranges: *A. americanus* 1199–1378, *A. dubius* 1378–1572. Component scores were calculated using the following equation: (8.09 × number of plicae) + (2.44 × number of dorsal rays) + (2.31 × total number of vertebrae) + (1.23 × total number of gill rakers) + (1.03 × number of anal rays) + (0.45 × number of pectoral rays).

Results

Number of lateral plicae was the most useful single character in separating the two species, even though plicae numbers varied considerably between individuals and slightly from side to side in individual specimens (Table 1). Of 723 specimens included in the analysis, 98.8% could be separated into species at a line of separation between 124 and 125 plicae (Fig. 5). *Ammodytes americanus* had fewer plicae, ranging from 106 to 126 ($\bar{x}$ 117.4) with virtually no geographic variation; *A. dubius* had more plicae (124–147, $\bar{x}$ 132.1) and exhibited geographic variation. Plicae means for *A. dubius* ranged from 131.2 in the New York-North Carolina region to approximately 132–136 from Massachusetts northward.

Number of vertebrae, a standard character examined by previous researchers interested in *Ammodytes*, also proved to be a relatively good character in separating species. Although some overlap in vertebral numbers exists, particularly south of Nova Scotia, 92.3% separation was achieved at a line of separation between 68 and 69 vertebrae (Table 2). *Ammodytes americanus* had fewer vertebrae, with mean values ranging from 65.2 in specimens from New York to North Carolina and increasing to a mean value of 67.2 in specimens from Quebec to Labrador. *Ammodytes dubius* characteristically had more vertebrae than *A. americanus*, with means ranging between 70–71 in the southern portions of its range (Maine to North Carolina) to 73.8 in the Quebec-Nova Scotia region and 71.9 off Labrador. There is a distinct increase in vertebral number ($\bar{x}$ 72.9) in specimens of *A. dubius* taken off the Scotian Shelf and northward.

Dorsal ray counts were also effective in separating specimens. Using this character alone, 92.3% of the specimens could be separated at a line of separation between 59 and 60 dorsal rays. *Ammodytes americanus* had relatively consistent dorsal ray counts throughout the entire geographic range (Table 3; 52–61, $\bar{x}$ 57.4); however, in comparison, number of dorsal rays for *A. dubius* was higher for specimens collected north of

Table 1

Frequency distribution of plicae counts for *Ammodytes americanus* and *A. dubius* in four geographic regions.

	A. americanus					*A. dubius*				
	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total
106			1		1					
107			1		1					
108	1		1		2					
109	1		—	1	2					
110	1	1	1	2	5					
111	2	5	—	1	8					
112	5	1	7	3	16					
113	2	2	1	8	13					
114	5	4	8	16	33					
115	7	4	7	7	25					
116	10	4	3	11	28					
117	10	7	8	10	35					
118	18	9	5	12	44					
119	13	2	6	6	27					
120	8	2	6	5	21					
121	8	9	6	5	28					
122	8	3	6	2	19					
123	1	2	4	7	14					
124	1	2	8	5	16	1		2	2	5
125	1			2	3	3	1	—	8	12
126	1				1	2	—	2	10	14
127						4	—	2	25	31
128						1	—	3	14	18
129						1	3	4	24	32
130						2	2	8	33	45
131						1	2	6	20	29
132						2	3	9	18	32
133						—	1	1	22	24
134						1	6	8	23	38
135						1	2	2	19	24
136						—	3	3	9	15
137						1	8	3	6	18
138						—	4	4	5	13
139						4	4	1	3	12
140						1	2	2	1	6
141						—	2	—	—	2
142						—	—	—	—	—
143						2	3	—	1	6
144							1	1	1	3
145							1	—		1
146								—		—
147								1		1
$\bar{x}$	117.6	117.4	117.7	116.1	117.4	131.8	136.0	132.6	131.2	132.1
N	103	57	79	103	342	27	48	62	244	381

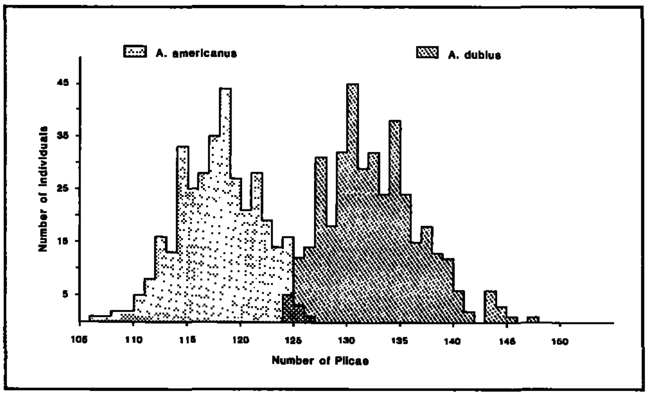

Figure 5

Histogram of counts of lateral plicae for *Ammodytes americanus* (106–126, $\bar{x}$ 117.4) and *A. dubius* (124–147, $\bar{x}$ 132.1).

Table 2
Frequency distribution of vertebral counts for *Ammodytes americanus* and *A. dubius* in four geographic regions.

	A. americanus					*A. dubius*				
	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total
62				2	2					
63	1			8	9					
64	6	1	11	18	36					
65	4	3	9	40	56					
66	17	8	14	16	55					
67	24	21	16	7	68					
68	29	16	18	3	66	2			16	18
69	15	4	7	4	30	3		12	39	54
70	1	1	2	1	5	5		23	87	115
71						3	1	22	64	90
72						2	3	3	23	31
73						2	15	1	4	22
74						6	14			20
75						4	8			12
76							3			3
$\bar{x}$	67.2	67.2	66.6	65.2	66.4	71.9	73.8	70.3	70.2	70.8
N	97	54	77	99	327	27	44	61	233	365

Table 3
Frequency distribution of dorsal ray counts for *Ammodytes americanus* and *A. dubius* in four geographic regions.

