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Zooplankton Distribution and Abundance in West Greenland Waters, 1950–1984

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Abstract

Abundance indices of zooplankton obtained from offshore plankton surveys carried out in June–July from 1950 to 1984 off West Greenland were examined for trends and relationships with sea temperature and salinity. The zooplankton displacement volume and most of the zooplankton taxa showed higher abundance indices in the generally warmer period 1950–68 compared to the more variable period 1969–84. Sandeel larvae (*Ammodytes* sp.) were generally more abundant during cold periods after 1969. Zooplankton displacement volume showed a positive correlation ($r = 0.28$) with temperature, whereas correlations of individual zooplankton taxa with temperature or salinity were weaker. The relationships of zooplankton abundance indices with temperature suggest changes in zooplankton productivity during 1950–84.

Key words: distribution, fish, ichthyoplankton, Greenland, shrimp, species interactions, zooplankton

Introduction

In the twentieth century there have been major changes in the international annual landings of commercially important fish species in West Greenland waters (NAFO, 1995, 1998; Anon., 1998a). Historically, Atlantic cod (*Gadus morhua*) and redfish (*Sebastes marinus* and *S. mentella*) were the most important commercial fish species. In the late-1960s landings of both species declined drastically and have fluctuated at much lower levels since then. A few strong cod year-classes in the 1970s and 1980s were of Icelandic origin (Buch *et al*., 1994). During the last two decades Northern shrimp (*Pandalus borealis*) and Greenland halibut (*Reinhardtius hippoglossoides*) have been the most important fishery resources at West Greenland with annual landings peaking in 1992 at 87 000 and 30 000 tons, respectively (NAFO, 1998). The shift in landings composition over the last decades is assumed to be due mainly to changes in recruitment patterns driven by changes in oceanographic characteristics. Investigations of climatic variability off West Greenland indicate general decreasing trends in air and seasurface temperatures from the late-1960s onwards (Stein and Borovkov, 1997), which have been related to an increasing trend in the North Atlantic Oscillation index (Buch, MS 1990; Hurrell, 1995; Buch, MS 1998; Stein, 1998). Recruitment overfishing has not been described as an important cause of recruitment variability in West Greenland fish stocks.

Long time-series of plankton samples can be used to identify patterns of variation in marine systems (Aebischer *et al*., 1990; Mackas *et al*., 1998; Anderson and Piatt, 1999). Correlations with hydrographic data may reveal processes underlying the patterns. Understanding these processes provides building blocks for better understanding of the dynamics of marine systems, and thereby for better management of marine resources (Cushing, 1995a and b). Retrospective analyses of time-series of fishery-relevant environmental data is important for detection and prediction of climatic changes and their influence on the living marine resources (Anon., 1998b).

This paper presents data from zooplankton surveys conducted in West Greenland waters during 1950–84. The main objectives of the zooplankton investigations were: 1) to obtain abundance indices of larval Atlantic cod and other fish species to predict year-class strengths, 2) to obtain zooplankton abundance indices as indicators of food availability and quality for larval fish, 3) to provide a basis for identifying trends over time in species composition and productivity, 4) to identify indicator species for different hydrographical conditions.

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The West Greenland survey data represent one of the longest time-series of zooplankton data from the Northwest Atlantic. In this paper we analyse abundance indices of zooplankton for variation and trends, and examine relationships between zooplankton abundance, temperature and salinity, particularly in relation to long-term variations in the ocean climate before and after 1968.

Materials and Methods

Hydrography and zooplankton sampling

Annual oceanographic surveys were made in the Labrador Sea and in the Davis Strait off Southwest Greenland during late June–mid-July from 1950 to 1984 by the Greenland (Danish) Fisheries Research Institute. Over the time period the surveys have been made with the two Danish research vessels R/V *Dana* (before 1967) and R/V *Adolf Jensen* (after 1967). Zooplankton was sampled and physical and chemical oceanographic observations taken. Generally samples were taken at fixed positions along sections. However, the number of samples and distance from the coast varied greatly among years. In some years additional samples were taken at positions off the sections e.g. during the NORWESTLANT survey in 1963 (ICNAF, 1968; Smidt, 1971). Hydrography and zooplankton samples analysed in this paper were collected along three sampling sections Store Hellefiske Bank (S1), Sukkertop Bank (S2), and Fyllas Bank (S3), nearly perpendicular to the Greenland coast, at approximately 66º45'N, 65º06'N, and 63º50'N (Fig. 1). Analyses include all samples from the three sections (areas) most consistently sampled over the whole time-period (Fig. 2). In some years sampling at the five fixed positions at each section was hindered by bad weather conditions (reduced sampled size); additional samples from other positions (stations) were included in others years (increased sample size) (Table 1).

Sea temperature and water samples for measuring salinity were obtained at standard depths using modified Nansen reversing water bottles equipped with protected reversing thermometers (accurate to 0.01ºC.) (Sverdrup *et al.*, 1946). Temperature and salinity at each sampling station were calculated as means of measurements taken in 10–50 m (usually sampled at 10, 25, and 50 m or 10, 20, 30, and 50 m).

The zooplankton sampling gear was a 2 m (diameter) stramin ring-net with 1 mm mesh. Tows were made for 30 minutes at about 2 knots. Prior to 1963, and in 1964 and 1966, hauls were horizontal, stratified with two nets on the same wire, in three 10 minutes deployments. In this "step-wise setting" procedure two nets operated simultaneously on the same wire with a distance of 100 m of wire between them. Wire lengths were 200, 150, and 125 m for the deeper net, and 100, 50, and 25 for the shallower net. In 1963 all tows were made obliquely with a single net with a maximum wire length at deployment of 225 m (which corresponds to a depth of approximately 50 m). In 1964 and 1966, stratified hauls with two nets were again made, but in all the following years, 1968 to 1984, all tows were made obliquely with a single net as in 1963. No sampling was done in 1951, 1965, and 1967. To make all zooplankton samples comparable on the scale of a single haul at each station, all samples were standardized to a 30 minutes tow. For the years (before 1963 and in 1964 and 1966) with stepwise settings and two concurrent sampling nets in two depth ranges (200 to 125 and 100 to 25 m wire length) the catch by each of the two nets was averaged. In the stepwise sampling procedure some extra hauling time was generally allocated. Based on records from the research vessel logs and data sheets, a conversion factor of 0.75 was used for the stratified hauls before 1963 and 0.85 for hauls in the years 1964 and 1966, to scale these catches to 30 minutes tows. Calibration experiments performed in 1984 on oblique tows estimated that a 30-minute tow at 2 knots filtered approximately 6 125 m^3 of seawater. We used this sampling unit for volumes and counts of zooplankton and fish larvae.

Preservation and species identification

Zooplankton samples were preserved in 4% formaldehyde supersaturated with borax. All large organisms (generally post-larval fish) were picked out from each sample. Because the gear is unlikely to retain salps and schyphomedusae effectively, those organisms were removed from the catch without quantification. The displacement volume of all remaining plankton, scaled to a 30-minute tow, was recorded. Subsamples were taken for counts of the zooplankton taxa. The subsample size in number depended on the size of the taxa and was adjusted so that all or a minimum of about 400 animals was counted per sample. Samples were split in a flat rectangular dish by a metal cross, or subsamples were taken volumetrically. Identification was made to species if possible or at least to family. In some years not all zooplankton taxa in the samples were sorted and counted; however, fish larvae were always quantified.

The zooplankton groups and species selected for analysis in this paper are listed in Table 2. Small animals are not caught by the 1 mm mesh size ring net

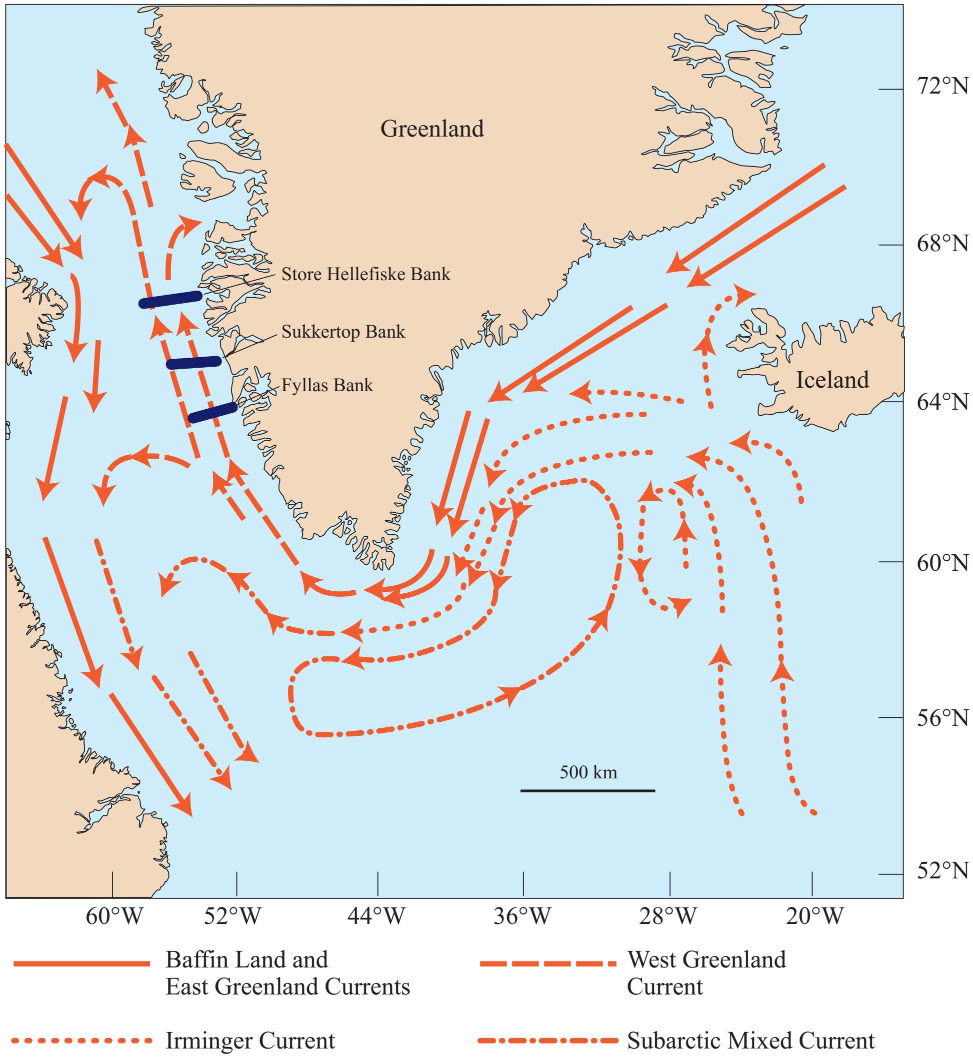

Fig. 1. Surface currents around Greenland and locations of the three hydrographic sections off West Greenland most consistently sampled for zooplankton, 1950–84 (surface currents simplified after Hachey *et al.*, 1954).

used, and many small developmental stages and small species are therefore not included (Table 2).

Analyses

The distributions of the zooplankton abundance indices by individual hauls and taxa showed non-normality in the residuals. Therefore, the effects of sampling year, section, depth to bottom, month and interactions were tested using multi-way nonparametric ANOVAs on the ranked dependent variables: temperature, salinity and abundance indices of different zooplankton taxa (SAS RANK and GLM procedures; Anon., 1985). ANOVA F tests on ranked data approximate p-values for large samples (Wannacott and Wannacott, 1985).

The model tested was:

$$E(rd) = y_i + s_j + d_k + m_n + ys_{ij} + ym_{in} + e,$$

where $E(rd)$ is the expected value of the ranked dependent variable;

y, s, d, m, e is the effects of year, section, depth to bottom, month of sampling, and error, respectively;

i is the year (1950–84),

j is the section (1–3),

k is the depth to bottom (100 m intervals), and

n is the month of sampling (June or July).

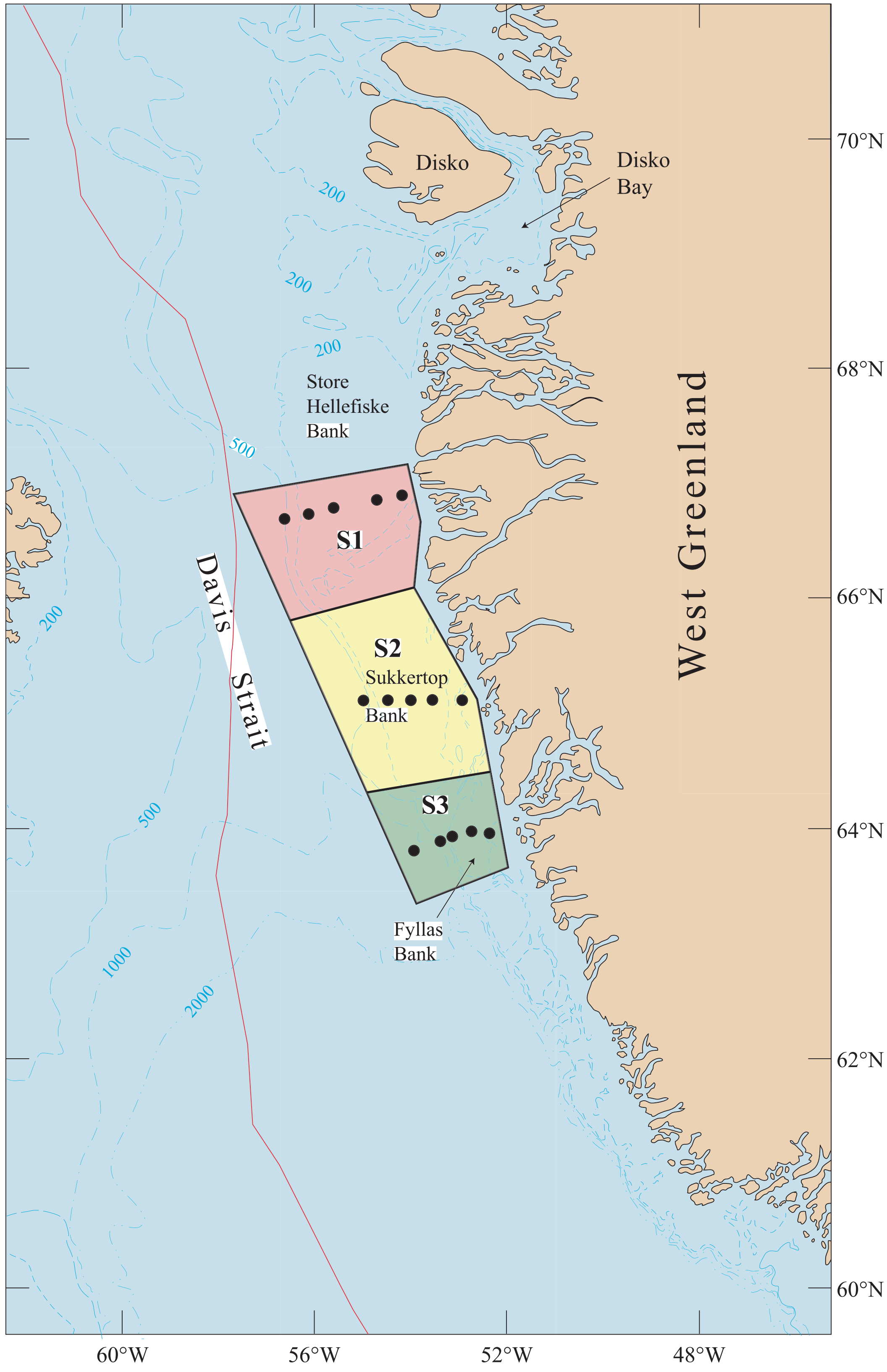

Fig. 2. Map showing the major physiographic features off West Greenland and the location of the study area and three sampling sections S1, S2 and S3. Dots are positions of sampling stations.

TABLE 1. Number of stations with hydrographic recordings and haul stations in which specific zooplankton were recorded, in surveys conducted in standard sections S1, S2 and S3 (see Fig. 1) through 1950–84 (zooplankton displacement volume was measured in most hauls). Abbreviations are given in Table 2.

	Number of Observations																												
	MTEMP			MSAL			PLVOL			WAGLA			RAGLA			COP			CALFI			CALHY			EUCH			HYPER		
YEAR	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
1950	4	4	2	4	4	2	8	7	3																					
1952	6	3	3	5	3	3	4	3	3																					
1953	6	5	5	6	5	5	7	4	4																					
1954	4	4	5	4	4	4	6	7	6																					
1955	5	3	3	5	3	3	8	5	3																					
1956	3	2	4	3	2	4	3	3	6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3
1957	4	2	4	4	2	4	5	3	5	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1
1958	4	3	4	4	3	4	4	5	5	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1
1959	5	4	4	5	4	3	5	3	6																					
1960			2				2	2	2																					
1961	6	4	2	6	4	2	6	4	3	6	4	3	6	4	3	6	4	3	6	4	3	6	4	3	6	4	2	6	4	3
1962	1		3			3																								
1963	6	15	10	6	15	10	12	26	13							12	20	6	12	20	6	12	20	6	12	20	6	12	20	6
1964	5	5	8	5	5	8	6	6	8	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5
1966	5	6	5	5	6	5	7	8	5	6	7	5	6	7	5	7	7	5	7	7	5	7	7	5	7	6	5	7	7	5
1968	4	5	8	4	5	8	6	7	9																					
1969	6	8	5	6	8	5	6	8	5																					
1970	5	5	15	5	5	15	6	7	15			4			4						12			12			14			14
1971	7	6	10	7	6	10	8	7	10			4			4						10			10			10			10
1972	6	4	8	6	4	8	7	7	9	7	6	4	7	6	4	7	7	9	7	7	9	7	7	9	7	7	9	7	7	9
1973	5	5	5	5	5	5	5	5	5			1			1						4			4			5			5
1974	5	5	5	5	5	5	7	6	5			4			4						3			3			5			5
1975	6	6	4	6	6	4	6	6	4												4			4			5			5
1976	6	6	5	6	6	5	6	6	5			5			5	1		5	1		5			5	1		5	1		5
1977	4	6	4	4	6	4	4	6	5							3	5	5		4	4		4	4		4	4	3	5	5
1978	6	6	5	5	5	5	6	6	5	5	6	5	5	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5
1979	7	6	6				7	6	6	7	6	5	7	6	5	7	6	5	7	6	5	7	6	5	7	6	5	7	6	5
1980	3	4	5	3	4	5	5	5	5	5	5	5	5	5	5	5	5	5										5	5	5
1981	5	4	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5										5	5	5
1982	2	5	4	2	5	4	2	5	5	2	5	5	2	5	5	1	4	5		4	5		4	5	2	5	5	2	5	5
1983	3	4		3	4		4	4		2	1		2	1		4	4		4	4		4	4		4	4		4	4	
1984	5	3	4	5	3	4	5	5	4																					

TABLE 1. (Continued). Number of stations with hydrographic recordings and haul stations in which specific zooplankton were recorded, in surveys conducted in standard sections S1, S2 and S3 (see Fig. 1) through 1950-84 (zooplankton displacement volume was measured in most hauls). Abbreviations are given in Table 2.