	A. americanus					*A. dubius*				
	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total
52			1		1					
53	1		2	1	4					
54	1	2	3	2	8					
55	1	4	5	7	17					
56	12	5	9	7	33				1	1
57	15	16	8	8	47				—	—
58	21	10	8	5	44	1		1	2	4
59	19	10	8	2	39	4		1	11	16
60	12		3	2	17	2		3	35	40
61	1		1	3	5	1		12	77	90
62						3	2	19	80	104
63						1	7	6	23	37
64						2	14		6	24
65						2	11			13
66						3	6			9
67						1	2			3
$\bar{x}$	57.9	57.2	56.9	56.9	57.4	62.4	64.4	61.5	61.3	61.8
N	83	47	48	37	215	20	42	42	235	341

Maine. Overall, dorsal ray counts for *A. dubius* varied from 56 to 67 rays. Specimens examined had means of 62.4 and 64.4 for Labrador and Quebec–Nova Scotia, respectively, compared with 61.5 in Maine–Massachusetts and 61.3 in the New York–North Carolina region.

Anal rays, the least successful character for separating specimens (Table 4), provided only 75.7% separation of individuals (at a line of separation between 29 and 30 anal rays). Means for *A. americanus* ranged from 29 in southern regions to 29.7 off the coast of Quebec northward to Labrador, with total number of rays varying between 26 and 33 (overall $\bar{x}$ 29.4). Geographic variation was again evident in anal ray counts for *A. dubius*. Counts averaged between 30 and 31 rays

Table 4
Frequency distribution of anal ray counts for *Ammodytes americanus* and *A. dubius* in four geographic regions.

	A. americanus					*A. dubius*				
	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total
26			2		2					
27	4	2	6	6	18					
28	10	4	15	3	32				4	4
29	23	13	8	15	59			1	27	28
30	27	18	8	9	62	2		17	76	95
31	13	9	7	4	33	6	2	15	99	122
32	6	2	3		11	6	6	11	32	55
33	1				1	4	17		5	26
34						3	14			17
35						1	7			8
$\bar{x}$	29.7	29.7	29.0	29.1	29.4	32.1	33.4	30.8	30.6	31.1
N	84	48	49	37	218	22	46	44	243	355

Table 5
Frequency distribution of pectoral ray counts for *Ammodytes americanus* and *A. dubius* in four geographic regions.

	A. americanus					*A. dubius*				
	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total
11			1		1					
12	12	5	14	10	41	1			4	5
13	62	40	49	53	204	17	2	10	35	64
14	20	11	14	35	80	6	25	39	155	255
15	1	1	1	5	8	3	21	14	47	85
16									2	2
$\bar{x}$	13.1	13.1	13.0	13.3	13.2	13.4	14.4	14.1	14.0	14.0
N	95	57	79	103	334	27	48	63	243	381

for specimens collected south of the Scotian Shelf (New York–North Carolina, $\bar{x}$ 30.6; Maine–Massachusetts, $\bar{x}$ 30.8) while specimens collected further north had mean values of 33.4 (Quebec–Nova Scotia) and 32.1 (Labrador).

The number of pectoral rays varied little geographically (Table 5) and was one of the least successful characters for separating the species. Modally, *A. americanus* had 13 rays (11–15, $\bar{x}$ 13.2) while *A. dubius* had one more ray, 14 (12–16, $\bar{x}$ 14.0). Only 78.0% of the specimens could be separated solely on this character (at a line of separation between 13 and 14 pectoral rays).

Gill rakers did not show pronounced geographic trends as was evident for vertebral counts (Table 6). For *A. americanus*, counts varied between 21 and 28, with means ranging from 23.7 (Labrador) to 24.9 (Massachusetts–Maine). Mean values for *A. dubius* clustered around 26 or 27 gill rakers ($\bar{x}$ 26.6, range 23–31 overall). At a line of separation between 25 and 26 gill rakers, 81.4% of the specimens could be separated into species using only this character.

Ammodytes dubius showed geographic variation in all the meristic characters examined. Meristic values increased northward with the exception of Labrador. Offshore Labrador collections were sparse; therefore, sample size is only half as large as other regions. Examination of additional material is necessary to determine if meristic values for *A. dubius* collected off Labrador are consistently lower.

The meristic characters used in this study separate the western North Atlantic sand lances into low- and high-count species. Each character, however, exhibited some overlap (ranging from approximately 3% for plicae counts to 49% for anal rays) and did not separate 100% of the specimens. Combinations of characters then became important in verifying identifications, particularly for individuals with intermediate counts.

Table 6
Frequency distribution of gill raker counts for *Ammodytes americanus* and *A. dubius* in four geographic regions.

	A. americanus					*A. dubius*				
	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total	Labrador	Quebec–Nova Scotia	Maine–Massachusetts	New York–N. Carolina	Total
21	1				1					
22	9	5	1		15					
23	30	18	7	13	68	4		1		5
24	28	22	19	29	98	5	1	4	7	17
25	18	7	23	22	70	4	3	8	37	52
26	2	5	14	15	36	4	9	18	70	101
27			5	5	10	4	10	7	66	87
28			1	1	2	2	13	6	50	71
29							7	—	9	16
30							1	1	3	5
31							2			2
$\bar{x}$	23.7	23.8	24.9	24.7	24.3	25.2	27.4	26.1	26.6	26.6
N	88	57	70	85	300	23	46	45	242	356

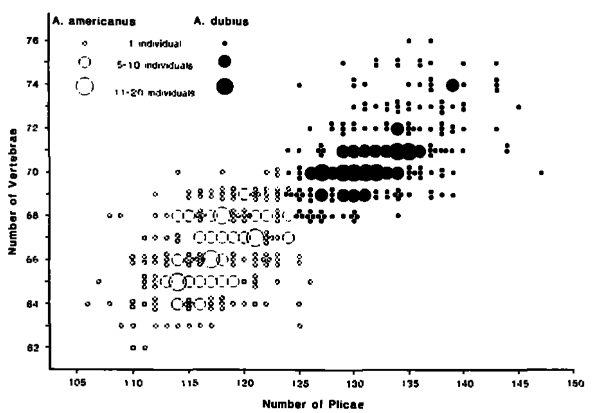

Figure 6
Scattergram of vertebral count plotted against number of lateral plicae for *Ammodytes americanus* and *A. dubius*.

Plicae and vertebral counts, when plotted against one another, were the most useful combination of characters for the entire geographic range producing virtually 100% separation (Fig. 6).

The results of a PCA run on meristic data confirmed the usefulness of these characters. Since factor 1 accounted for 91% of the variation and all the meristic characters loaded heavily on this factor, factor 1 was the only factor used. Plicae had the highest component loading score (8.09) followed by dorsal rays (2.44), vertebrae (2.31), gill rakers (1.23), anal rays (1.03), and pectoral rays (0.45).

The histogram of component scores (Fig. 4) produced a bimodal distribution with little overlap above or below a score of 1378 for the first set of individuals evaluated. When the scores were compared with the earlier tentative identifications (based only on meristics), only 10 (5 of each species) were either borderline or placed into the wrong species grouping. These 10 individuals were then reexamined and either the proposed identification was verified (3 cases) or errors in the counts of certain meristic characters were found (7 cases).

At most, 2% of the specimens were misclassified using the component scores. Of 54 additional specimens tested against the equation, none were misclassified. This methodology, therefore, was consistent and reliable.

Based on these results, diagnoses for the two species follow:

Ammodytes americanus

Diagnosis *Ammodytes americanus* tends to have lower counts than *A. dubius*: lateral plicae 106–126 ($\bar{x}$ 117.4); vertebrae 62–70, usually 64–69 ($\bar{x}$ 66.4); dorsal fin rays 52–61 ($\bar{x}$ 57.4), anal fin rays 26–33 ($\bar{x}$ 29.4), and pectoral fin rays 11–15 ($\bar{x}$ 13.2), with the most common dorsal, anal, and pectoral ray counts being 55–59, 27–31, and 13 rays, respectively; gill rakers on the first arch 21–28 ($\bar{x}$ 24.3).

Six meristic characters in combination provide a good separation of this species from *A. dubius*. Number of plicae, however, is the single best character for distinguishing *A. americanus* from *A. dubius* in the western North Atlantic. Vertebrae plotted against plicae separate individuals of the two species with little overlap (Fig. 6).

Distribution Based on our samples, *A. americanus* ranges coastally from southern Delaware north through

Labrador (Fig. 2). Previous studies reported its occurrence in Chesapeake Bay (Richards 1982, Norcross et al. 1961); however, no specimens were examined from Chesapeake Bay during this study.

This species occurs in shallow coastal waters and in protected bays and estuaries. Frequently, specimens were collected with seines or dipnets on sandy beaches in less than 2 m of water. Identification of individuals based only on locality (i.e., inshore vs. offshore) can be made with discretion, but some collections (approximately 20%), mainly from inshore stations, contain both species.

Ammodytes dubius

Diagnosis *Ammodytes dubius* shows geographic variation in meristic features (Tables 1–6), and counts for this species are higher than those of *A. americanus*: lateral plicae 124–147 ($\bar{x}$ 132.1); vertebrae 68–76 ($\bar{x}$ 70.8) with 69–74 being the most common; dorsal fin rays 56–67 ($\bar{x}$ 61.8), anal fin rays 28–35 ($\bar{x}$ 31.1), and pectoral fin rays 12–16 ($\bar{x}$ 14.0). The majority of individuals examined have ≥60 dorsal, ≥29 anal, and 14 pectoral rays. More gill rakers (23–31, $\bar{x}$ 26.6) are present on the first arch than in *A. americanus*. As described previously, plicae count is the best single distinguishing character; however, vertebrae plotted against plicae separate the species with little overlap (Fig. 6).

Distribution *Ammodytes dubius* ranges from North Carolina to Greenland (Fig. 2) and is found in deeper, more offshore waters than *A. americanus*. *Ammodytes dubius* is occasionally found inshore but is generally taken in deeper, open waters. This species has a broad bathymetric distribution in coastal waters and ranges in depth from 7 to 80 m. Both species were taken together in approximately 20% of the samples examined, with the majority of these samples being collected at inshore stations or around islands just offshore. Winters and Dalley (1988) reported co-occurrence inshore of *A. americanus* and *A. dubius*, particularly in Newfoundland waters. Although none of the collections that we examined from Quebec–Nova Scotia contained both species, mixed collections were found in all other geographic areas. Several mixed collections (6 of 11 collections) contained only one or two individuals of *A. dubius*, with the remainder of the lot being *A. americanus*. Two of the 11 collections were all *A. dubius* except for one specimen of *A. americanus*.