	Number of Observations																													
	EUP			CLIO			LIMA			LIMR			LIMH			CHAE			SHR			CRAB			GONA			Fish larvae		
YEAR	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
1950																												8	7	3
1952																												6	4	3
1953																												11	6	6
1954																												6	7	6
1955																												8	6	3
1956	3	3	3	3	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	6
1957	2	2	1	2	4	3	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	5	3	5
1958	2	1	1	2	3	4	2	1		2	1		2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	4	5	5
1959																												5	4	6
1960																												2	2	2
1961	6	4	3	6	7	6	6	4	3	5	4	3	5	4	3	6	4	3	6	4	3	6	4	3	6	4	3	6	4	3
1962																												1		3
1963	12	20	6	12	26	15	12	20	6	12	20	6	12	20	6	12	20	6	12	20	6	12	20	6	12	20	6	13	26	14
1964	6	6	5	6	9	8	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	8
1966	7	6	5	7	9	8	7	7	5	7	7	5	7	7	5	7	7	5	7	7	5	7	7	5	7	8	5	7	8	5
1968																												6	7	9
1969																												6	8	5
1970			14			14						14			14			14			14			14			14	6	7	15
1971			10			10						10			10			10			10			10				8	7	10
1972	7	7	9	7	7	10	7	7	9	7	7	9	7	7	9	7	7	9	7	7	9	7	7	9	7	7	9	7	7	9
1973			5			5						5			5			5			5			5			5	5	5	5
1974			5			5						5			5			5			5			5			5	7	6	5
1975			5			5						3			3			5			5			5			5	6	6	5
1976	1		5	1		5	1		5	1		2	1		2	1		5	1		5	1		5	1		5	6	6	5
1977	3	5	5	3	5	5	3	5	5	2	3	2	2	3	2	3	5	5	3	5	5	3	5	5	3	5	5	4	6	5
1978	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5	6	6	5
1979	7	6	5	7	6	5	7	6	5	7	6	5	7	6	5	7	6	5	7	6	5	7	6	5	7	6	5	7	6	6
1980	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
1981	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
1982	2	5	5	2	5	5	2	5	5	2	5	5	2	5	5	2	5	5	2	5	5	2	5	5	2	5	5	2	5	5
1983	4	4		4	4		4	4		4	4		4	4		4	4					4	4		4	4		4	4	
1984																												5	5	4

TABLE 2. List of species identified in the West Greenland zooplankton samples. X indicates group or species included in the analyses, abbreviations given in parentheses.

	Ctenophora:	
		Beroe cucumis
		Mertensia ovum
	Hydromedusae:	
X		*Aglantha digitale* (WAGLA = white form and RAGLA = red form)
		Sarsia tubulosa
		Sarsia princeps
		Euphysa sp.
		Bougainvillia superciliaris
		Ratkea ocopunctata
		Catablema vesicarium
		Catablema multicirrata
		Halitholus cirratus
		Laodicea undulata
		Staurophora mertensi
		Ptychogena lactea
		Halopsis ocellata
		Obelia sp.
		Aeginopsis laurentii
	Scyphomedusae: (Discarded, not included in plankton displacement volume)	
		Aurelia aurita
		Aurelia limbata
		Cyanea capillata
		Periphylla periphylla
	Siphonophora:	
		Physophora hydrostatica
		Dimophyes arctica
	Polychaeta:	
		Tomopteris spp.
		Autolytus sp.
	Ostracoda:	
		Concoecia elegans
		Concoecia obtusata
X	Copepoda (COP):	
X		*Calanus hyperboreus* (CALHY)
X		*Calanus finmarchicus* (include also *C. glacialis*) (CALFI)
X		*Euchaeta* (*Pareuchaeta*) *norwegica* (EUCH)
		Other species in total copepoda:
		Pleuromamma robusta
		Eucalanus elongatus
		Rhincalanus nastutus
		Euchirella rostrata
		Centropages sp.
		Metridia longa
		Heterorhabdus norwegicus
X	Hyperiidae (HYPER):	
		Parathemisto abyssorum
		Parathemisto gadicaudi
		Parathemisto libellula
		Hyperoche medusarum
		Hyperia galba
		Hyperia medusarum

TABLE 2. (Continued). List of species identified in the West Greenland zooplankton samples. X indicates group or species included in the analyses, abbreviations given in parentheses.

	Gammaridea:	
		Gammarus wilkitaki and others
X	Euphausiacea (EUP):	
		Thysanoessa longicaudata
		Thysanoessa inermis
		Thysanoessa raschii
		Meganyctiphanes norwegica
	Mysidacea:	
		Boreomysis nobilis
	Pteropoda:	
X		*Limacina* (*Spiratella*) *retroversa* (LIMR)
X		*Limacina* (*Spiratella*) *helicina* (LIMH)
X		*Limacina* sp. (LIMA)
X		*Clione limacina* (CLIO)
X	Chaetognatha (CHAE):	
		Eukrohnia hamata
		Sagitta elegans
		Sagitta maxima
	Copelata:	
		Oikopleura spp.
		Fritillaria borealis
	Decapod crustacean larvae:	
X		Shrimp (*Pandalus* sp.), mainly *Pandalus borealis* (SHR).
		Other shrimp larvae: *Spirontocaris* sp., *Sabinea septemcarinata*, and *Pontophilus norvegicus*.
X		Brachyuran zoeae, *Hyas* sp. and *Chionoecetes opilio* (CRAB)
	Gastropoda:	
		Velutina velutina
	Cephalopoda:	
X		*Gonatus fabricii* juv. (GONA)
	Fish eggs and larvae:	
X		Atlantic cod (*Gadus morhua*) (COD)
X		Greenland halibut (*Reinhardtius hippoglossoides*) (GHL)
X		Redfish (*Sebastes* sp.) (RED)
X		American plaice (*Hippoglossiodes platessoides*) (PLA)
X		Wolffish (*Anarhichas* sp.) (WOLF)
X		Sandeel (*Ammodytes* sp.) (SAND)
X		Capelin (*Mallotus villosus*) (CAP)

Correlations between temperature, salinity, and abundance indices of different zooplankton taxa were investigated using Spearman rank correlations (SAS CORR procedure; Anon., 1985) using data for individual stations. One-way ANOVA were used to examine residuals and test trends in the abundance of the different zooplankton taxa and covariability with temperature.

Results

Mean sea temperature and salinity

Residuals and least squares means of multi-way nonparametric ANOVA showed general trends of higher mean sea temperatures (MTEMP) during 1952–66, 1977 and 1979, on section 2, at depth to bottom between 200–400 m and in July (Fig. 3, Table 3).

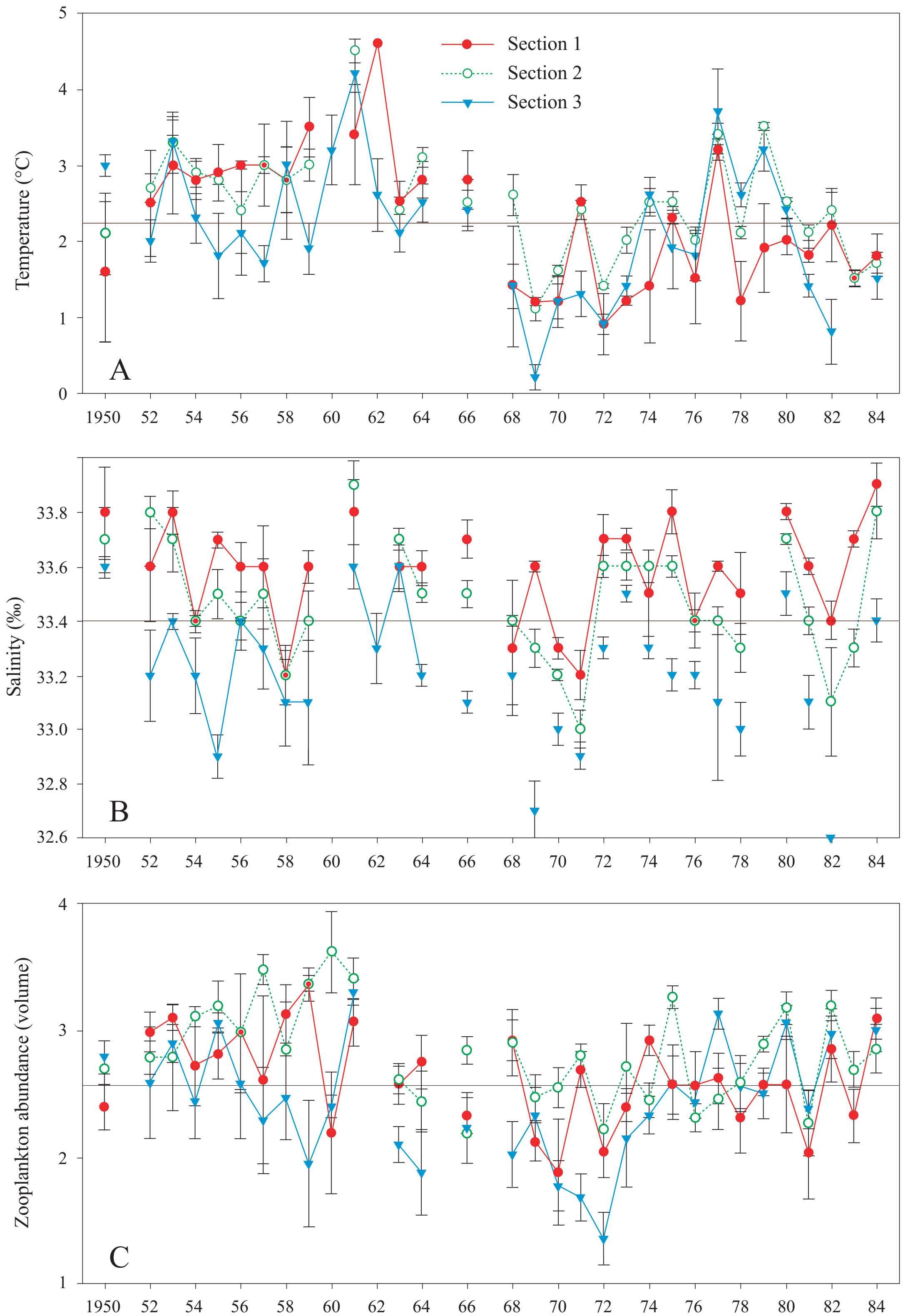

Fig. 3. Mean with standard error (**A**) sea temperature and (**B**) salinity of the 10–50 m layer, and (**C**) zooplankton displacement volume (ml) [*log*10(*x*+1)] in June–July by year and section (see Appendix 1). Horizontal reference lines indicate long-term mean (1950–84).

TABLE 3. Results of nonparametric multi-way analysis of variance (ANOVA) of hydrography data and abundance indices of different zooplankton taxa from individual stations. *DF* = degrees of freedom. 0.00 = (*Pr* <0.005). Abbreviations shown in Table 2.

	Source of variation					
	Year	Section	Depth	Month	Year × Section	Year × Month
Dependent variable=MTEMP			Total *DF*=454	R-square=0.75		
DF	31	2	10	1	57	13
F Value	12.41	8.55	9.32	50.34	1.95	2.04
Pr>F	0.00	0.00	0.00	0.00	0.00	0.02
Dependent variable=MSAL			Total *DF*=427	R-square=0.78		
DF	29	2	10	1	54	10
F Value	13.52	157.81	8.61	17.51	1.84	1.79
Pr>F	0.00	0.00	0.00	0.00	0.00	0.06
Dependent variable=PLVOL			Total *DF*=531	R-square=0.66		
DF	31	2	10	1	58	13
F Value	5.6	13.9	13.06	62.17	1.8	2.59
Pr>F	0.00	0.00	0.00	0.00	0.00	0.00
Dependent variable=AGLA			Total *DF*=270	R-square=0.69		
DF	20	2	10	1	28	2
F Value	10.48	11.46	8.52	2.5	0.91	1.38
Pr>*F*	0.00	0.00	0.00	0.12	0.60	0.26
Dependent variable=COP			Total *DF*=268	R-square=0.58		
DF	20	2	10	1	28	2
F Value	5.78	2.57	4.84	2.95	2.27	0.14
Pr>F	0.00	0.08	0.00	0.09	0.00	0.87
Dependent variable=CALFI			Total *DF*=226	R-square=0.56		
DF	18	2	10	1	22	2
F Value	4.95	7.42	3.64	1.47	1.73	0.28
Pr>F	0.00	0.00	0.00	0.23	0.03	0.76
Dependent variable=CALHY			Total *DF*=226	R-square=0.60		
DF	18	2	10	1	22	2
F Value	7.39	5.14	3.28	2.73	0.78	0.42
Pr>*F*	0.00	0.01	0.00	0.10	0.75	0.66
Dependent variable=EUCH			Total *DF*=230	R-square=0.54		
DF	18	2	10	1	22	2
F Value	4.18	0.77	5.19	1.02	2.51	0.86
Pr>F	0.00	0.47	0.00	0.31	0.00	0.43
Dependent variable=HYPER			Total *DF*=270	R-square=0.50		
DF	20	2	10	1	28	2
F Value	4.18	0.5	5.74	0.59	2.5	0.66
Pr>F	0.00	0.61	0.00	0.44	0.00	0.52
Dependent variable=EUP			Total *DF*=269	R-square=0.50		
DF	20	2	10	1	28	2
F Value	3.74	1.84	5.42	0.28	1.44	0.52
Pr>F	0.00	0.16	0.00	0.60	0.08	0.60

TABLE 3. (Continued). Results of nonparametric multi-way analysis of variance (ANOVA) of hydrography data and abundance indices of different zooplankton taxa from individual stations. *DF* = degrees of freedom. 0.00 = (*Pr* <0.005). Abbreviations shown in Table 2.

	Source of variation					
	Year	Section	Depth	Month	Year × Section	Year × Month
Dependent variable=LIMR			Total *DF*=257		R-square=0.65	
DF	20	2	10	1	27	2
F Value	6.76	18.6	6.51	0.65	2.75	0.26
Pr>F	0.00	0.00	0.00	0.42	0.00	0.77
Dependent variable=LIMH			Total *DF*=258		R-square=0.68	
DF	20	2	10	1	28	2
F Value	8.68	11.51	5.21	2.44	3.07	0.19
Pr>F	0.00	0.00	0.00	0.12	0.00	0.83
Dependent variable=CLIO			Total *DF*=270		R-square=0.56	
DF	20	2	10	1	28	2
F Value	5.31	0.4	2.97	8.35	2.55	3.27
Pr>F	0.00	0.67	0.00	0.00	0.00	0.04
Dependent variable=CHAE			Total *DF*=270		R-square=0.53	
DF	20	2	10	1	28	2
F Value	4.5	3.51	6.99	2.02	1.67	0.3
Pr>F	0.00	0.03	0.00	0.16	0.02	0.74
Dependent variable=SHR			Total *DF*=262		R-square=0.46	
DF	19	2	10	1	27	2
F Value	4.1	0.51	3.67	0.01	1.4	0.59
Pr>F	0.00	0.60	0.00	0.91	0.10	0.56
Dependent variable=CRAB			Total *DF*=270		R-square=0.55	
DF	20	2	10	1	28	2
F Value	4.58	15.18	4.04	0.77	1.55	0.04
Pr>F	0.00	0.00	0.00	0.38	0.04	0.96
Dependent variable=GONA			Total *DF*=261		R-square=0.59	
DF	19	2	10	1	28	1
F Value	4.53	7.15	11.67	0.01	1.59	0
Pr>F	0.00	0.00	0.00	0.92	0.04	0.95
Dependent variable=COD			Total *DF*=550		R-square=0.47	
DF	31	2	10	1	59	15
F Value	4.49	11.9	1.61	5.06	1.69	2.17
Pr>F	0.00	0.00	0.10	0.03	0.00	0.01
Dependent variable=GHL			Total *DF*=550		R-square=0.57	
DF	31	2	10	1	59	15
F Value	2.78	69.08	12.04	12.41	1.74	1.68
Pr>F	0.00	0.00	0.00	0.00	0.00	0.05
Dependent variable=RED			Total *DF*=550		R-square=0.38	
DF	31	2	10	1	59	15
F Value	2.78	1.54	1.15	4.4	1.5	2.65
Pr>*F*	0.00	0.22	0.32	0.04	0.01	0.00
Dependent variable=PLA			Total *DF*=550		R-square=0.52	
DF	31	2	10	1	59	15
F Value	3.28	51.23	5.36	1.3	1.67	1.12
Pr>F	0.00	0.00	0.00	0.26	0.00	0.34

TABLE 3. (Continued). Results of nonparametric multi-way analysis of variance (ANOVA) of hydrography data and abundance indices of different zooplankton taxa from individual stations. *DF* = degrees of freedom. 0.00 = (*Pr* <0.005). Abbreviations shown in Table 2.

	Source of variation					
	Year	Section	Depth	Month	Year × Section	Year × Month
Dependent variable=WOLF			Total *DF*=550		R-square=0.37	
DF	31	2	10	1	59	15
F Value	1.64	12.02	2.82	2.45	1.28	0.95
Pr>*F*	0.02	0.00	0.00	0.12	0.09	0.50
Dependent variable=SAND			Total *DF*=549		R-square=0.57	
DF	31	2	10	1	59	15
F Value	7.68	13.22	7.37	4.71	1.41	2.55
Pr>*F*	0.00	0.00	0.00	0.03	0.03	0.00

Effects of year and month explained most of the variation in mean temperature. The investigated interactions were also significant but explained minor parts of the variation (Table 3). Mean salinity (MSAL) was significantly lower during 1969–71 and 1982, from section 1 to 3 (north to south) and in July. Section and month explained most of the variation in mean salinity; interactions between year and month were not significant (Table 3).

One-way ANOVA and examination of the pattern of the residuals showed a significant decreasing trend in the mean sea temperature over the period 1950–84 ($r^2 = 0.14$, $p < 0.005$, $n = 91$). There was no significant trend in the salinity over the period.

Zooplankton displacement volume

Zooplankton displacement volume (PLVOL) showed decreasing trends from 1961 to 1972 (Fig. 3). PLVOL were generally higher on section 2, with increasing depth to bottom and in July. Sampling month explained most of the variations (Table 3). Distribution maps of zooplankton displacement volumes sampled in the years 1957 (warm year), 1963 (the year of the international NORWESTLANT survey – an average year for temperature) and 1982 (cold year) illustrate general trends in the data (Fig. 4). The highest densities of zooplankton were generally observed offshore in the Davis Strait, but in 1982 high densities of zooplankton were sampled inshore in the Disko Bay area (Fig. 4). Zooplankton displacement volume showed positive correlations with mean temperature and depth to bottom (Table 4).

Indices of invertebrate abundance

Aglantha digitale, including a white (WAGLA) and a red (RAGLA) form, showed a decreasing trend during the 1960s and an increasing trend from the early-1970s onwards (Fig. 5). Sampling section explained most of the variation and *A. digitale* showed a trend of higher abundance on section 2 (Table 3). Distribution maps of abundance indices of *A. digitale* in 1957, 1964 and 1982 illustrate trends in the data (Fig. 6). *Aglantha digitale* were generally more abundant in the deeper parts of Davis Strait, however, in 1982 high densities of the red form was sampled inshore in Disko Bay area (Fig. 6). The white form was positively correlated with temperature, whereas the red form was negatively correlated with temperature (Table 4).

Copepods (COP), *Calanus finmarchicus* (CALFI) and *C. hyperboreus* (CALHY) abundance indices showed decreasing trends during the 1960s, and copepods and *C. hyperboreus* increase again from 1977 onwards (Fig. 5). *C. finmarchicus* and *C. hyperboreus* showed trends of being more abundant on section 3 and 2, respectively. Highest abundances of *C. finmarchicus* and *C. hyperboreus* were observed in the Davis Strait and in Disko Bay with a trend of *C. hyperboreus* being more abundant than *C. finmarchicus* in Southwest Greenland (Fig. 7 and 8). The abundance of *C. finmarchicus* and *C. hyperboreus* were correlated ($r = 0.57$, $p < 0.005$, $n = 227$) and the abundance of both species showed correlations with the abundance of e.g. Pandalus shrimp larvae, juvenile squids (*Gonatus fabricii*), and larval fish of American

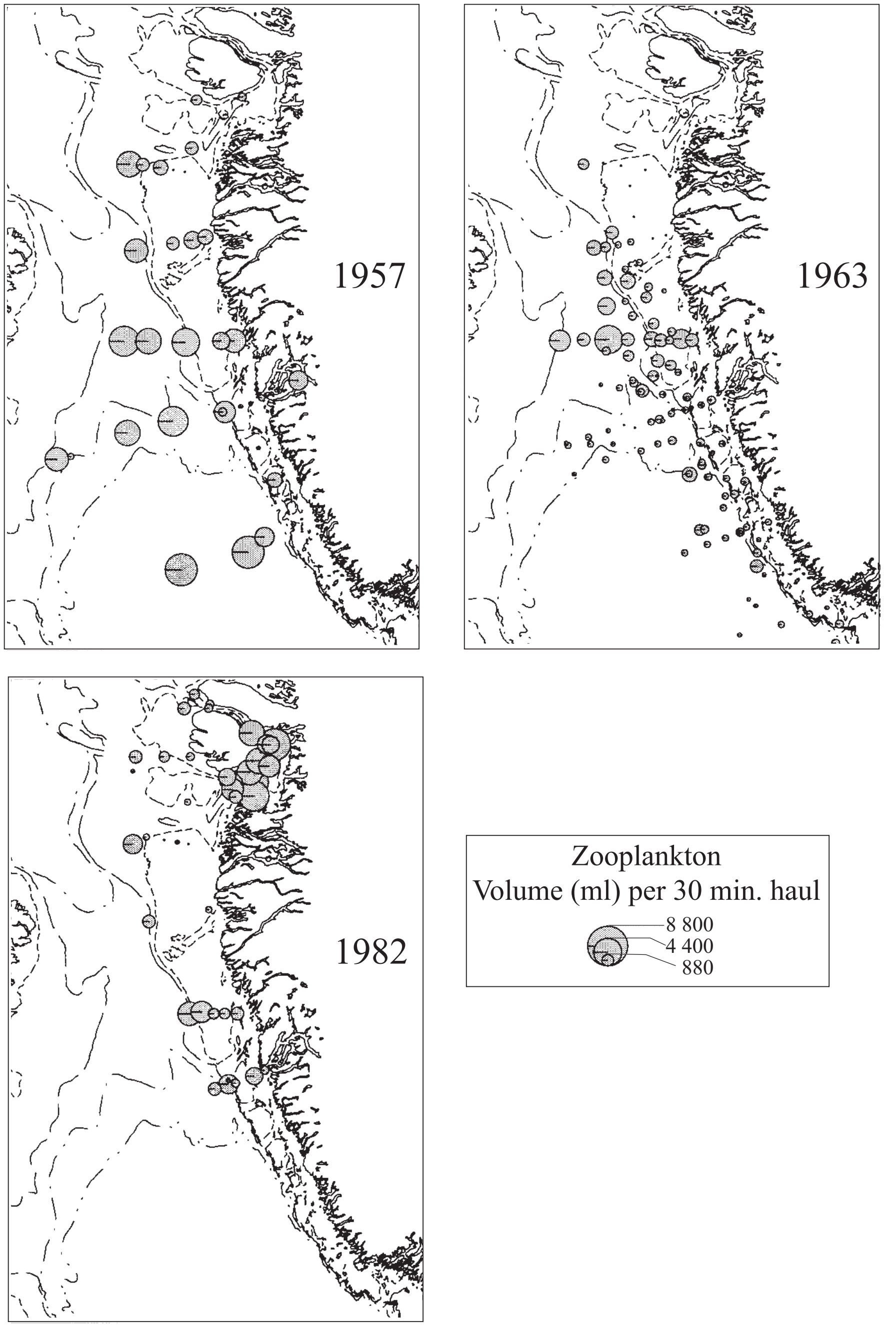

Fig. 4. Zooplankton displacement volume (ml) per 30 min. haul; all samples in June–July 1957, 1963 and 1982. Dot diameter is graduated by square root of the displacement volume.

plaice, and Greenland halibut (Table 4). The abundance of *C. finmarchicus* and *C. hyperboreus* showed no correlations with temperature or salinity (Table 4).

Euchaeta norwegica (EUCH) showed trends of being most abundant on section 2 and over deep water (above 500 m) (Fig. 9). *Euchaeta norwegica* showed relatively high abundance in the mid-1970s where the abundance of *C. finmarchicus* and *C. hyperboreus* were nil (Fig. 5). *Euchaeta norwegica* abundance was positively correlated with several zooplankton taxa e.g. *C. finmarchicus* (r = 0.52, p <0.005, n = 222); but not with temperature or salinity (Table 4).

TABLE 4. Spearman correlation coefficients (r) between temperature, salinity, depth to bottom and abundance indices of zooplankton taxa in the study area. p = prob >|r| under Ho: r Ho = 0. n = number of observations. 0.00 = (p<0.005). Abbreviations shown in Table 1.

	r/p/n	MTEMP	MSAL	DEPTH	PLVOL	AGLA	WAGLA	RAGLA	COP	CALFI	CALHY	EUCH	HYPER	EUP	LIMA
MTEMP	r	1	0.30	-0.23	0.28	0.29	0.26	-0.26	-0.07	-0.01	-0.03	-0.06	-0.21	0.09	-0.12
	p	0	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.86	0.72	0.39	0.00	0.18	0.06
	n	459	432	455	446	232	160	160	230	193	193	198	232	231	231
MSAL	r		1	-0.24	0.03	0.15	0.02	0.19	0.12	0.02	0.11	0.10	-0.06	0.16	-0.01
	p		0	0.00	0.49	0.03	0.81	0.02	0.08	0.80	0.13	0.17	0.36	0.02	0.87
	n		432	428	420	212	140	140	210	173	173	178	212	211	211
DEPTH	r			1	0.30	0.33	0.31	0.19	0.32	0.30	0.28	0.32	0.25	0.33	0.42
	p			0	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	n			551	532	271	180	180	269	227	227	231	271	270	270
AGLA	r					1			0.35	0.27	0.35	0.24	0.18	0.37	0.49
	p					0			0.00	0.00	0.00	0.00	0.00	0.00	0.00
	n					271			268	226	226	230	271	269	270
WAGLA	r						1	0.08	0.31	0.25	0.33	0.18	0.17	0.26	0.45
	p						0	0.29	0.00	0.00	0.00	0.03	0.02	0.00	0.00
	n						180	180	177	144	144	144	180	178	179
RAGLA	r							1	0.06	0.12	0.12	0.19	0.14	0.09	0.01
	p							0	0.40	0.14	0.16	0.03	0.05	0.25	0.88
	n							180	177	144	144	144	180	178	179
COP	r								1				0.43	0.55	0.54
	p								0				0.00	0.00	0.00
	n								269				268	268	267
CALFI	r									1	0.57	0.52	0.26	0.50	0.45
	p									0	0.00	0.00	0.00	0.00	0.00
	n									227	227	222	226	226	225
CALHY	r										1	0.33	0.38	0.53	0.48
	p										0	0.00	0.00	0.00	0.00
	n										227	222	226	226	225
EUCH	r											1	0.29	0.41	0.35
	p											0	0.00	0.00	0.00
	n											231	230	230	229
HYPER	r												1	0.28	0.49
	p												0	0.00	0.00
	n												271	269	270
EUP	r													1	0.40
	p													0	0.00
	n													270	268
LIMA	r														1
	p														0
	n														270

TABLE 4. (Continued). Spearman correlation coefficients (r) between temperature, salinity, depth to bottom and abundance indices of zooplankton taxa in the study area. p = prob >|r| under Ho: r Ho = 0. n = number of observations. 0.00 = (p<0.005). Abbreviations shown in Table 1.

	r/p/n	LIMR	LIMH	CLIO	CHAE	SHR	CRAB	GONA	COD	GHL	RED	PLA	WOLF	SAND
MTEMP	r	-0.08	-0.16	0.02	-0.10	-0.08	-0.04	0.13	0.27	0.07	-0.08	0.21	0.06	-0.20
	p	0.25	0.02	0.77	0.14	0.25	0.53	0.06	0.00	0.15	0.11	0.00	0.17	0.00
	n	220	221	232	232	225	232	223	459	459	459	459	459	459
MSAL	r	0.02	-0.07	0.00	-0.13	-0.13	0.11	0.16	0.15	0.12	0.04	0.12	0.00	0.21
	p	0.82	0.29	1.00	0.06	0.07	0.11	0.02	0.00	0.01	0.39	0.01	0.95	0.00
	n	200	201	212	212	205	212	203	432	432	432	432	432	432
DEPTH	r	0.40	0.23	0.17	0.42	0.28	-0.19	0.47	-0.08	0.31	0.11	0.15	0.18	-0.28
	p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.01	0.00	0.00	0.00
	n	258	259	271	271	263	271	262	551	551	551	551	551	550
AGLA	r	0.53	0.28	0.40	0.08	0.27	-0.18	0.56	0.35	0.57	0.07	0.43	0.30	-0.36
	p	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00
	n	258	259	271	270	263	271	261	271	271	271	271	271	271
WAGLA	r	0.49	0.30	0.29	0.08	0.22	-0.22	0.52	0.38	0.57	0.13	0.40	0.32	-0.30
	p	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00
	n	175	176	180	179	177	180	176	180	180	180	180	180	180
RAGLA	r	0.05	-0.03	0.10	0.08	0.03	0.02	0.04	0.05	0.13	-0.10	0.23	0.06	0.24
	p	0.54	0.71	0.19	0.29	0.69	0.77	0.64	0.54	0.08	0.18	0.00	0.44	0.00
	n	175	176	180	179	177	180	176	180	180	180	180	180	180
COP	r	0.48	0.41	0.16	0.53	0.36	-0.03	0.40	0.05	0.33	0.10	0.17	0.09	-0.17
	p	0.00	0.00	0.01	0.00	0.00	0.68	0.00	0.45	0.00	0.11	0.00	0.15	0.01
	n	255	256	268	268	260	268	259	269	269	269	269	269	269
CALFI	r	0.42	0.19	0.08	0.60	0.39	0.08	0.31	0.05	0.23	0.15	0.31	0.07	-0.09
	p	0.00	0.00	0.26	0.00	0.00	0.23	0.00	0.45	0.00	0.02	0.00	0.30	0.19
	n	217	218	226	226	218	226	217	227	227	227	227	227	227
CALHY	r	0.42	0.38	0.17	0.46	0.32	-0.03	0.28	0.08	0.27	0.11	0.13	0.03	-0.16
	p	0.00	0.00	0.01	0.00	0.00	0.61	0.00	0.24	0.00	0.10	0.04	0.66	0.01
	n	217	218	226	226	218	226	217	227	227	227	227	227	227
EUCH	r	0.34	0.19	0.06	0.49	0.25	0.01	0.31	-0.15	0.19	0.04	0.20	0.05	-0.05
	p	0.00	0.00	0.35	0.00	0.00	0.89	0.00	0.03	0.00	0.50	0.00	0.41	0.42
	n	220	221	230	231	222	230	221	231	231	231	231	231	231
HYPER	r	0.47	0.45	0.28	0.23	0.29	-0.07	0.25	0.04	0.31	0.05	0.10	0.20	0.03
	p	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.51	0.00	0.45	0.10	0.00	0.62
	n	258	259	271	270	263	271	261	271	271	271	271	271	271
EUP	r	0.39	0.17	0.14	0.41	0.35	0.01	0.39	-0.05	0.27	0.08	0.18	0.07	-0.18
	p	0.00	0.01	0.02	0.00	0.00	0.85	0.00	0.45	0.00	0.17	0.00	0.24	0.00
	n	256	257	269	269	261	269	260	270	270	270	270	270	270
LIMA	r			0.45	0.27	0.35	-0.15	0.50	0.12	0.54	0.09	0.26	0.38	-0.24
	p			0.00	0.00	0.00	0.01	0.00	0.05	0.00	0.15	0.00	0.00	0.00
	n			270	269	262	270	260	270	270	270	270	270	270

TABLE 4. (Continued). Spearman correlation coefficients (r) between temperature, salinity, depth to bottom and abundance indices of zooplankton taxa in the study area. p = prob >|r| under Ho: r Ho = 0. n = number of observations. 0.00 = (p<0.005). Abbreviations shown in Table 1.

	r/p/n	LIMR	LIMH	CLIO	CHAE	SHR	CRAB	GONA	COD	GHL	RED	PLA	WOLF	SAND
LIMR	r	1	0.60	0.41	0.25	0.37	-0.12	0.55	0.13	0.56	0.11	0.27	0.40	-0.24
	p	0	0.00	0.00	0.00	0.00	0.06	0.00	0.04	0.00	0.07	0.00	0.00	0.00
	n	258	258	258	257	250	258	248	258	258	258	258	258	258
LIMH	r		1	0.42	0.19	0.15	-0.23	0.21	0.12	0.42	-0.10	0.08	0.27	-0.13
	p		0	0.00	0.00	0.02	0.00	0.00	0.05	0.00	0.09	0.22	0.00	0.04
	n		259	259	258	251	259	249	259	259	259	259	259	259
CLIO	r			1	0.01	0.07	-0.10	0.28	0.13	0.32	-0.08	0.16	0.21	-0.13
	p			0	0.92	0.25	0.12	0.00	0.03	0.00	0.17	0.01	0.00	0.03
	n			271	270	263	271	261	271	271	271	271	271	271
CHAE	r				1	0.31	0.05	0.27	-0.09	0.10	0.02	0.09	-0.10	-0.12
	p				0	0.00	0.41	0.00	0.14	0.09	0.80	0.14	0.11	0.04
	n				271	262	270	261	271	271	271	271	271	271
SHR	r					1	0.27	0.27	0.15	0.23	0.07	0.15	0.16	0.01
	p					0	0.00	0.00	0.01	0.00	0.26	0.02	0.01	0.85
	n					263	263	253	263	263	263	263	263	263
CRAB	r						1	-0.12	0.10	-0.10	0.01	-0.01	-0.06	0.42
	p						0	0.05	0.11	0.09	0.91	0.86	0.34	0.00
	n						271	261	271	271	271	271	271	271
GONA	r							1	0.08	0.56	0.13	0.37	0.33	-0.28
	p							0	0.18	0.00	0.04	0.00	0.00	0.00
	n							262	262	262	262	262	262	262
COD	r								1	0.31	0.02	0.32	0.17	0.09
	p								0	0.00	0.56	0.00	0.00	0.04
	n								559	559	559	559	559	558
GHL	r									1	0.10	0.52	0.39	-0.10
	p									0	0.02	0.00	0.00	0.02
	n									559	559	559	559	558
RED	r										1	-0.10	0.05	0.02
	p										0	0.02	0.26	0.59
	n										559	559	559	558
PLA	r											1	0.24	0.01
	p											0	0.00	0.81
	n											559	559	558
WOLF	r												1	-0.05
	p												0	0.22
	n												559	558
SAND	r													1
	p													0
	n													558

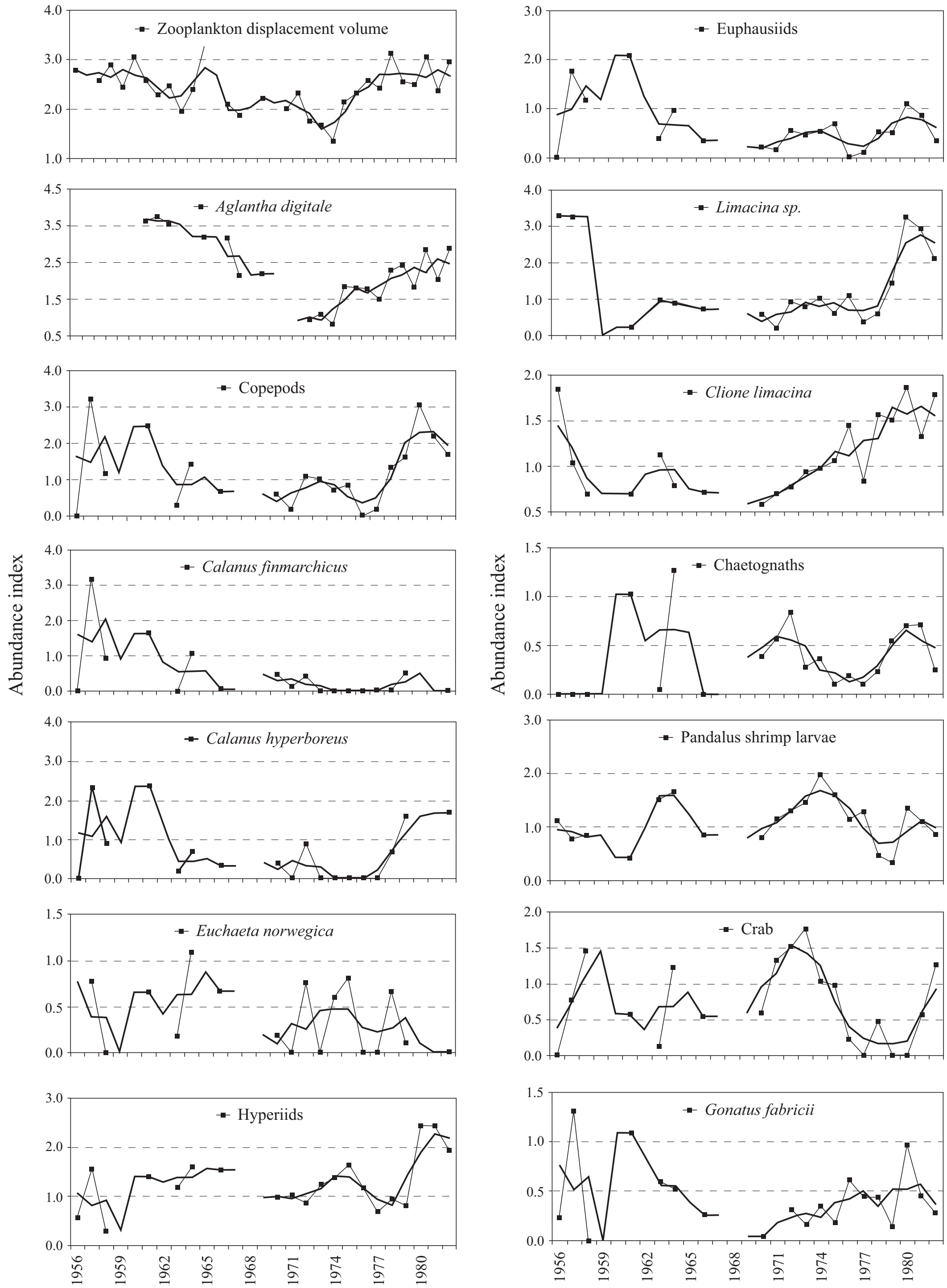

Fig. 5. Indices of invertebrate abundance. Mean of logarithmic transformed data [*log*10(*x*+1)] from the Fylla Bank section (S3) (see Appendix 2). Trends were smoothed by taking 3-year running averages (heavy solid line).