Greenland *Ammodytes* Since doubts exist with regard to the number of species and the appropriate names of species occurring in Greenland, these specimens were analyzed separately using the PCA equation and diagnoses used in analyzing and describing the species in other regions. Only those specimens ($N = 51$) with complete meristic data were included in the analysis. The majority of specimens fit our definition of *A. dubius*. Vertebral counts ranged from 66 to 75 ($\bar{x}$ 70.8); plicae counts from 124 to 156 ($\bar{x}$ 133.4); PCA scores from 1388 to 1636. Two specimens, however, fit our definition of *A. americanus*; one specimen had 70 vertebrae, 123 plicae, and a PCA score of 1374, and the other had 68 vertebrae, 124 plicae, and a score of 1372.

Discussion

Results of this study demonstrate, in accordance with the majority of previous research (Richards et al. 1963, Leim and Scott 1966, Winters 1970, Scott 1972, Richards 1982), that two species of sand lances occur in the western North Atlantic: an inshore species, *A. americanus*, with low meristic features, and an offshore species, *A. dubius*, characterized by high meristics.

No unequivocal method has been demonstrated previously to consistently identify individuals of *A. americanus* and *A. dubius*. Counts purportedly delineating the two species varied between studies, and considerable variation in meristic features for either one or both of these species has been reported. Additionally, earlier studies relied principally on vertebral counts (with supporting data from dorsal and anal ray counts) but this approach was inadequate to accurately identify all individuals. Plicae count, the most useful character in our study, was not used in the majority of previous studies. Furthermore, the lack of published detailed locality data in the majority of previous studies, consistent inshore/offshore designations, and a full understanding of migration patterns (Reay 1970) have added to the confusion in taxonomic status and ability to accurately identify species.

With no clear-cut definition of the western North Atlantic species, identification problems have hindered previous investigators. A case in point is the reported discrepancy in geographic distribution of *A. dubius* and resultant interpretations of species. Since the earliest studies by Reinhardt (1838) and DeKay (1842), species designations have not been consistent. Reinhardt (1838) described *A. dubius* from Greenland. Jordan and Evermann (1896) later reported that this species occasionally reached as far south as Cape Cod. In the revision of the Ammodytidae by Duncker and Mohr (1939), *A. dubius* was reported from throughout the North Atlantic. However, the majority of recent researchers disagree and have limited the range of *A. dubius* to the western North Atlantic. In 1963, Richards et al. reported *A. dubius* as extending further south to Virginia (37°N). Later Richards (1982), for no stated reason, reported a more limited distribution for *A. dubius*, with no individuals found further south than the Scotian Shelf. Winters and Dalley (1988) also reported *A. dubius* as ranging no further south than Georges Bank.

Restricting the southern limit of the range for *A. dubius* to Georges Bank creates several problems, in particular the explanation of a southern offshore, high-meristic form. Richards et al. (1963), Richards (1982), and Winters and Dalley (1988) recognized two populations of *A. americanus* in southern waters: one an inshore low-meristic form, and the other an offshore, intermediate- to high-meristic form. This conclusion seems to stem from Perlmutter's (1940) recognition of two offshore populations, one occurring north and one south of Cape Cod, which were designated as subspecies of *A. tobianus*. In those studies (Richards et al. 1963, Richards 1982, Winters and Dalley 1988), *A. americanus* was probably chosen for the species name for southern offshore specimens because meristic values (vertebrae, dorsal and anal fin rays) were more similar to the counts they found for *A. americanus* than for northern *A. dubius*. However, all of these studies reported and accepted the existence of a north-south and/or an inshore-offshore cline for at least one (but not always the same) species. Furthermore, the offshore *A. americanus* occupied the habitat commonly inhabited by *A. dubius*. Also, the morphometric description given by Winters and Dalley (1988) for their southern offshore *A. americanus* was the same as that for their *A. dubius*. Meristic differences between inshore and offshore *Ammodytes* in southern waters are consistent with a hypothesis of two distinct sympatric—but not necessarily syntopic—species, *A. americanus* and *A. dubius*, occurring in these waters. Additionally, meristic variation between northern and southern offshore forms supports the hypothesis of geographic intraspecific variation for *A. dubius*. The data are not consistent with a hypothesis recognizing only *A. americanus* in the southern region.

Misconceptions regarding species designations of western North Atlantic *Ammodytes* are further compounded by the tendency of some authors (Richards et al. 1963, Winters and Dalley 1988) to create three groups—a low, intermediate, and high meristic group—within their data sets to explain the variation, instead of recognizing geographic variation in the offshore species. Recognizing three groups results in considerable overlap between groups, thus adding to the difficulty of identifying species. Modal analysis (only for vertebrae; Winters and Dalley 1988) in some cases seems to identify modes that are not immediately obvious in the accompanying figures or data. The accuracy of identifying groups within collections, let alone individuals, is questionable using this method. The number of components and first estimates of the modes and standard deviation must be specified first. Additionally, as Winters and Dalley (1988) point out, the reported high standard error for certain modes indicates that these means are estimated poorly.

To eliminate confusion or guesswork surrounding identification of individuals of *Ammodytes*, it was necessary to devise an objective method of identification. PCA achieves this goal since this method identifies patterns of variation between individuals without regard to the groups represented. PCA scores were utilized as a tool to summarize the data and to verify the usefulness of these meristic characters. A plot of the component scores of 332 individuals clearly showed two groups (Fig. 4). Further testing showed that these groups represent the two species. Thus, the two species can be separated using meristic characters instead of morphometric ratios of questionable validity (i.e., length-weight; see Scott 1972) with little overlap.

Furthermore, by designating a component score boundary between the two groups, the two species are clearly defined and meristic variation can be delimited for each of the two species. This is particularly important for individuals with intermediate counts, especially those occurring in collections containing both species. These individuals were the hardest to identify, but defined limits for plicae, vertebral, and dorsal ray counts made identifications easier.