Hyperiids (HYPER) were more abundant in 1980, 1981 and 1982, over deep water in Davis Strait and in Disko Bay (Fig. 5, and Fig. 10). The abundance of hyperiids were positively correlated with several

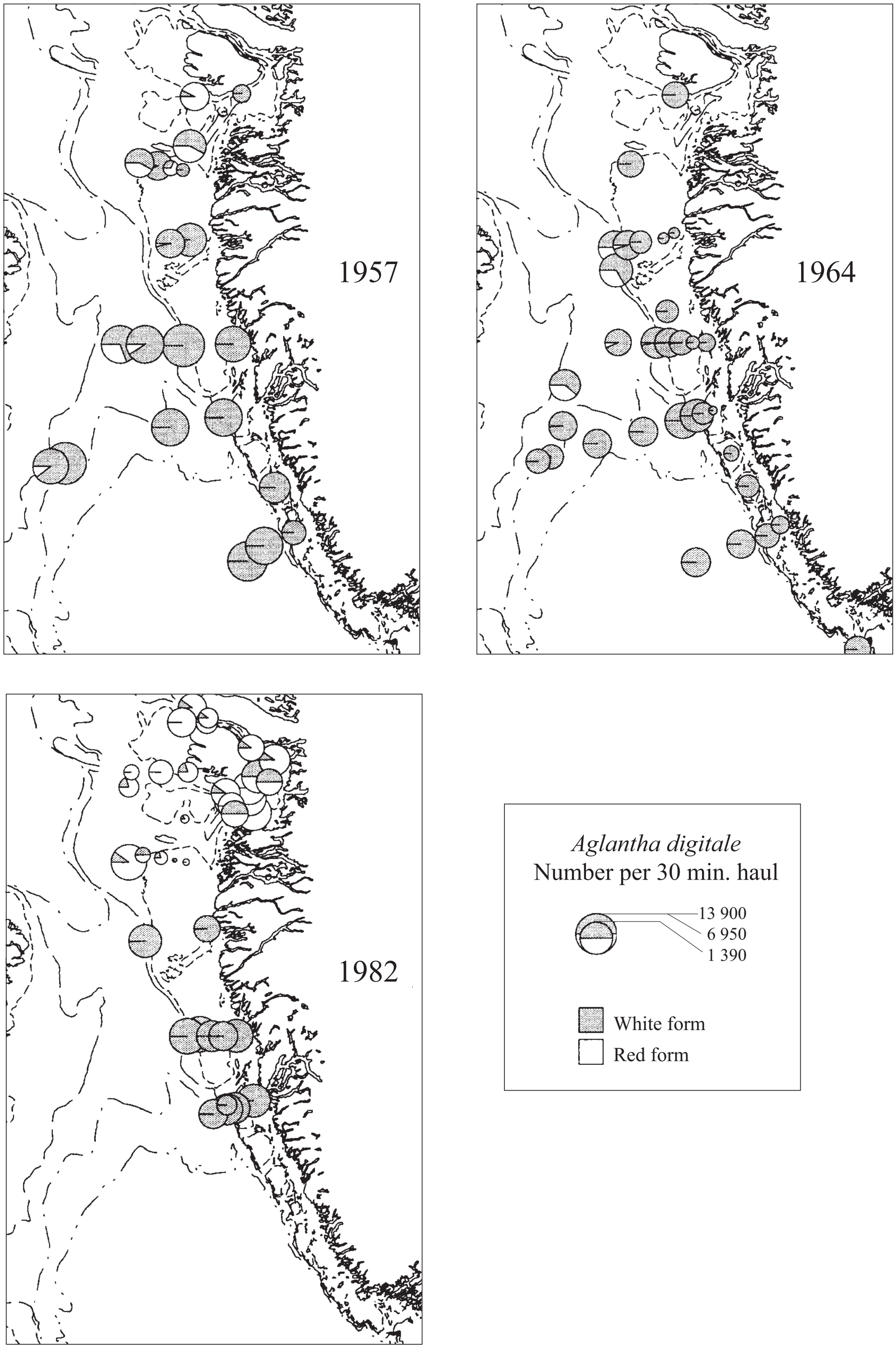

Fig. 6. Number of *Aglantha digitale* (white (WAGLA) and red (RAGLA) form) per 30 min. haul; all samples in June–July 1957, 1964 and 1982. Dot diameter is graduated by log (number of *Aglantha digitale*). 1964 used for comparison instead of 1963 as there was no sorting in red and white in 1963.

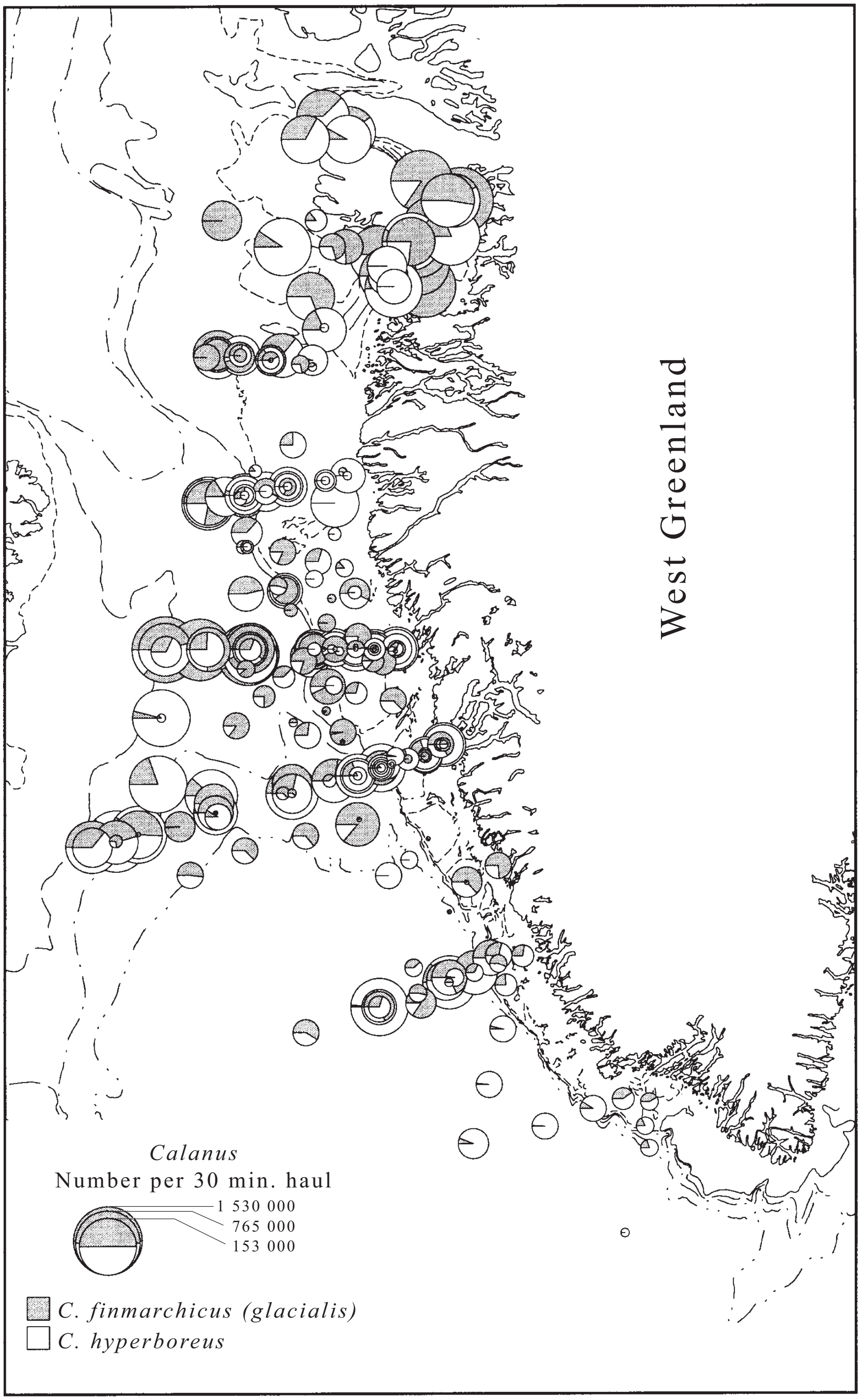

Fig. 7. Number of *Calanus* (*C. finmarchicus* (*glacialis*) (CALFI) and *C. hyperboreus* (CALHY)) per 30 min. haul; all samples in June–July 1956–83. Dot diameter is graduated by log (number of *Calanus*).

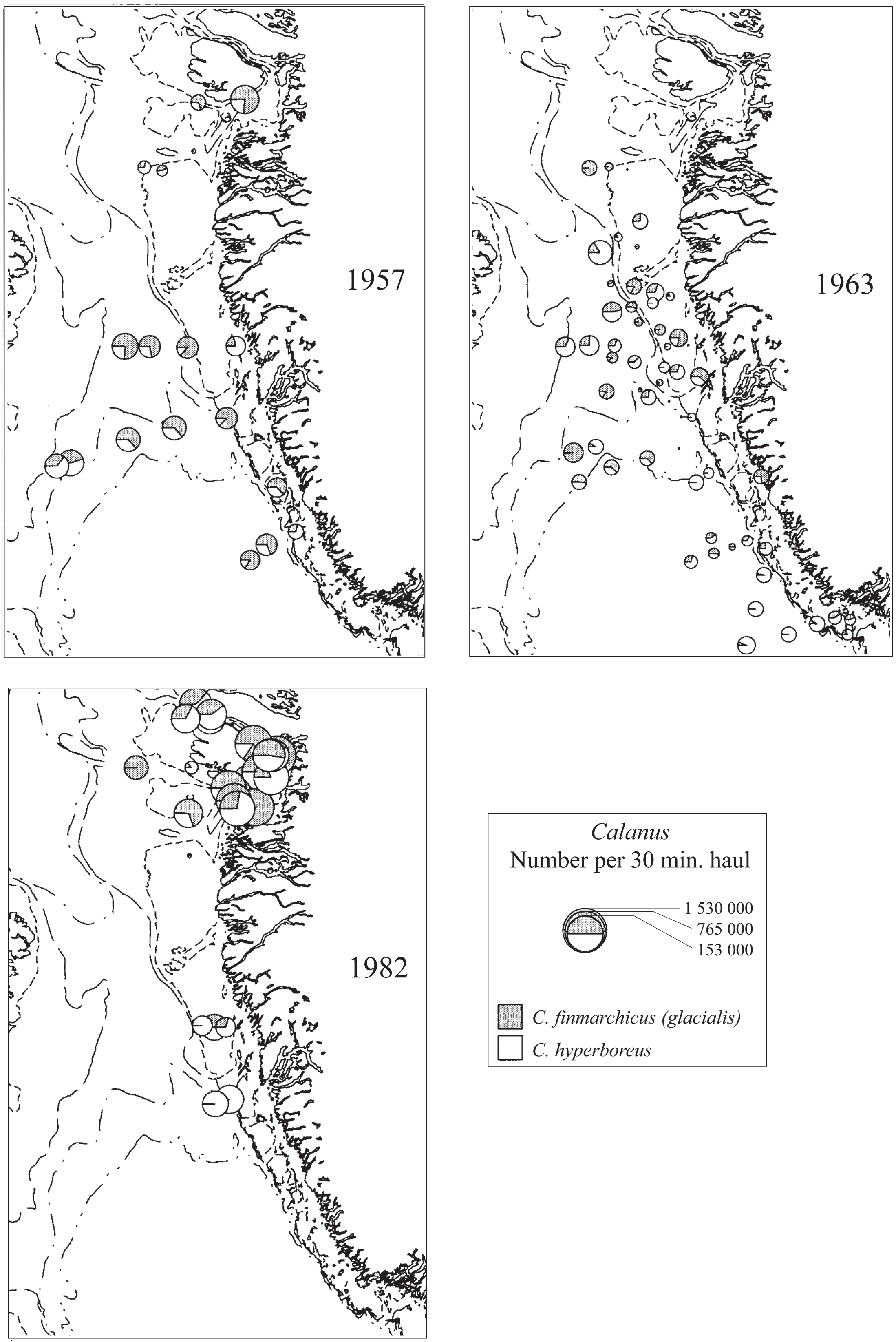

Fig. 8. Number of *Calanus* (*C. finmarchicus* (*glacialis*) (CALFI) and *C. hyperboreus* (CALHY)) per 30 min. haul; all samples in June–July 1957, 1963 and 1982. Dot diameter is graduated by log (number of *Calanus*).

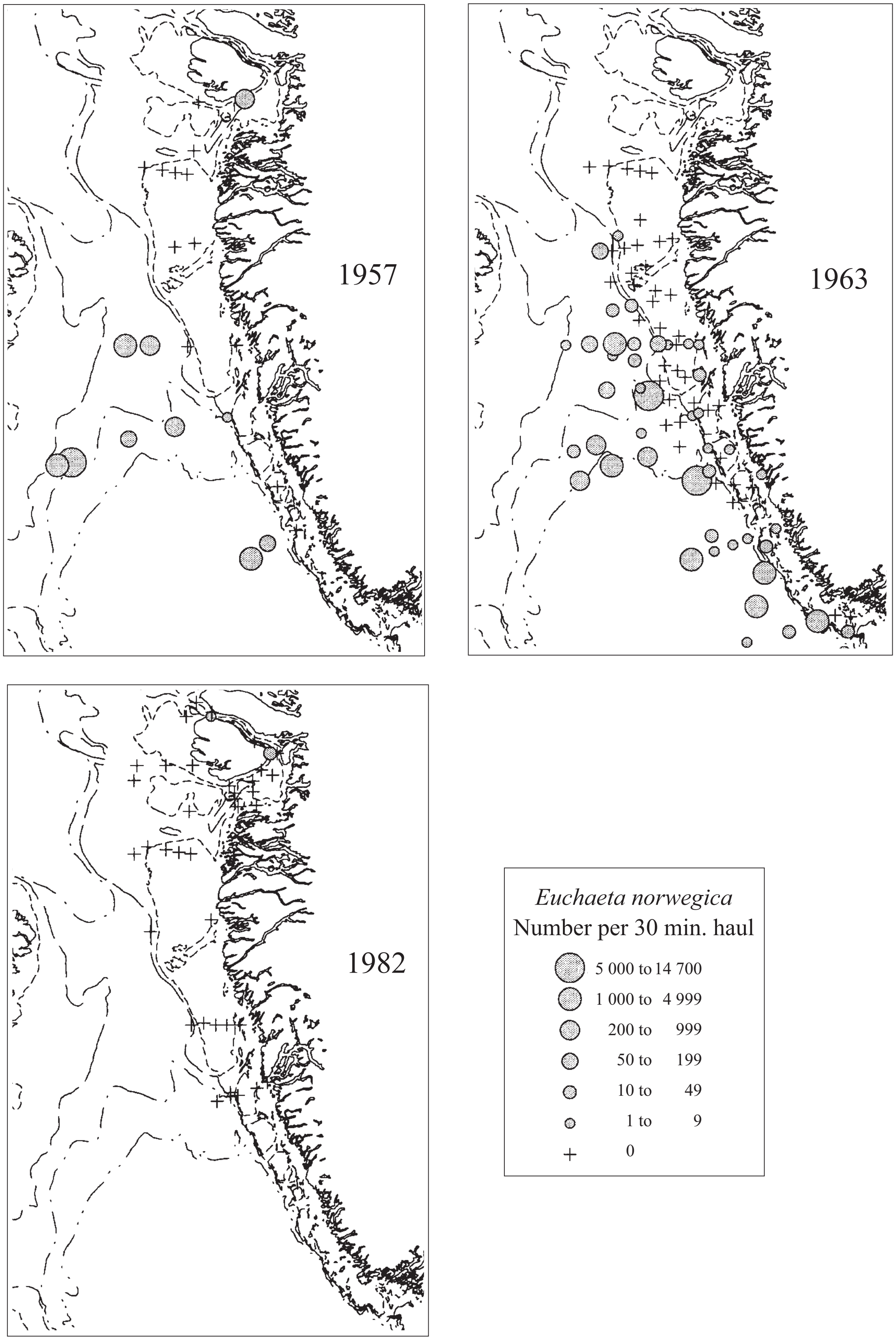

Fig. 9. Number of *Euchaeta norwegica* (EUCH) per 30 min. haul; all samples in June–July 1957, 1963 and 1982.

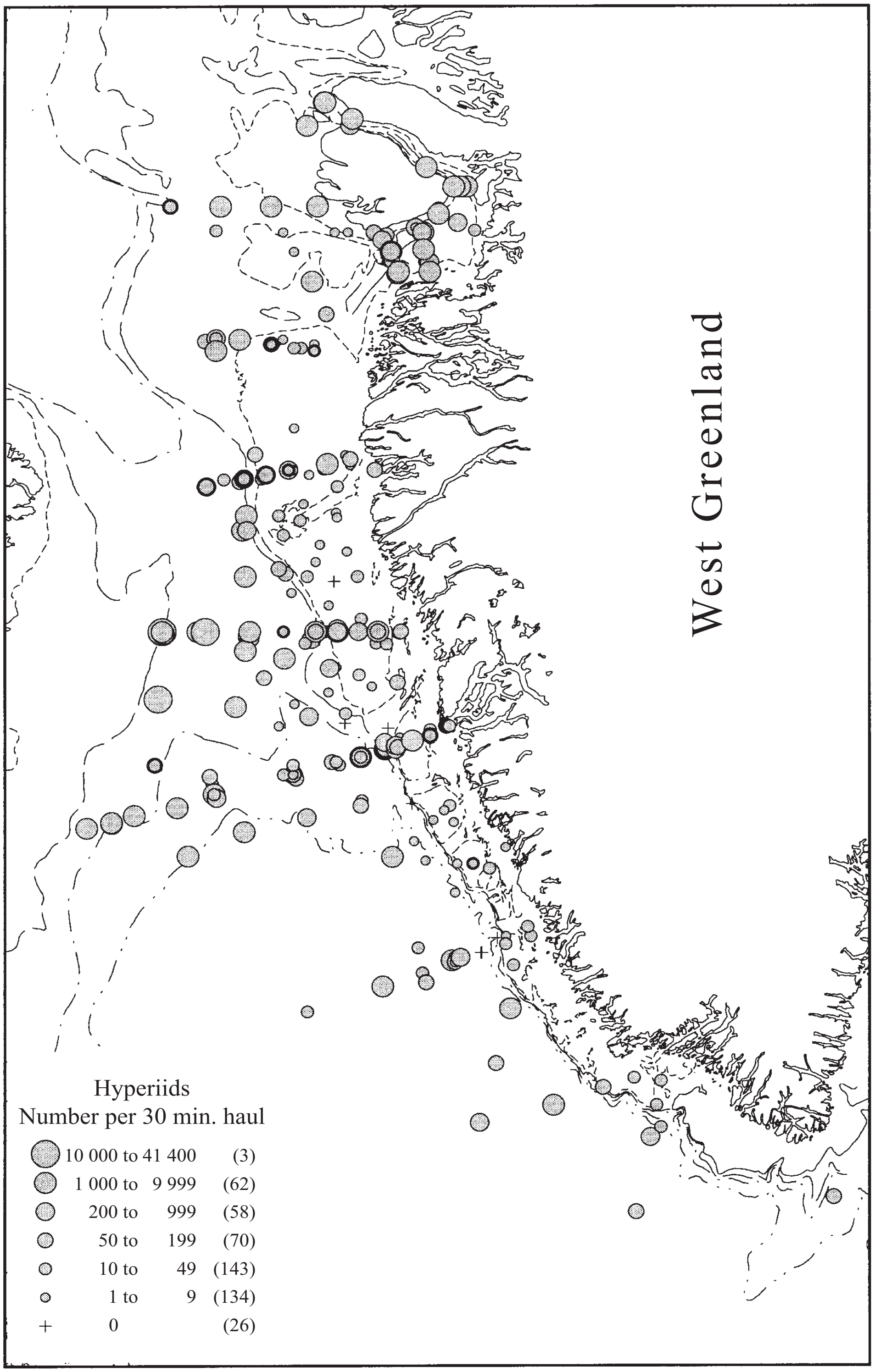

Fig. 10. Number of hyperiids (HYPER) per 30 min. haul; all samples in June–July 1956–83. Frequency of occurrence in parentheses.

zooplankton taxa e.g. *Limacina* sp., *C. hyperboreus*, Greenland halibut larvae and were negatively correlated with temperature (Table 4).