To support our data analysis, a comparison with Perlmutter's 1940 data was made (Table 7; in the present study, Northern = Labrador and Quebec–Nova Scotia, Southern = Maine–Massachusetts and New York–North Carolina). The Perlmutter (1940) data were utilized because the data collected and geographic locations were similar. Designations of north-south as well as inshore-offshore locations were given also. Means for meristic data were surprisingly similar between the two studies.

Perlmutter (1940) recognized north-south and inshore-offshore clines in his data, yet misinterpreted these results. He designated several subspecies within a single worldwide polytypic form instead of recognizing geographic variation within two parapatric species. Evidence for recognition of two species is that both species have been collected in sympatry in coastal waters, particularly in the Newfoundland area. It has been postulated that *A. dubius* spawns inshore along the Newfoundland coast (Dalley and Winters 1987). The continued occurrence of high meristic individuals inshore suggests that these species are reproductively isolated (Winters and Dalley 1988). Our data provide additional support for recognition of two parapatric species since there tend to be ecological differences between the species, in particular, habitat preference.

Table 7

Comparison of mean meristic values for characters used by Perlmutter (1940) and in the present study.

	Perlmutter (1940) $\bar{x}$	Nizinski et al.[1] $\bar{x}$
Vertebrae[2]		
A. americanus		
Northern	67.3	67.0
Southern	65.5	65.2
A. dubius		
Northern	73.5	72.0
Southern	70.0	70.2
Dorsal rays		
A. americanus		
Northern	57.0	57.3
Southern	55.3	56.9
A. dubius		
Northern	63.3	62.8
Southern	60.3	61.3
Anal rays		
A. americanus		
Northern	28.8	29.5
Southern	27.6	29.1
A. dubius		
Northern	32.3	32.1
Southern	29.6	30.6
Pectoral rays		
A. americanus		
Northern	13.2	13.1
Southern	13.7	13.3
A. dubius		
Northern	14.4	14.0
Southern	14.2	14.0

[1]Northern = Labrador and Quebec–Nova Scotia
Southern = Maine–Massachusetts and New York–North Carolina
[2]Hypural plate excluded.

The majority of individuals have been collected either inshore (*A. americanus*) or offshore (*A. dubius*) with little syntopic occurrence. We conclude, therefore, that two distinct species, *A. americanus* and *A. dubius*, occur in the western North Atlantic Ocean.

A similar case has been reported for the species of *Ammodytes* (*A. personatus* and *A. hexapterus*) found off Japan. Populations of morphologically and meristically similar individuals are difficult to distinguish from one another. Electrophoretic data, however, suggest that two sympatric, genetically distinct groups do occur among these *Ammodytes* species (Okamoto 1989). Perhaps a similar analysis is needed for the western North Atlantic ammodytids to confirm species designations.

As previously mentioned, this study is a preliminary step toward understanding a more complex problem. Many other questions, including the taxonomic status of Greenland *Ammodytes*, remain unanswered. Specimens examined in our study ($N = 51$) had high counts, similar to those obtained for *A. dubius*. But counts for these individuals were highly variable and did not agree completely with those of *A. dubius* from the western North Atlantic. In particular, some specimens had low vertebral counts and extremely high plicae counts. Others with low plicae counts, albeit still in the range for *A. dubius*, tended to have high vertebral counts. Based on meristic combinations and computed PCA scores, the Greenland sand lance is most similar to *A. dubius*. This finding adds to the existing conflict over which species are found in Greenland. Published accounts indicate two species of sand lances occur in this region: high-meristic *A. dubius*, and a low-meristic, inshore species that has been called *A. marinus* by Winters and Dalley (1988) as were all western Atlantic *A. americanus*. However, there is some question to the identity of the low-meristic sand lance occurring in Greenland. Counts for these specimens match those of *A. americanus* as well as the European *A. marinus*. The low-meristic Greenland species has reportedly been dipnetted and seined on shallow beaches and in protected fjords. *Ammodytes marinus*, on the other hand, is described as the commonly occurring offshore, deeper-water species in the eastern North Atlantic (Richards et al. 1963, Wheeler 1969, Reay 1970), although this species has also been reported from inshore stations (Raitt 1934, Kirillov 1936).

A limited number of *A. marinus* from the British Isles were examined; however, the data from these fish posed more questions than solved existing problems. Meristic features of these specimens spanned the ranges recorded for *A. americanus/dubius*, and morphological differences between these three species were not distinctive. The problem is further complicated since *A. dubius* and *A. marinus* are believed to be on opposite shores of the Atlantic (Reay 1970) yet both have been reported from Greenland. The taxonomic status of *Ammodytes* occurring in Greenland waters cannot be resolved until meristic and geographic ranges of European *A. marinus* are determined.

Taxonomic confusion is not restricted to Atlantic species; the taxonomy of North Pacific *Ammodytes* is problematical as well. Researchers agree that *A. hexapterus* and *A. personatus* occur in Japanese waters (Kitaguchi 1979, Hashimoto 1984), with *A. hexapterus* reported as the more northern species and *A. personatus* as the more southerly species. But these species also are similar morphologically and have overlapping counts (vertebrae and dorsal and anal fin rays). Additionally, high variability with two existing modes in the meristic data suggest the presence of two subpopulations in the southern *A. personatus* group (Hashimoto and Kawasaki 1981, Hashimoto 1984). Isozyme differences have indicated three separate genetic stocks (one *A. hexapterus* and two *A. personatus*; Hashimoto 1984), and recent electrophoretic analysis confirms the existence of a northern and southern population of *A. personatus* as well as a possible new species or subspecies (Okamota et al. 1988, Okamota 1989). Morphological differences, however, are not significant between populations and between species, and it remains to be decided if designation of subspecies within this species complex is appropriate (Hashimoto 1984).

Problems also occur in defining limits between North Pacific and western North Atlantic species of *Ammodytes*. Some investigators (Lindberg 1937, Andriashev 1954, Walters 1955, Richards et al. 1963) have suggested that *A. hexapterus* is circumpolar and extends from the Pacific into the Arctic and North Atlantic oceans. These workers have argued that *A. hexapterus* is synonymous with *A. americanus* and/or *A. marinus*. A limited number of *A. hexapterus* ($N=5$) from Alaska and *A. marinus* ($N=15$) from the British Isles were examined and no distinct morphological or meristic characters were found to clearly separate these species from those occurring in the western North Atlantic. Both *A. hexapterus* and *A. marinus*, however, are usually characterized as occurring in deeper, offshore waters. Obviously, the entire genus is in need of revision.

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Appendix 1: Material examined

Abbreviations of institutions

AMNH	American Museum of Natural History, New York
ANSP	Academy of Natural Sciences, Philadelphia
ARC	Atlantic Reference Centre, Huntsman Marine Laboratory, St. Andrews, New Brunswick
FMNH	Field Museum of Natural History, Chicago
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge
NMC	National Museum of Natural Science, Ottawa, Canada
UMMZ	University of Michigan Museum of Zoology, Ann Arbor, MI
USNM	National Museum of Natural History, Smithsonian Institution, Washington, DC
VIMS	Virginia Institute of Marine Science, Gloucester Point, VA
ZMUC	Kobenhavns Universitet Zoologisk Museum, Copenhagen, Denmark

Material is listed by species, geographically from north to south.

Ammodytes americanus

Labrador 177 specimens (49–157 mm SL) from nine collections. FMNH 31106–31116, 31118–31132 (25, 49–126) Anatalak Bay, Nain, Labrador; July–Aug. 1928. MCZ 12471 (8, 98–143) Labrador. MCZ 12480 (52, 80–145) Labrador. MCZ 12481 (17, 105–157) Labrador; Packard; 1865. MCZ 12482 (30, 85–155) Labrador. MCZ 51802 (4, 69–76) Hamilton Inlet, Collingham's Cove; *Blue Dolphin*; 7 Feb. 1952. USNM 165262 (1, 96) Indian Cove, Assyis Run, St. Lewis Sound, 52°15′N 55°04′W; *Blue Dolphin*; 12 July 1949. USNM 165300 (35, 96–147) Labrador, Hare Harbor, 53°43′N 56°46′W; *Blue*

Dolphin; 2 July 1950. USNM 165371 (5, 92–104) Labrador, mouth of Tessiujarsuk near Nain; *Blue Dolphin*; 8 Aug. 1951.

Newfoundland, Nova Scotia, and Quebec 90 specimens (52–147 mm SL) from 11 collections. MCZ 49725 (1, 147) Newfoundland, Nolan's Beach, Sweet Bay, Bonavista Bay; R.H. Backus; 7 June 1948. NMC 73-380 (3, 121–140) Newfoundland; Bonne Bay at Norris Point Wharf; B.E. Bowen; 9 July 1973. NMC 66-174 (1, 80) North Newfoundland, Griguet Harbor at Griguet, 51°32.5'N 55°28.5'W; D.E. McAllister and W.H. Vliet; 0–1 m; 18 June 1966. NMC 59-266 (38, 96–140) Quebec, Perce on tip of Gaspe Peninsula, Gaspe Co. 48°30'N 64°15'W; D.E. and N.A. McAllister; 0–1 m; 10 June 1959. NMC 81-0888 (11, 76–101) Quebec, Fleuve St. Laurent, 49°35'N 67°25'W; J.D. Dutil and B. Legare; 24 June 1981. USNM 88849 (1, 131) Quebec, north side of Matamer River; Amory-Bowman Expedition; 1927. ARC 8600807 (12, 97–124) Tabusintac estuary (gulley); M.J. Dadswell and G. Melvin; 0–1 m; 20 July 1977. ARC 8600809 (1, 90) New Brunswick; New River Beach; M.J. Dadswell et. al.; intertidal; 16 Sept. 1977. ARC 8600803 (1, 114) New Brunswick, St. Andrews; Oct 1949. UMMZ 193387 (20, 52–63) New Brunswick, Miramichi, inside West End Bay du Vin Island; R.A. McKenzie; 22 July 1942. ARC 8600802 (1, 125) Prince Edward Island; Aug. 1953.

Maine and Massachusetts 285 specimens (60–168 mm SL) from 14 collections. FMNH 17181-17185 (5, 141–168) Boothbay Harbor, ME; July 1931. MCZ 44877 (2, 95–102) MA, Barnstable Harbor; J. Morin. MCZ 57161 (14, 60–121) Chatham, upper Cockle Cove off Mill Creek Rd.; K.E. Hartel. MCZ 12464 (15, 86–123) Yarmouth; L. Agassiz. UMMZ 140537 (15, 106–133) MA, beach near Scituate between second cliff and third cliff; C.L. and L.C. Hubbs; 0–3 ft; 17 June 1928. USNM 302255 (126+, 75–105) Nahant, East Point, Marine Science Institute; B.B. Collette, BBC 1759; 0–1 m; 7 Aug. 1981. USNM 302256 (11, 76–108) 41°18'N 70°28'W; *Gloria Michelle* Cr. 8592, Sta. 57; 12 Sept. 1985. USNM 83720 (15, 91–128) MA, Truro; W.C. Kendall; 14 Sept. 1892. USNM 36925 (20, 101–119) MA, Bass Rocks, New Gloucester; A.H. Clark; Oct. 1879. USNM 132092 (20, 73–115) ME, Wood Island; *Grampus*; surface; 13 Oct. 1915. USNM 73499 (3, 97–105) MA, "The Cut" and Pavillion Beach, Gloucester; *Grampus*; 29 July 1895. USNM 302254 (10, 79–112) Newberry Port, MA, Merrimack R. USNM 302253 (22, 73–122) Martha's Vineyard Sound, MA. Fahay collection (7, 80–130) Nauset Marsh, Cape Cod; Fahay and Able.