Euphausiid (EUP) abundance showed decreasing trend during the 1960s (Fig. 5). Euphausiids were most abundant over deep water (Fig. 11). The abundance of euphausiids was most highly correlated with copepods, chaetognaths, *Limacina* sp. (Table 4). Euphausiid abundance was correlated with salinity, but not with temperature (Table 4).

Limacina sp. (LIMA) and *Clione limacina* (CLIO) showed similar decreasing trends from the late-1950s to 1970 and increasing trends thereafter (Fig. 5). *Limacina retroversa* (LIMR) and *L. helicina* (LIMH) both showed significantly higher abundance on section 2. Although significant, there were no clear trends with depth to bottom. However, abundance indices of both species showed generally highest abundances over deep water, and *L. retroversa* show a more southerly distribution than *L. helicina* (Fig. 12). *Limacina retroversa* and *L. helicina* abundances were correlated and the abundance of both species were correlated with the abundance of e.g. Greenland halibut larvae, copepods, juvenile squids (*Gonatus fabricii*), and hyperiids (Table 4). Abundance of *L. retroversa* showed no correlation with temperature or salinity, but abundance of *L. helicina* was negatively correlated with temperature (Table 4). *Clione limacina* was generally more abundant in July and sampling month explained most of the variation (Table 3). Although the effect of depth to bottom were significant there were no trend in abundance with depth to bottom (Table 3, Fig. 13). *Clione limacina* abundance showed highest correlations with abundance of *Limacina helicina* and *L. retroversa* (Table 4). Abundance of *C. limacina* showed no correlation with temperature or salinity.

For chaetognaths (CHAE), depth to bottom and section explained most of the variation in the abundance indices (Table 3). Chaetognaths were generally most abundant on section 2. Although significant, trends with depth to bottom were not clear. However, high abundances of chaetognaths were observed in the deeper parts of Davis Strait and in Disko Bay (Fig. 14). Chaetognath abundance showed highest correlations with abundance of *Calanus finmarchicus* and no correlations with temperature or salinity (Table 4).

Shrimp larvae (SHR) were assumed to be primarily *Pandalus borealis*, although no documentation for this exists (see Pedersen, 1998). Sampling year and depth to bottom explained most of the variation in the abundance (Table 3). Although significant, there was no clear trend in abundance with year (Fig. 5). Shrimp larvae were generally more abundant at depth to bottom above 200 m and showed high abundances mainly over the West Greenland shelf and in the Disko Bay area (Fig. 15). Shrimp larvae abundance correlated most highly with copepods and Greenland halibut larvae (Table 4). Shrimp larvae abundance showed no correlation with temperature or salinity.

Crab larvae (*Zoea stages*) (CRAB) showed trends of being more abundant on section 1 and at depth to bottom below 300 m revealed from least square means of multi-way nonparametric ANOVA (Table 3). High crab larvae abundance were observed in Disko Bay (Fig. 16). Crab larvae abundance correlated positively with sandeel larvae abundance (Table 4). Crab larvae abundance and temperature or salinity showed no correlation.

Gonatus fabricii (juveniles) (GON) showed trends of being more abundant during the late-1950s and early-1960s, on section 2 and at depth to bottom above 500 m (Fig. 5, Table 3). *Gonatus fabricii* was abundant in hauls from the southern and deeper parts of the Davis Strait, and seldom in the northern part and in Disko Bay (Fig. 17). Abundance was positively correlated with e.g. Greenland halibut larvae, *Calanus finmarchicus*, *Aglantha digitale*, and *Limacina retroversa* (Table 4). *Gonatus fabricii* abundance was correlated with salinity but not with temperature (Table 4).

Indices of larval fish abundance

Atlantic cod larvae (COD) showed trends of being more abundant during 1950–68 and early-1980s, on section 2 and in July (Table 3, Fig. 18). Sampling section explained most of the variation (Table 3). There was no significant effect of depth to bottom and Atlantic cod larvae occured in hauls from coastal shelf areas as well as in the deeper parts of the Davis Strait (Fig. 19). Atlantic cod larvae abundance were positively correlated with *Aglantha digitale* (white form), American plaice larvae, Greenland halibut larvae, temperature and salinity (Table 4).

Greenland halibut larvae (GHL) showed trends of being more abundant on section 2, at depth to bottom above 400 m and in July (Table 3, Fig. 18). Sampling section explained most of the variation. There was no clear trend over the time period. Greenland halibut

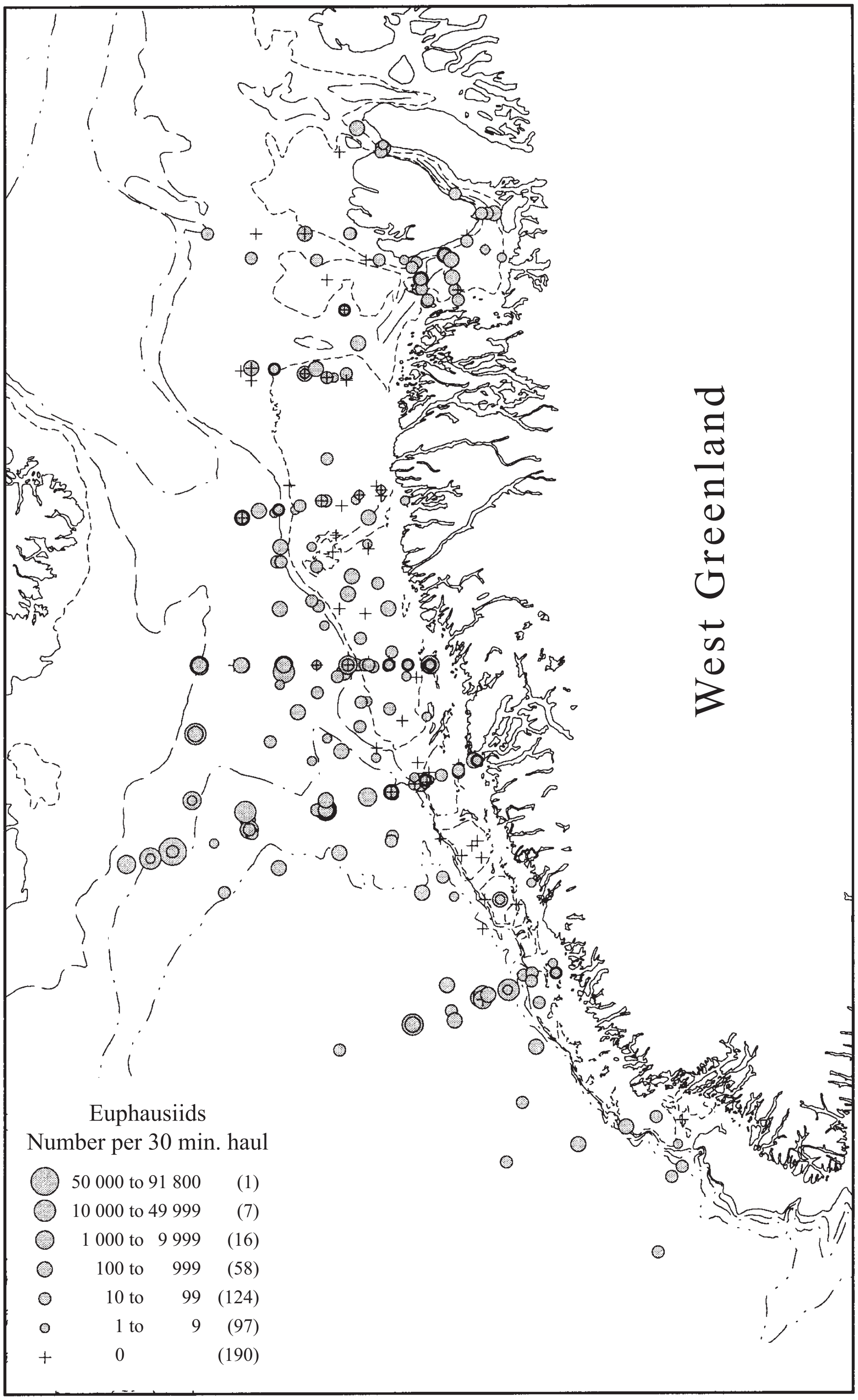

Fig. 11. Number of euphausiids (EUP) per 30 min. haul; all samples in June–July 1956–83. Frequency of occurrence in parentheses.

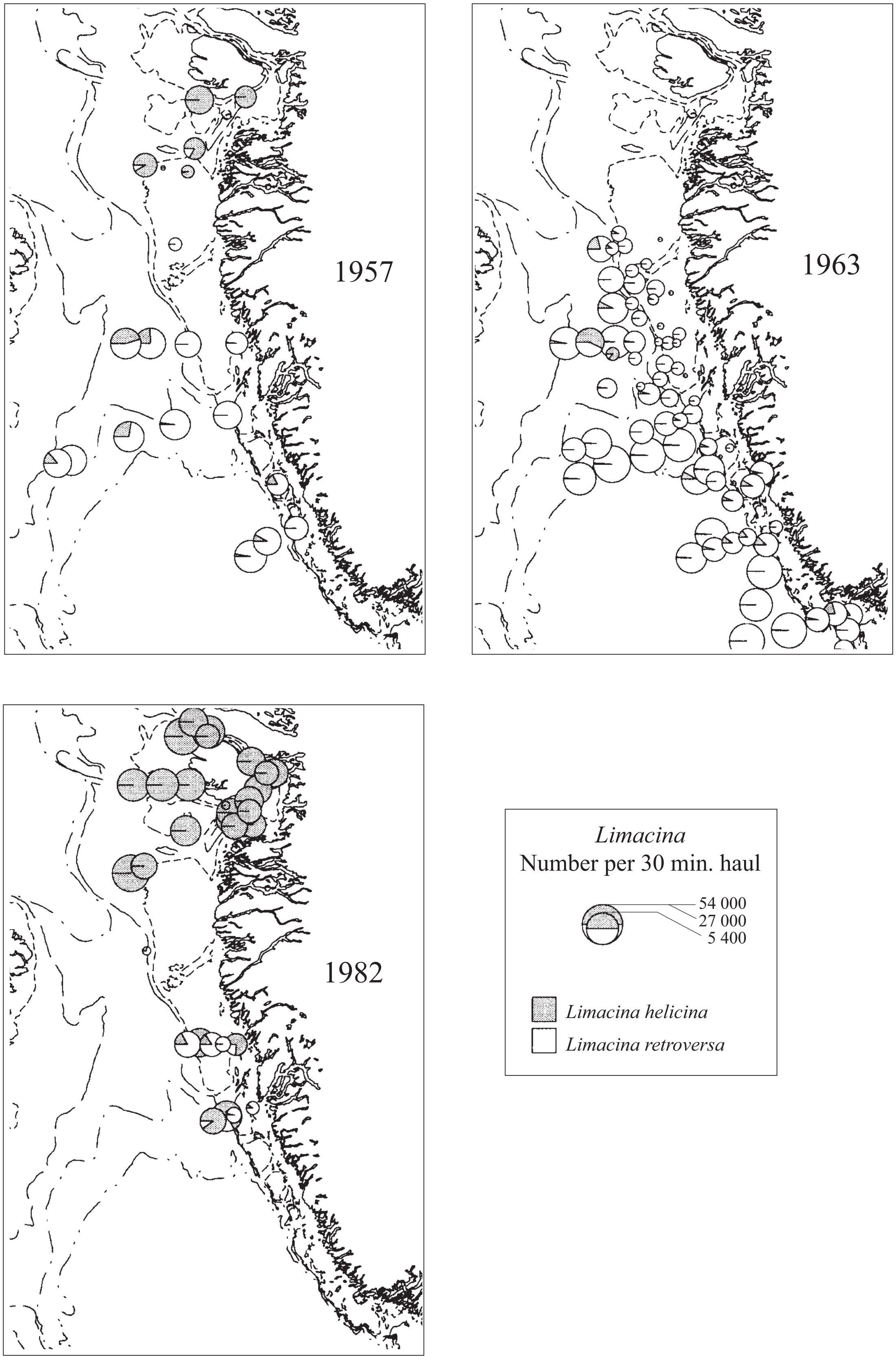

Fig. 12. Number of *Limacina* (*L. helicina* (LIMH) and *L. retroversa* (LIMR)) per 30 min. haul; all samples in June–July 1957, 1963 and 1982. Dot diameter is graduated by log (number of *Limacina*).

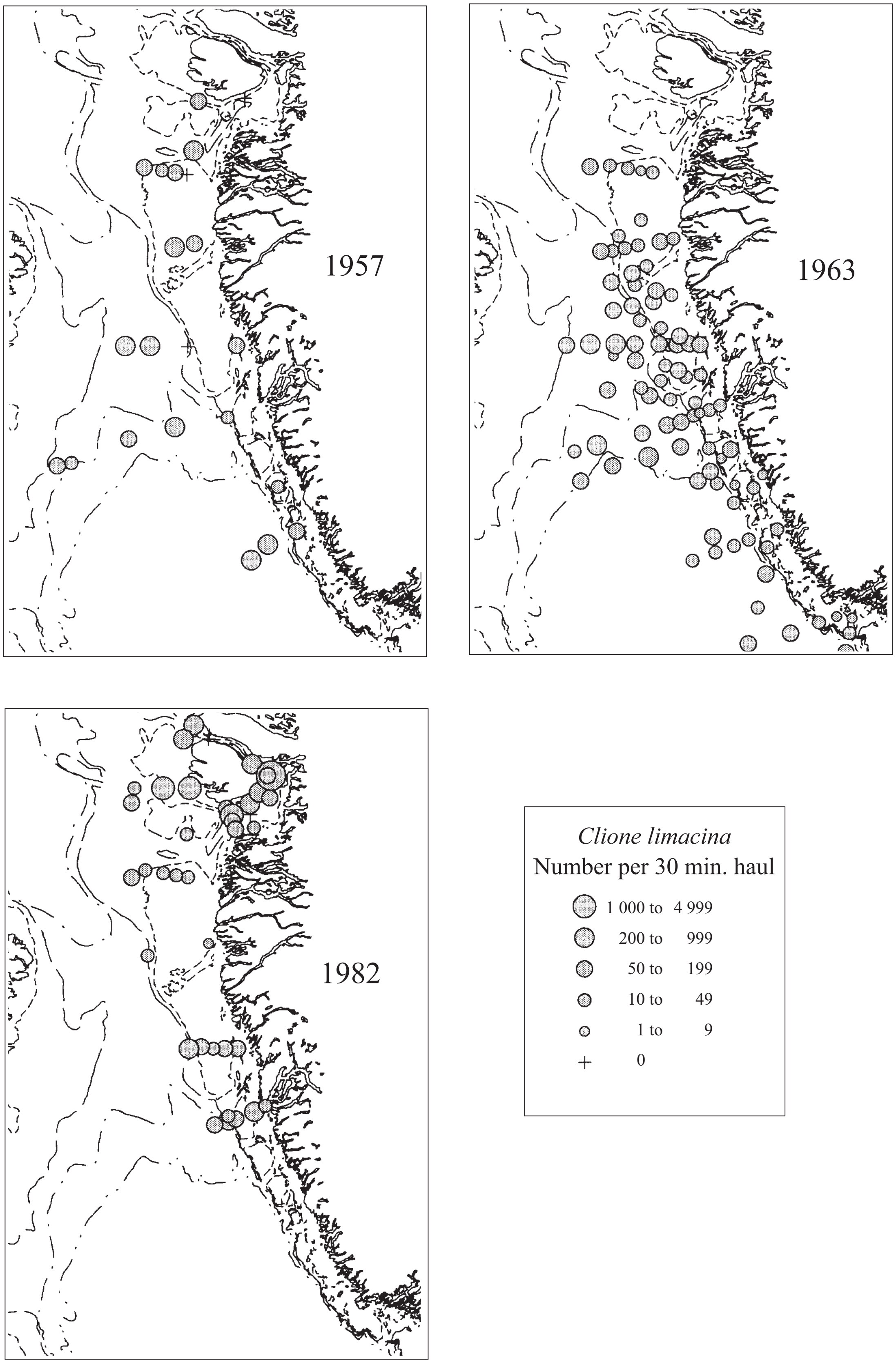

Fig. 13. Number of *Clione limacina* (CLIO) per 30 min. haul; all samples in June–July 1957, 1963 and 1982.