New York to Virginia 199 specimens (83–137 mm SL) from three collections. AMNH 36590 (72, 89–120) NY, Suffolk Co., Sunken Meadows' State Park, east of Jetty Seine; G.J. Nelson et al.; 19 May 1977. AMNH 37692 (30, 83–118) Suffolk Co., Gardener's Island, tidal outlet, Bostwick's Pond; D.E. Rosen et al.; 22 Apr. 1977. ANSP 165786 (97, 83–137) approx. 2.5 naut. mi. SE of Little Egg Inlet, along axis of lump-5252; C.B. Milstein, CBM 72-145.

Ammodytes dubius

Labrador 14 specimens (121–203 mm SL) from two collections. USNM 165263 (11, 121–187) Pack's Harbor, 53°54'N 56°59'W; *Blue Dolphin*; 24 July 1949. USNM 165264 (3, 143–203) Hare Harbor; *Blue Dolphin*; 2 July 1950.

Newfoundland, Nova Scotia, and Quebec 72 specimens (107-244 mm SL) from five collections. NMC 64-763 (16, 178–209) off Newfoundland, Grand Banks, 45°06'30"N 49°01'00"W; *A.T. Cameron*; 14 Oct. 1964. NMC 64-764 (11, 169–244) off Newfoundland, Grand Banks, 54°02'50"N 49°04'15"W; *A.T. Cameron*; 5 Oct. 1964. VIMS 1224 (30, 192–230) 44°05'05"N 60°04'30"W; *A.T. Cameron* Cr. 176, Sta. 16. UMMZ 201715 (14, 107–195) Nova Scotia, caught on Middle Bank of Atlantic Ocean, 44°35'N 60°25'W; *S.T. Venosta*; Nov. 1938. ARC 8600808 (1, 155) Grand Bank, SE shoal water; G. Somerville; 8 July 1954.

Maine and Massachusetts 264 specimens (77–253 mm SL) from 15 collections. MCZ 40699 (1, 177) N. end Stellwagen Bank; F. Buinett. MCZ 62955 (3, 77–102) Martha's Vineyard, just off south coast between Chilmark and Edgartown; *Gloria Michelle* Cr. 8592, Sta. 53–56. VIMS 2293 (2, 249–253) 42°36'N 66°17'W; *Albatross IV* Cr. 6911, Sta. 214. USNM 67636 (4, 83–98) MA, North Truro, Cape Cod; *Grampus*; 9 June 1896. USNM 163734 (1, 256) Georges Bank, 41°21'N 67°33'W; R.L. Wigley; 1950. USNM 302242 (6, 80–128) 40°59'N 69°(26–28)'W; *Delaware II* Cr. 8207, Sta. 91; 44 m; 13 Oct. 1982. USNM 302245 (3, 112–122) 40°49'N 69°04'W - 40°48'N 69°05'W; *Delaware II* Cr. 8207, Sta. 92; 69 m; 14 Oct. 1982. USNM 302247 (15, 98–123) 41°21'N 67°26'W; *Delaware II* Cr. 8207, Sta. 123; 38 m; 21 Oct. 1982. USNM 302258 (55, 87–125) 41°28'N 67°46'W; *Delaware II* Cr. 8207, Sta. 124; 40 m; 21 Oct. 1982. USNM 302250 (26, 86–142) 41°33'N 67°58'W; *Delaware II* Cr. 8207, Sta. 125; 30 m; 21 Oct. 1982. USNM 302240 (17, 96–140) 41°38'N 68°27'W; *Delaware II* Cr. 8207, Sta. 128; 60 m; 22 Oct. 1982. USNM 302249 (10, 87–128) 41°35'N 66°58'W; *Delaware II* Cr. 8207, Sta. 143; 58 m; 23 Oct. 1982. USNM 302248 (50, 121–175) 41°51'N 70°29'W; *Gloria Michelle* Cr. 8592, Sta. 3; 13 m; 6 May 1986. USNM 302246 (45, 59–184) 41°35'N 69°56'W; *Gloria Michelle* Cr. 8592, Sta. 77; 7 m; 18 May 1986. USNM 302251 (46, 100–161) 42°05'N 70°08'W; *Gloria Michelle* Cr. 8592, Sta. 91; 16 m; 18 Sept. 1985. USNM 302257 (17, 84–108) 41°18'N 70°28'W; *Gloria Michelle* Cr. 8592, Sta. 57; 12 Sept. 1985.

New York to North Carolina 415 specimens (54–249 mm SL) from 24 collections. ANSP 36662-73 (13, 146–207) NJ, Carson's Inlet, Cape May Co.; R.J. Phillips; 1 Nov. 1908. VIMS 2294 (3, 175–193) 41°2.5'N 69°00'W; *Albatross IV* Cr. 7002. VIMS 2295 (19, 194–249) 39°03'N 73°41'W; *Albatross IV* Cr. 6908, Sta. 161. VIMS 2390 (1, 217) 28°28'N 74°37'W; *Sea Breeze*, Sta. T350. VIMS 2807 (3, 98–109) 37°51'N 75°08'W; McEachran. VIMS 2808 (9, 140–178) 38°07'N, 74°44'W; *Albatross IV* Cr. 6920, Sta. 2. VIMS 7377 (1, 186) 37°01'N 74°57'W, Virginia Shelf; *Captain Wool*. VIMS 7751 (4, 120–190) 40°47'N 69°40'W; *Albatross IV* Cr. 8005, Sta. 36, ANSP 165785 (153, 92–138) approx. 2.5 naut. mi. SE of Little Egg Inlet, along axis of lump-5252; C.B. Milstein, CBM 72-145. UMMZ 212624 (50, 100–185) NY, Plum Beach, Long Island; A. Perlmutter; 20 Dec. 1937. USNM 302243 (1, 159) 40°00'N 73°47'W - 40°01'N 73°44'W; *Delaware II* Cr. 8207, Sta. 44; 29 m; 8 Oct. 1982. USNM 302244 (3, 119–143) 41°11'N 71°24'W - 41°13'N 71°24'W; *Delaware II* Cr. 8207, Sta. 75; 38 m; 11 Oct. 1982. USNM 302241 (46, 54–182) 41°40'N 69°54'W; *Gloria Michelle* Cr. 8592, Sta. 78; 12 m; 19 May 1986. USNM 302229 (1, 132) 38°52'N 74°48'W; *Albatross IV* Cr. 8809, Sta. 78; 6.6 fm; 22 Sept. 1988. USNM 302230 (1, 117) 40°50'N 72°(22–24)'W; *Albatross IV* Cr. 8809, Sta. 135; 18 m; 27 Sept. 1988. USNM 302231 (1, 117) 36°55'N 75°52'W; *Albatross IV* Cr. 8809, Sta. 60; 5.7 fm; 19 Sept. 1988. USNM 302232 (15, 144–171) 39°24'N 73°29'W - 39°25'N 73°26'W; *Albatross IV* Cr. 8809, Sta. 95; 38 m; 23 Sept. 1988. USNM 302233 (25, 117–146) 38°47'N 74°08'W - 38°49'N 74°09'W; *Albatross IV* Cr. 8809, Sta. 84; 44 m; 22 Sept. 1988. USNM 302234 (1, 132) 40°40'N 72°58'W - 40°41'N 72°56'W; *Albatross IV* Cr. 8809, Sta. 130; 15 m; 26 Sept. 1988. USNM 302235 (20, 144–171) 39°23'N 73°43'W - 39°24'N 73°42'W; *Albatross IV* Cr. 8809, Sta. 94; 32 m; 23 Sept. 1988. USNM 302236 (2, 121–122) 37°(04–06)'N 75°18'W; *Albatross IV* Cr. 8809, Sta. 56; 27 m; 18 Sept. 1988. USNM 302237 (1, 125) 39°19'N 74°(21–23)'W; *Albatross IV* Cr. 8809, Sta. 88; 10 m; 22 Sept. 1988. USNM 302238 (24, 100–138) 36°46'N 75°24'W - 36°47'N 75°22'W; *Albatross IV* Cr. 8809, Sta. 54; 23 m; 18 Sept. 1988. USNM 302239 (18, 104–189)

38°47'N 73°15'W - 38°48'N 73°13'W; *Albatross IV* Cr. 8809, Sta. 3; 80 m; 13 Sept. 1988.

Ammodytes sp.

Greenland 55 specimens (48–192 mm). USNM 87373 (5, 48–55) P.H. Sorenson. MCZ 63338 (4, 63–77) 64°47.3'N 30°37.4'W; *Endevor* Cr. 133, Sta. 5. MCZ 63339 (2, 55–59) 65°23'N 29°22.8'W; *Endevor* Cr. 133, Sta. 12. ZMUC various lots (44, 57–192): 61150; store Hellefiskebanke, 24 Hum v.s.v. f. Rifkol, smaa sten; 10 July 1912; *Beskytteren*. P61152. P61153. P61154. P61158; Godhavn; Porsild. P61159; Bunden af. Kapisigdlitfjord øf lak seelven Aalehaandvaad; *Dana*, Sta. 2325. P61166; Greenland 66°44'N 53°W; *Dana*, Sta. 2349. P61312; Prøvens Havn, NV Grønland; Finn Salomonsen. P61322. P61324. 73; Grønland. 76. 78. 79. 84; 23/2, 49; N. 101. 89; Grønland. 9Od. 67°53'N 54°02'W. 121. 160; Jakobshavn; P. Müller. 161; Jakobshavn; P. Müller. 162; Claushavn; Ad. Jensen. 163; Disko Bügten. 165; Marrak i Sydostbugten, Opskyllet i Beg. af., Aug. 1906; Ad. Jensen. 169; Tkamiut i Sydostbugten; Lohmann. 170; Godhavn; Porsild. 176; Sukkertoppen; Bistrup. 178; Sukkertoppen; Bistrup. 179; Sukkertoppen; Bistrup. 180; Sukkertoppen; Bistrup. Uncat (15 spec.); Kigdluf Iluat, Grønland, 63°53'N 51°22'W.

Ammodytes marinus

USNM 302259 (2, 115–126) Brunswick Wharf; Thames and Wheeler. USNM 302260 (8, 88–148) Littlebrook and W. Thurrock; Thames. USNM 108812 (5, 160–171) British Isles; Firth of Forth, 56°12'N 2°43'W.

A. hexapterus

USNM 207553 (1, 159) AK, Cook Inlet, N. Barren Islands, S of Kenai Peninsula, 59°09'N 152°17'W; *Yaquina*; 60 fm; 30 July 1963. USNM 235313 (2, 91–143) AK, Aleutian Islands, NE Adak Island, southside of Clam Lagoon; J. Rosewater and P.R. Greenhall; 8 June 1979. USNM 266655 (2, 123–129) AK; *Miller Freeman*, Sta. B44; 14 Aug. 1982.