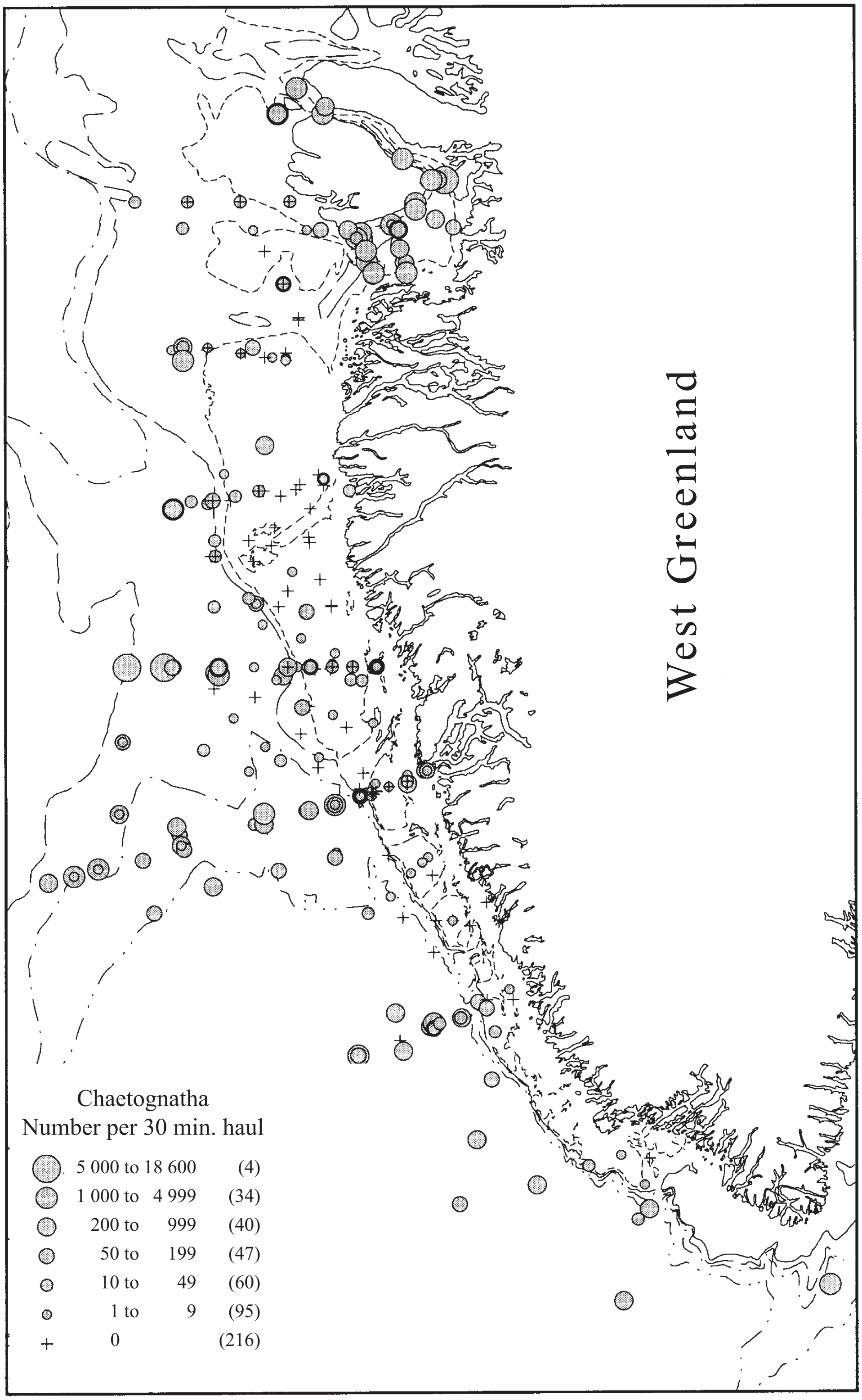

Fig. 14. Number of chaetognaths (CHAE) per 30 min. haul; all samples in June–July 1956–83. Frequency of occurrence in parentheses.

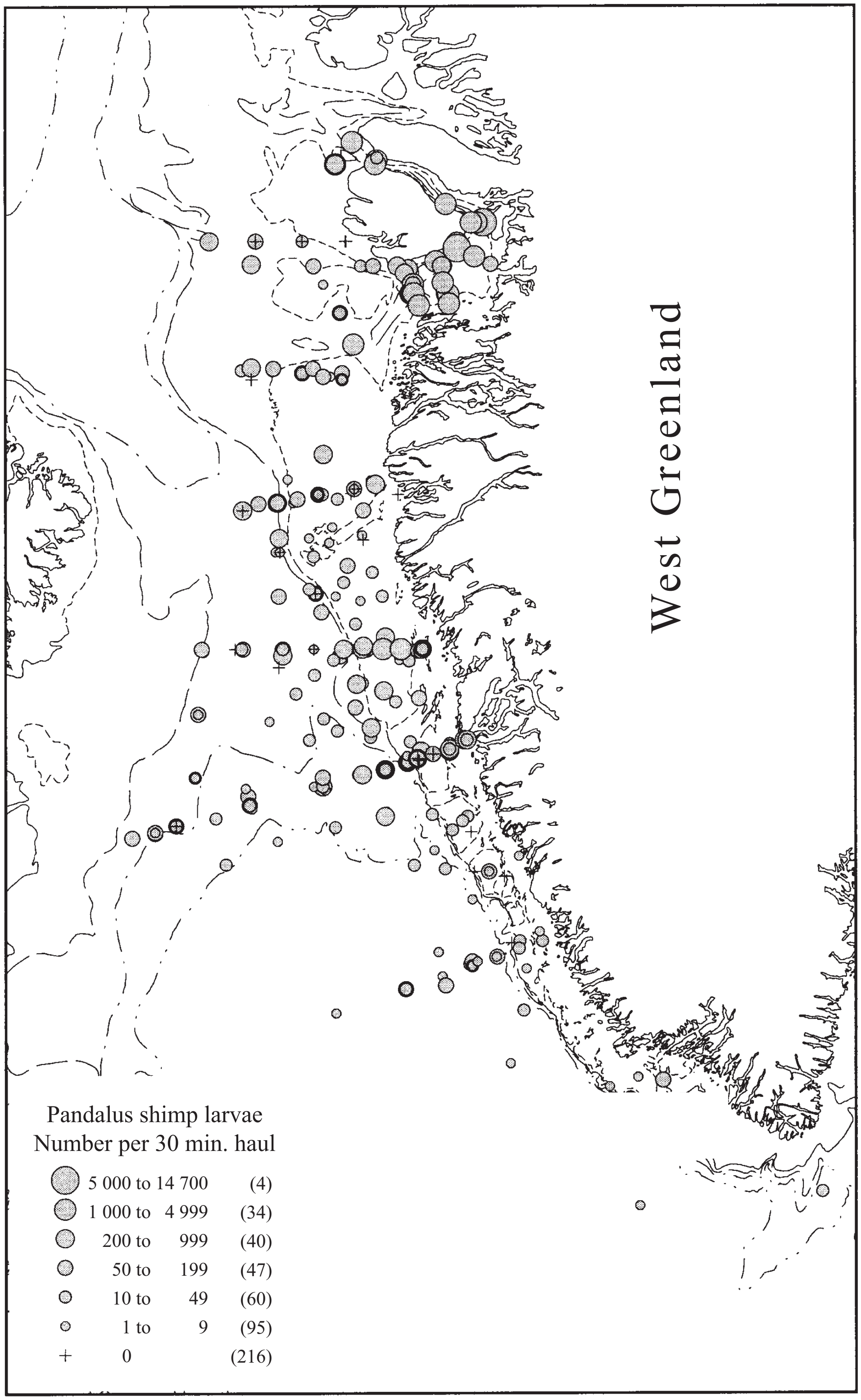

Fig. 15. Number of Pandalus shrimp larvae (mainly *P. borealis*) (SHR) per 30 min. haul; all samples in June–July 1956–82. Frequency of occurrence in parentheses.

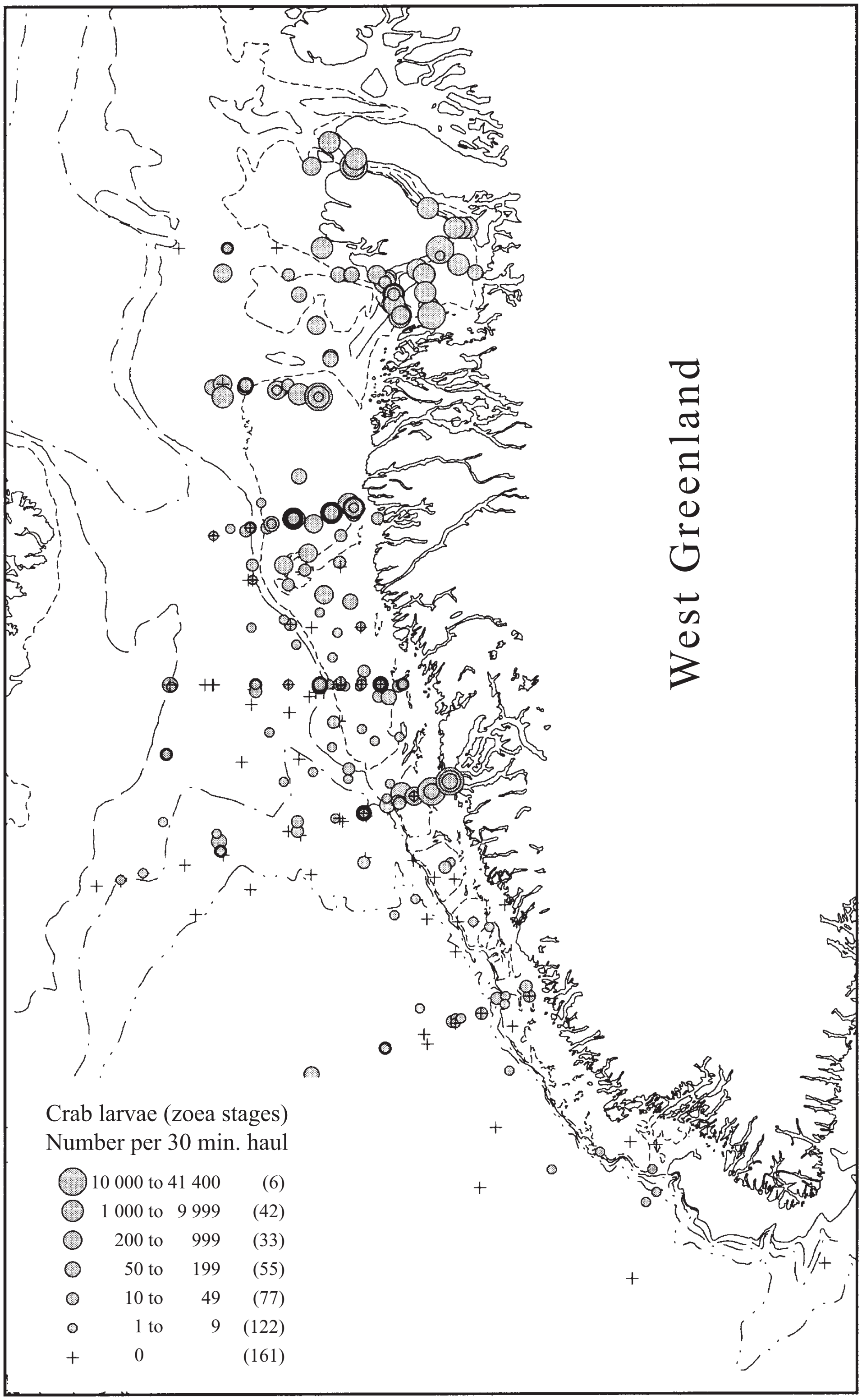

Fig. 16. Number of crab larvae (CRAB) per 30 min. haul; all samples in June–July 1956–83. Frequency of occurrence in parentheses.

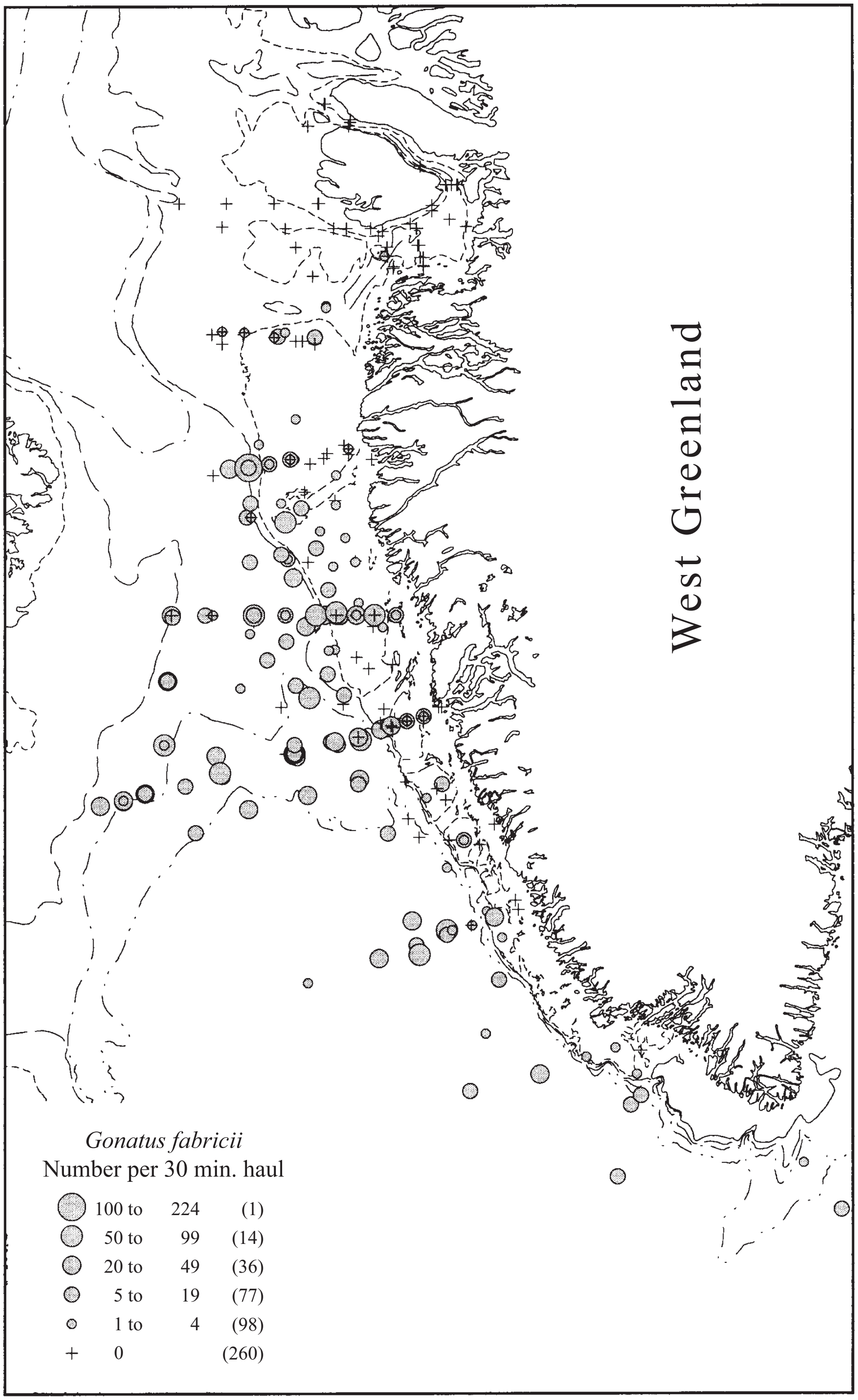

Fig. 17. Number of *Gonatus fabricii* (GONA) per 30 min. haul; all samples in June–July 1956–83. Frequency of occurrence in parentheses.

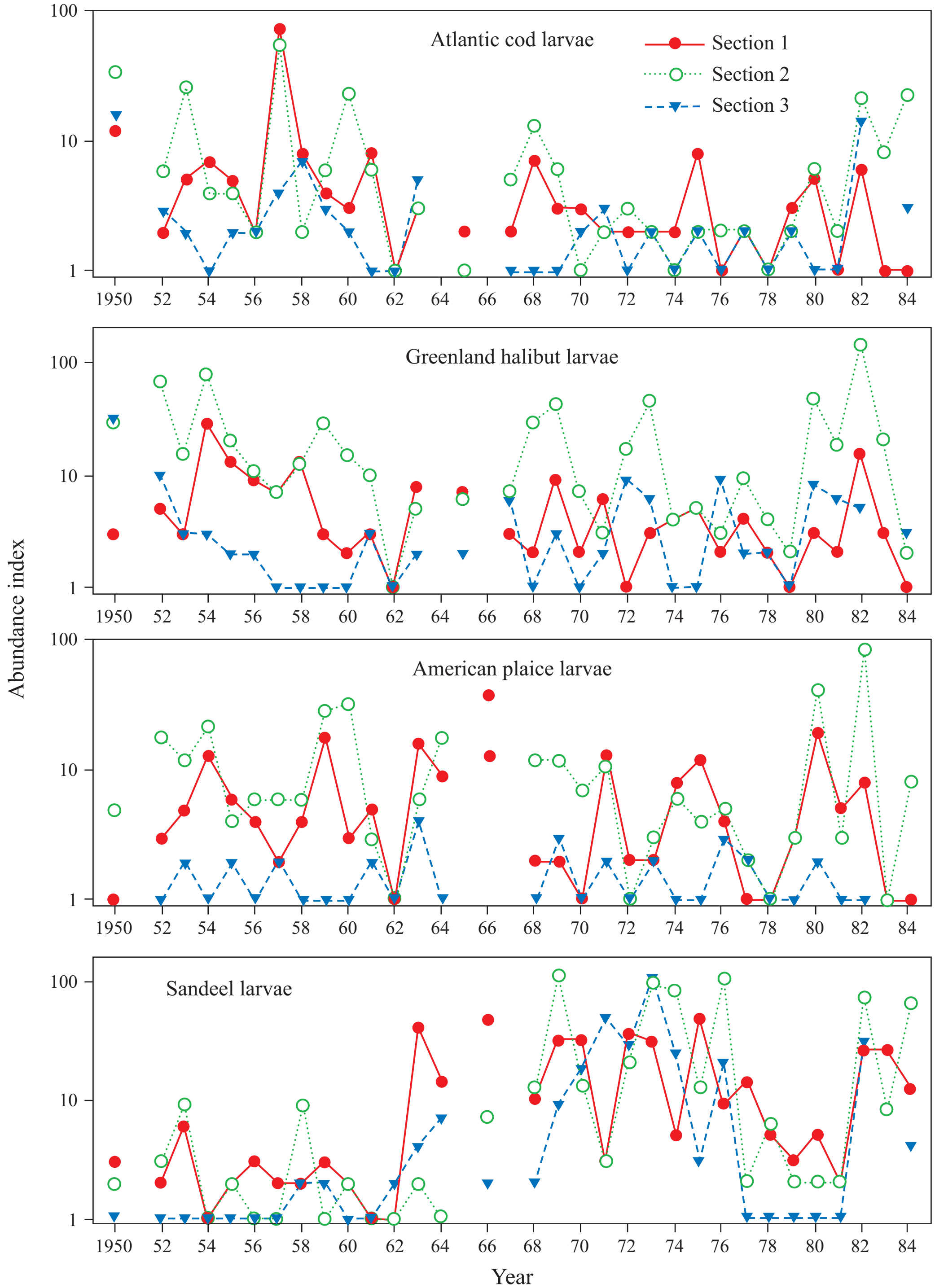

Fig. 18. Mean number of fish larvae per 30 min. haul in June–July in the study area by sampling year and section.

larvae were common also in the deeper parts of the Davis Strait (Fig. 20). Abundance indices were positively correlated with e.g. *Aglantha digitale* (white form), *Limacina retroversa*, American plaice, wolffish, cod larvae, and salinity (Table 4).

Redfish larvae (RED) occurrence showed annual variation between year and a trend of being more common in June (Table 3). Due to the infrequent samples of redfish larvae no effects of section or depth were found. Redfish larvae were abundant in samples

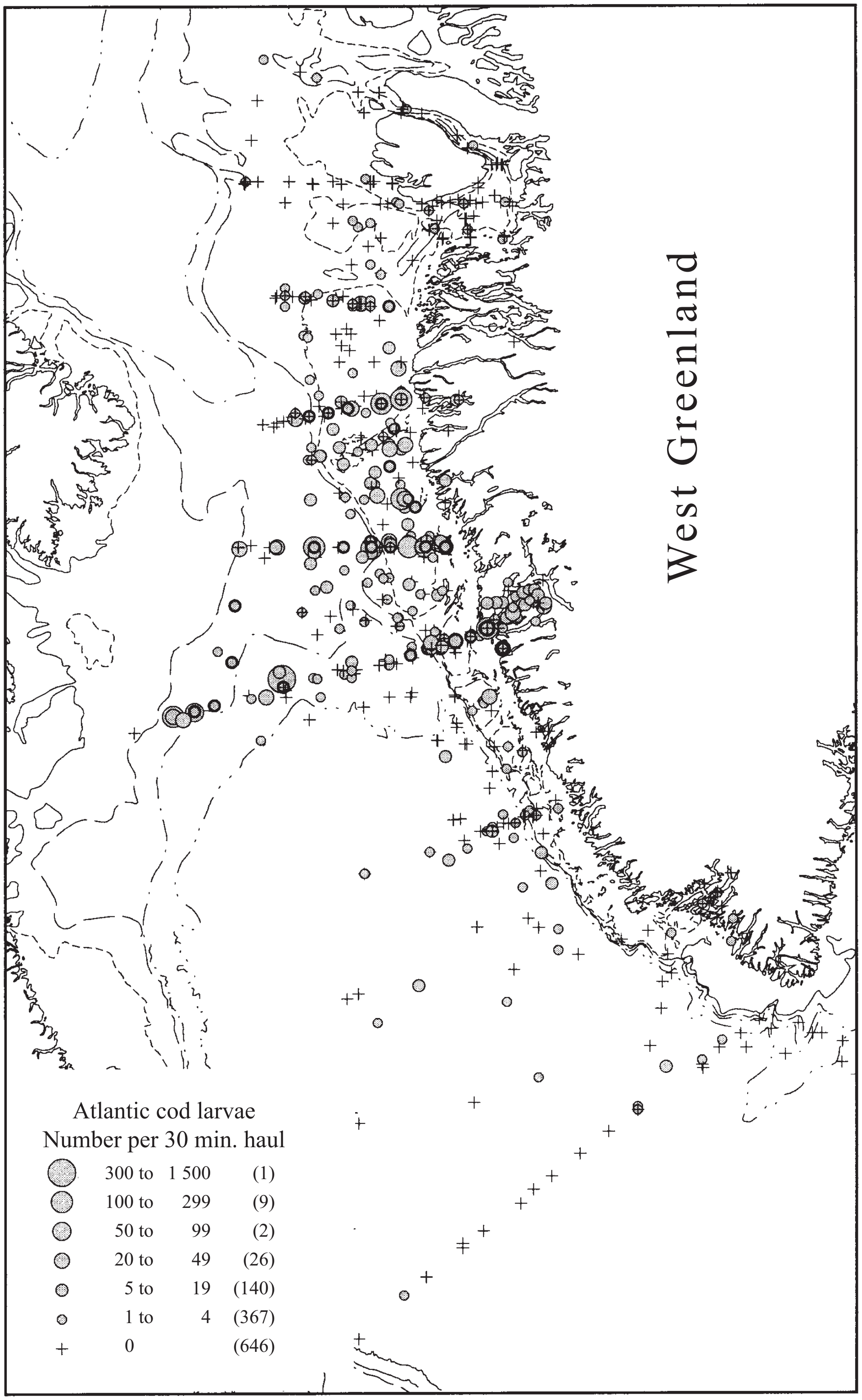

Fig. 19. Number of Atlantic cod larvae (COD) per 30 min. haul; all samples in June–July 1950–84. Frequency of occurrence in parentheses.

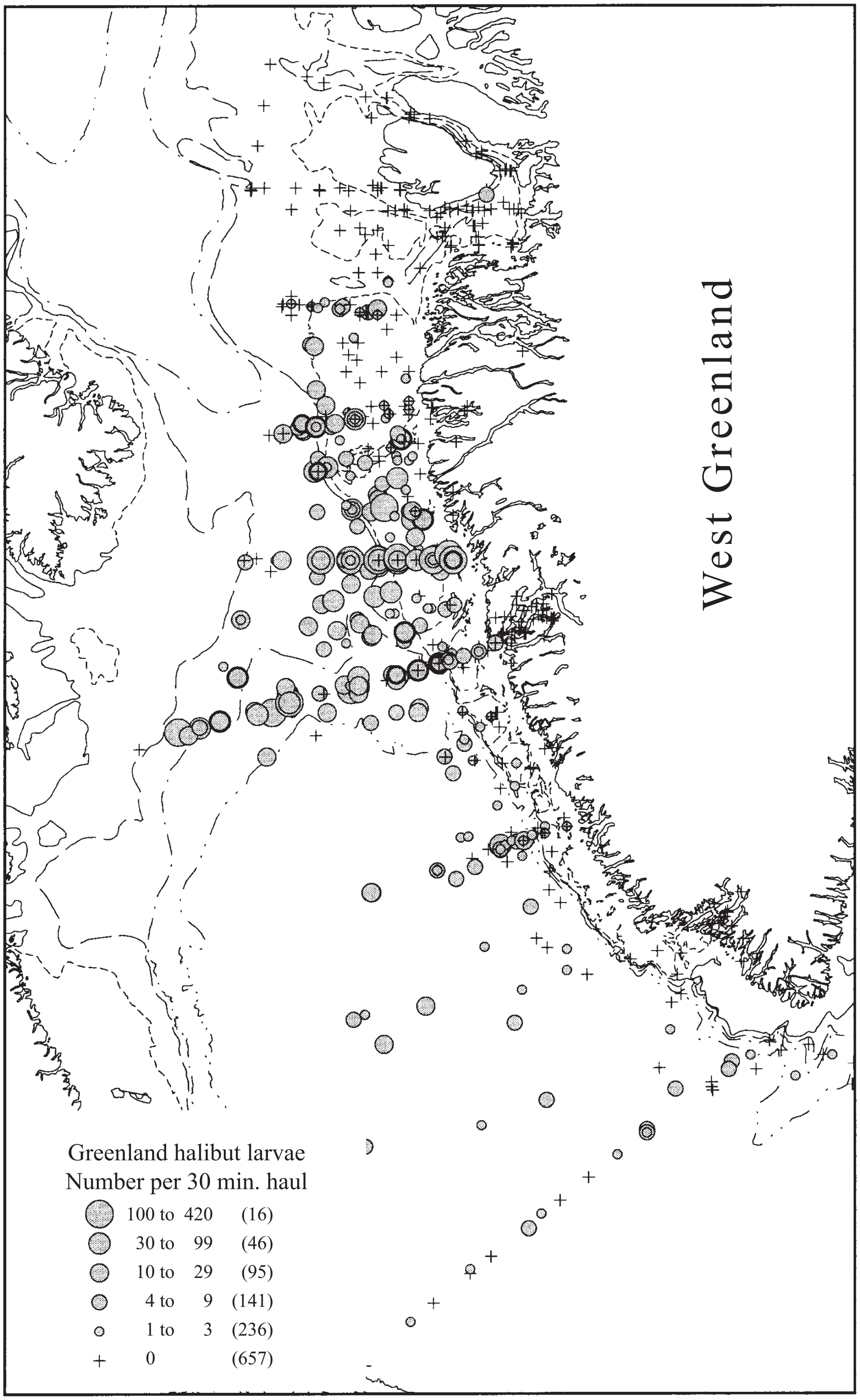

Fig. 20. Number of Greenland halibut larvae (GHL) per 30 min. haul; all samples in June–July 1950–84. Frequency of occurrence in parentheses.

from Southwest Greenland and the Labrador Sea (Fig. 21). Occurrence was positively correlated with e.g. *Calanus finmarchicus* and euphausiids (Table 4). Larval redfish occurrence was not correlated with temperature or salinity.

American plaice larvae (PLA) showed similar trends as Atlantic cod larvae, being more abundant during 1950–68 and early-1980s, on section 2 (Table 3, Fig. 18). Sampling section explained most of the variation. Although the effect of depth to bottom was significant, there was no clear trend in the abundance with depth to bottom. American plaice larvae were most abundant in samples from the shelf areas of the three sampling sections (Fig. 22). Abundance indices were positively correlated with Greenland halibut larvae, cod larvae, *Calanus finmarchicus*, *Aglantha digitale*, *Gonatus fabricii* (juveniles), temperature, and salinity (Table 4).

Wolffish larvae (WOLF) abundance showed a trend of being more common at section 2 (Table 3). No effects of sampling month were found. Although the effect of depth to bottom was significant there was no clear trend in the abundance with depth to bottom. Wolffish larvae were most abundant in samples from the shelf areas of the three sampling sections and in the Disko Bay area (Fig. 23). Wolffish larvae abundance indices were positively correlated with *Limacina* sp., Greenland halibut larvae, and *G. fabricii* (juveniles) (Table 4). Wolffish larvae abundance indices were not correlated with temperature or salinity.

Sandeel larvae (SAND) showed trends of being more abundant during 1963–76 and 1982–84, on section 1, at depth to bottom below 200 m, and in June (Table 3, Fig. 18). Sampling section explained most of the variation. Sandeel larvae were most abundant in samples in the shelf areas of the three sampling sections and in the Disko Bay area (Fig. 24). Abundance was positively correlated with crab larvae and *Aglantha digitale* (red form), but negatively correlated with most other zooplankton taxa (Table 4). Sandeel larvae were negatively correlated with temperature (Table 4).

Discussion

Long-term relationship between hydrography and zooplankton

The hydrographical data from the study area from 1950 to 1984 showed generally higher mean temperatures during 1950–68 compared with the period 1969–84. The latter period was more variable with unusual low temperatures and salinities from 1969 to 1971 and again from 1982 to 1984 (Fig. 3). While the cold period 1969–71 was explained by increased flow intensity of the East Greenland Polar Current, the cold period 1982–84 was explained mainly by inflow of extremely cold air masses from Canada which caused a cooling of the water masses (Rosenørn *et. al*., MS 1985; Buch, MS 1998).

The zooplankton displacement volume and most of the zooplankton taxa analysed showed higher abundance indices in the generally warmer period 1950–68. Only a few taxa such as hyperiids, the pteropod *Limacina helicina*, and sandeel were more abundant in the more variable and colder period after 1968. Correlations with temperature and salinity differed among zooplankton taxa e.g. American plaice larvae were positively related and sandeel larvae negatively related to temperature (Fig. 25). Of all correlations with temperature, zooplankton displacement volume (PLVOL) showed the highest positive correlation (r = 0.28, p <0.005, n = 446).

Several aspects of sampling design and biological processes weaken the ability to detect and describe relationships between hydrographical characteristics and zooplankton in this study. These include: 1) low numbers of sampling stations, 2) oblique and depth integrated hauls in the upper 50 m, which resulted in coarse spatial and temporal resolution of the samples with respect to hydrographical fronts and zooplankton distributions, 3) prey-predator interactions, if predators were very effectively grazing their prey.

Zooplankton displacement volume and most of the taxa investigated showed significantly higher abundance in section 2. Hyperiids, *Clione limacina* and shrimp larvae were exceptions, showing no effect of sampling section. *Calanus finmarchicus* was more abundant in the less saline section 3, whereas crab and sandeel larvae were more abundant in the more saline section 1. Crab and sandeel larvae were most common in the relatively shallow coastal areas over Store Hellefiske Bank. However, most zooplankton taxa were more abundant in the oceanic areas than in coastal areas. The differences in distributions and abundances are due to differences between the taxa in geographic origin, timing of their life cycle and development (Bainbridge and Corlett 1968; Pavshtiks, 1968, 1972; Smidt, 1979). For Pandalus shrimp larvae Pedersen (1998) found larger developmental stages over Lille Hellefiske Bank (section 2) than further north,

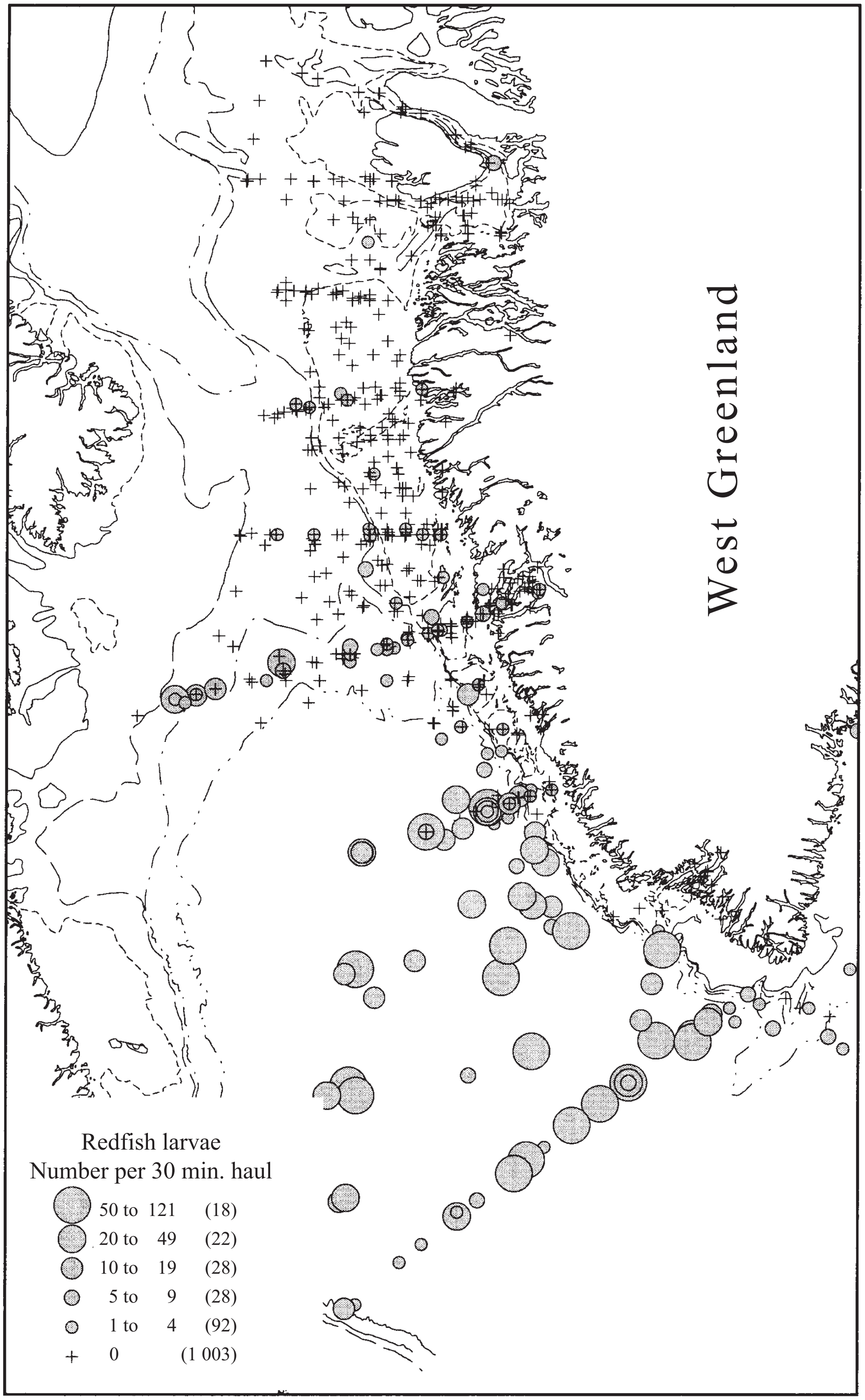

Fig. 21. Number of redfish larvae (RED) per 30 min. haul; all samples in June–July 1950–84. Frequency of occurrence in parentheses.

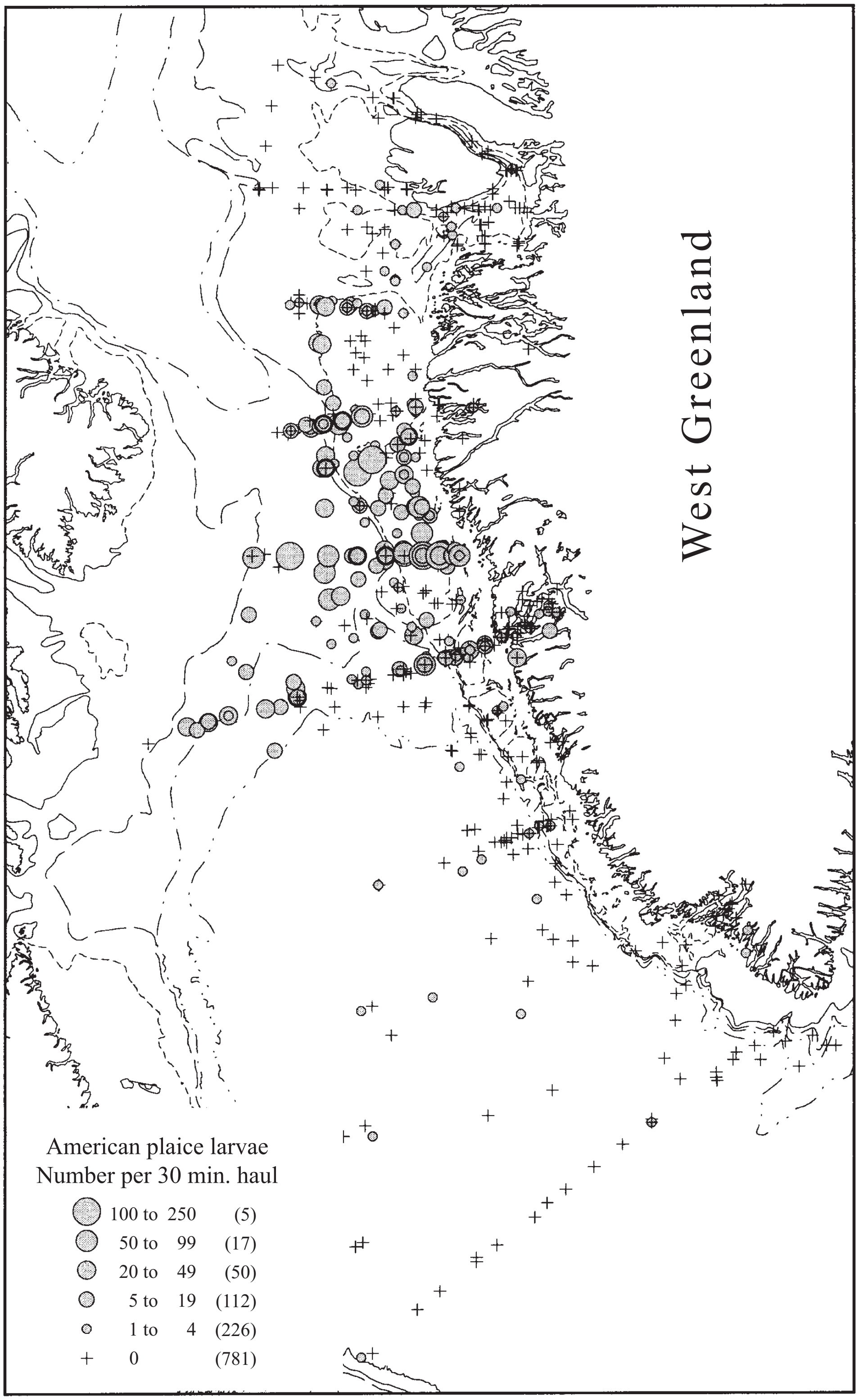

Fig. 22. Number of American plaice larvae (PLA) per 30 min. haul; all samples in June–July 1950–84. Frequency of occurrence in parentheses.

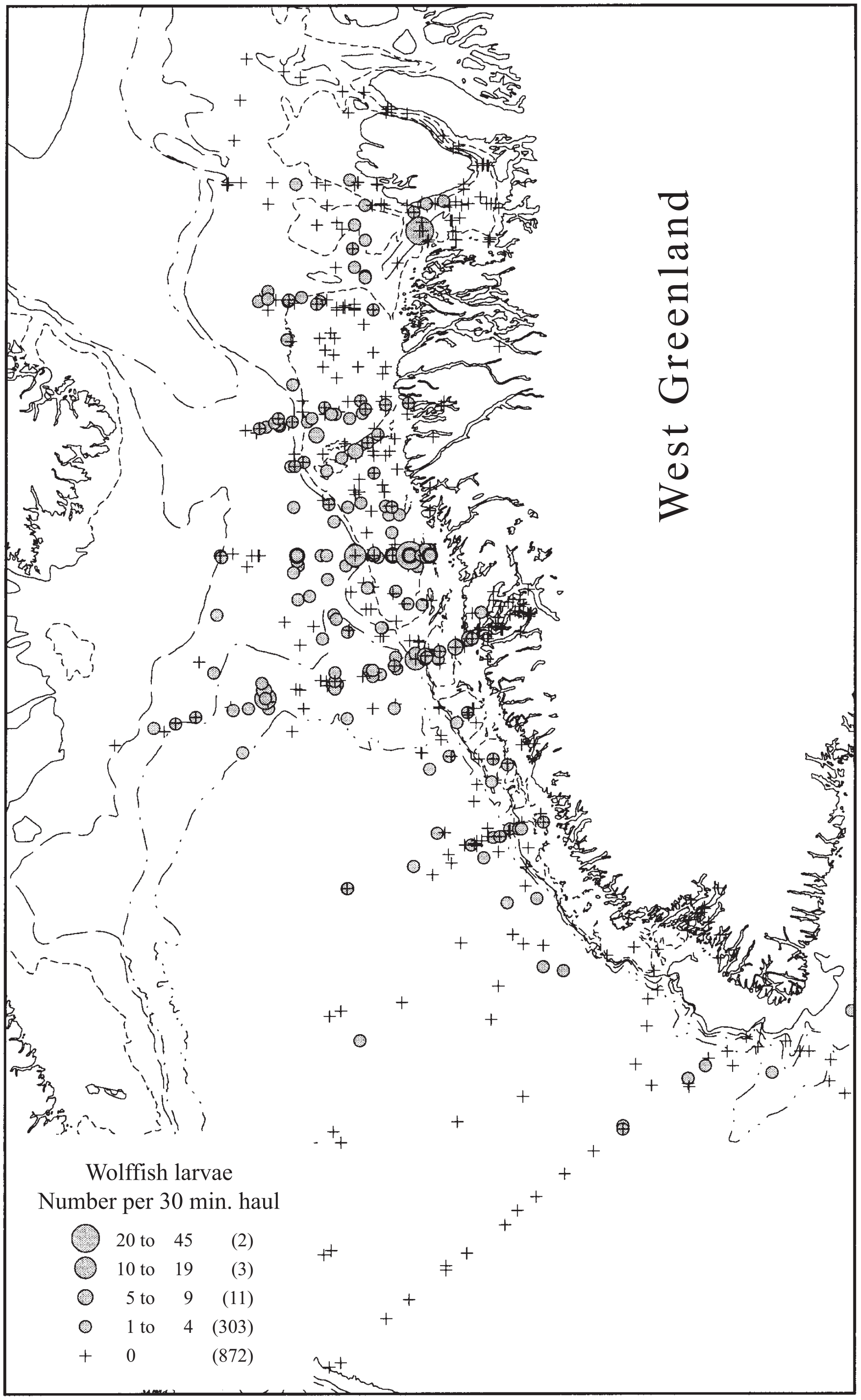

Fig. 23. Number of wolffish larvae (WOLF) per 30 min. haul; all samples in June–July 1950–84. Frequency of occurrence in parentheses.

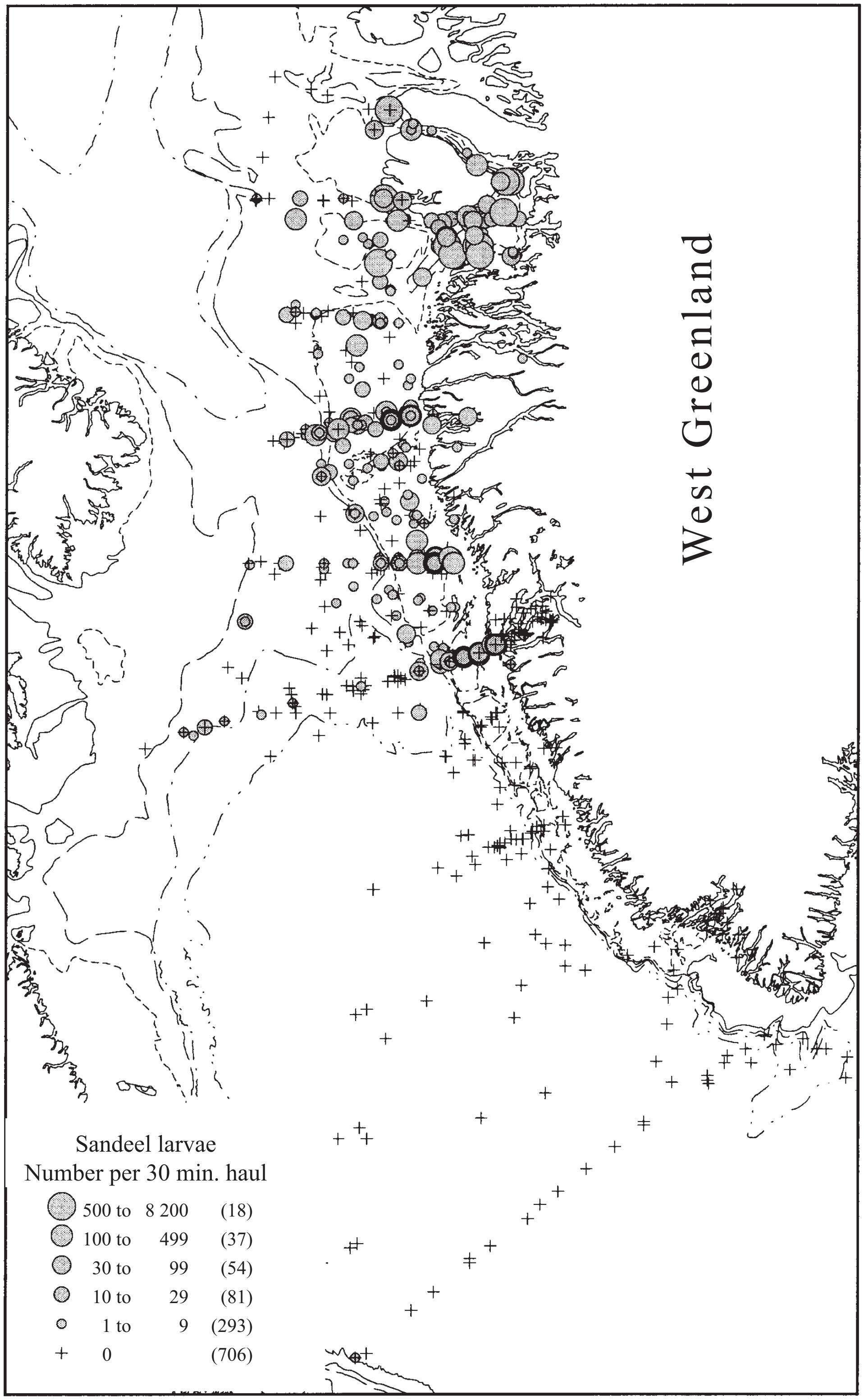

Fig. 24. Number of sandeel larvae (SAND) per 30 min. haul; all samples in June–July 1950–84. Frequency of occurrence in parentheses.

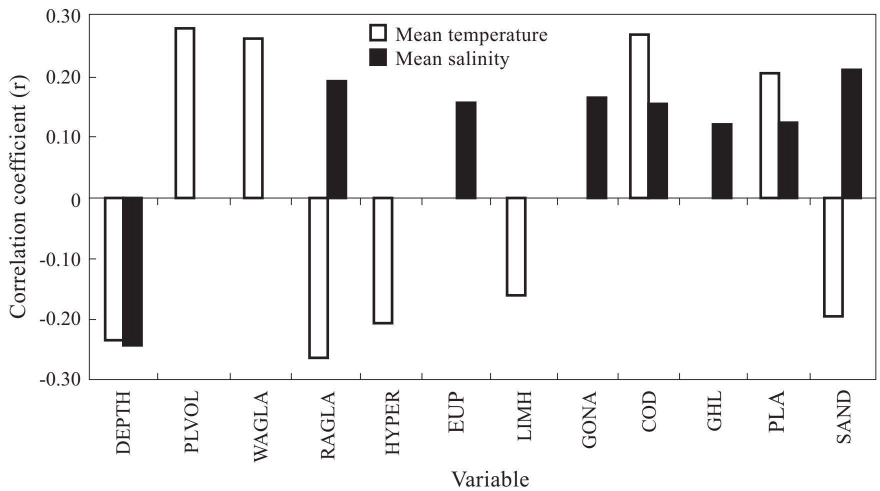

Fig. 25. Significant ($p<0.05$) correlations (r) between zooplankton abundance indices and mean temperature and salinity. All data included (Table 1 and 4).

suggesting a delay in hatching and development from south to north, related to the later warming and onset of primary and secondary production from south to north.

Seasonal and inter-annual variability in the hydrographic conditions in the Davis Strait influence the composition of the zooplankton and the timing of its development (Pavshtiks, 1968, 1972). However, by sampling the same stations on a particular section at approximately the same time each year and calculating the average density for that section one should get a measure of each years conditions and the most marked annual changes taking place (Astthórsson *et al*., 1983). Therefore the variable trends of both temperature and indices of zooplankton abundance presented in this study may be indicative of general trends in the overall zooplankton productivity and food for higher trophic level species e.g. Atlantic cod. This is consistent with reduced weight-at-age and recruitment of the West Greenland offshore cod stock during cold periods after 1968 (Brander, 1995; Riget and Engelstoft, 1998; Buch *et al*., 1994).

Decreasing trends in plankton abundance and especially in *Calanus finmarchicus* were observed in northern Icelandic waters between the periods 1958–64 to 1965–71 (Astthórsson *et al.*, 1983, Stefansson and Jakobsson, 1989). According to Astthórsson *et al*. (1983) a reduced influx of Atlantic water to the areas north of Iceland probably delayed the onset of the spring primary production and thus the zooplankton production. The hydrographic conditions probably also delayed and reduced the plankton production in West Greenland during cold periods, e.g. from 1969 to1971 and between 1982 and 1984. However, effects of these cold periods on the abundance indices of zooplankton and fish larvae in this study were minor, in fact the abundance indices of most zooplankton taxa including fish larvae were exceptionally high in 1982 (Fig. 18). Only the time-series for sandeel larvae showed markedly higher larvae abundance indices from 1969 to 1976 (Fig. 18). Possible explanations for this include 1) direct effects of oceanographic conditions on sandeel larval growth and survival, and 2) increased sandeel stock due to a reduction in the abundance of predators such as Atlantic cod.

Warm and cold water indicators

In this study, abundance indices of *Aglantha digitale* white form, Atlantic cod and American plaice larvae were positively correlated with temperature, whereas *Aglantha digitale* red form, hyperiids, *Limacina helicina* and sandeel larvae were negatively correlated with temperature (Fig. 25). No other zooplankton taxa were significantly correlated with temperature (Table 4). The white form of *Aglantha* occurs almost everywhere in the Davis Strait, but in decreasing numbers with colder water, and it is replaced by the red form in arctic waters (Bainbridge and Corlett, 1968). According to Pavshtiks (1972) boreal species (*Calanus finmarchicus*, *Euchaeta norwegica*, *Limacina retroversa*) and Arctic forms (*C. hyperboreus*, *C. glacialis*, *Metridia longa*, *Limacina helicina*) occur in the Davis Strait zooplankton during the greater part of the year. Arctic forms enter the Davis Strait with the cold Baffin Land Current (Labrador Current), and with the East Greenland Current (Fig. 1). The boreal species occur throughout the strait together with the cold water forms from the Arctic; they overwinter in the deep part of the strait (Pavshtiks, 1972). *Limacina retroversa* is a warm-water species found only off southern West Greenland whereas *Limacina helicina* is a cold water species found further to the north and with similar distribution as another cold water species, the gastropod *Clione limacina* (Smidt, 1979). Our findings agree with these patterns.

C. finmarchicus (*glacialis*) was positively correlated with *C. hyperboreus* (Table 4) indicating mixing between relatively warm and cold water. *C. finmarchicus* and *C. glacialis* were difficult to identify to species, therefore, the *C. finmarchicus* data may include some *C. glacialis*. According to Pavshtiks (1972) *C. finmarchicus* and *C. glacialis* form the bulk of the Davis Strait zooplankton during the greater part of the year and it is assumed that several populations of *Calanus* exist and spawn in this area. However, the most abundant *C. finmarchicus* population is brought into the Davis Strait with the Irminger Current (Atlantic water) during spring (Pavshtiks, 1972). Spawning of *C. finmarchicus* takes place from May to July both in the Atlantic water of the Irminger current and in the West Greenland coastal waters whereas *C. glacialis* is correlated with cold water in the Baffin Land Current and spawns in the coastal waters of Canada (Pavshtiks, 1972). Therefore, the *C. finmarchicus* data from the study area (section 1–3) of this paper were assumed to include only a low number or no *C. glacialis*.

Linking zooplankton with recruitment of fish

Of the large number of relationships between fish and zooplankton, the most important is that linking zooplankton with recruitment of fish (Cushing, 1995b). Recruitment success for fish and shellfish larvae depends on mainly two controlling biological processes – predation and food availability (the right food in sufficient amount at the right time) (Cushing, 1995a and b). In this study, the abundance indices of most fish larvae were positively correlated to each other (exceptions were sandeel and redfish larvae). This could indicate aggregation of fish larvae in locations of higher larval food production, growth rate and survival. However, the abundance indices of fish larvae were correlated to abundance indices of both potential prey and predators. Greenland halibut larvae showed positive correlations with white form *Aglantha digitale*, *Limacina* sp., small squids (*Gonatus fabricii*), American plaice larvae, wolffish larvae, *Clione limacina*, hyperiids, cod larvae, *C. hyperboreus*, and others (Table 4). Hence, larval fish, their prey and predators tend to aggregate.

An assessment of the possible intensity of predation on fish larvae is difficult since little is known of the relative importance of the various carnivorous species as predators of young fish (Bainbridge and Corlett, 1968). A common carnivorous species in the North Atlantic is *Clione limacina* but this gastropod may be a selective feeder on *Limacina* (*Spiratella*). Our results support this hypothesis because *Clione limacina* was positively correlated with *Limacina retroversa* and *L. helicina*. Little information on feeding ecology of fish larvae exists from West Greenland. However, in a study of the stomach contents of wolffish larvae collected from West Greenland in July 1980, 1981, and 1982 the principal fish prey of wolffish larvae were found to be sandeel larvae, followed by wolffish, cod and American plaice larvae (Alfonso Guzmán, Universidad de Los Lagos, Puerto Mont, Chile, unpublished). Cannibalism by larvae may thus be a population regulating mechanism in wolffish and probably in other fish species such as Atlantic cod and redfish. Predation on fish larvae (including cannibalism) may be avoided during good food conditions. However, larval fish will be vulnerable to predators if fish larvae co-occur with other organisms (e.g. medusae, chaetognaths) that compete for the same basic food. This latter predator group would be responsible for diminishing the food supply for fish larvae and consequently fish larvae may remain small and vulnerable to predators. As indicated by this study, the potential fish predators (e.g. *Aglanta*, chaetognaths) were generally more abundant in oceanic areas over deep water (depth to bottom more than 300 m) than in coastal areas (less than 300 m). Hence, fish larvae e.g. Atlantic cod, American plaice and sandeel larvae drifting northwards over the West Greenland fishing banks may be less exposed to predation than larvae drifting westwards over deep water in the Davis Strait.

Calanus finmarchicus is the most important food organism for both redfish and cod larvae (Bainbridge and McKay, 1968) and may be crucial for larvae survival. However, it has not been established whether inter-annual variability in fish stock recruitment depends directly upon variations of *Calanus* productivity (Miller, 1995). In this study, the abundance indices of Greenland halibut, American plaice and redfish larvae were significantly correlated with abundance indices of *C. finmarchicus*, whereas abundance indices of cod larvae were not (Table 4). Bainbridge and McKay (1968) found that cod larvae off West Greenland feed almost entirely on nauplii and copepodites of *C. finmarchicus*, which are not caught by the 1 mm mesh stramin net used for sampling. This may explain why we found no association for cod.

Year-class strength (as number at age 3) of Atlantic cod off West Greenland has been positively correlated with mean sea temperature (surface to 45 m over Fylla Bank in June) during the larval phase (Hermann *et al*., 1965; Hansen and Buch, 1986). Thus lower and more variable temperatures in West Greenland waters after 1968 may have contributed to decreased recruitment of the Atlantic cod stock. Year-class strength (at age 3) positively correlated with abundance indices of cod larvae (Hansen and Buch, 1986). In this study abundance indices of cod larvae were positively correlated with temperature. Cod eggs and larvae normally concentrate in the upper water layers and they are therefore exposed to relatively large temperature variations. In comparison eggs and larvae of American plaice are more deeply distributed and thus better protected against low temperatures. This may partly explain why the cod stock is more vulnerable to low temperatures than the American plaice stock in Greenland waters (Smidt, 1979).

In addition to direct effects of temperature on development time and survival of cod eggs and larvae, temperature can have indirect effects by altering the timing between first feeding and availability of food (Bainbridge and McKay, 1968; Cushing, 1990; Munk, 1997). Increased growth rates of cod larvae during warm years may increase survival if vulnerability to predation is size dependent. This may partly explain the relationship between water temperatures at West Greenland and year-class strength of the West Greenland cod stock.

Estimating the strength of new year-classes of fish and shellfish based on larval abundance is difficult due to the many variables affecting larval survival. Sea temperature, drift of larvae by surface currents, and stability of the water masses (hydrographic fronts) are important oceanographic factors affecting recruitment to harvestable fish and shellfish stocks (e.g. Taggart *et al*., 1989; Franks, 1992; Buch *et al*., 1994; Nilssen *et al*., 1994; Aadlandsvik and Sundby, 1994; Sundby *et al*., 1994; Stein and Lloret, 1995; Munk *et al*., 1995; Pedersen, 1998). In 1982, the relatively high mean number of Atlantic cod larvae caught in the stramin net hauls on the West Greenland sampling sections 1–3 indicated a good prospect for a large cod recruitment (Fig. 18), however, the 1982 year-class became poor. It has been assumed that the failure of the 1982 year-class mainly was caused by the extremely low winter temperatures in West Greenland during 1982–84 (Rosenørn *et. al*., MS 1985). The failure of the 1982 year-class of Atlantic cod and the general inability to relate catches of larvae to subsequent recruitment were the main reasons for terminating the time-series of zooplankton collections off West Greenland in 1985.

There is a need for better understanding of the dynamics between environmental conditions and variability in the fisheries resources in West Greenland waters. Progress in understanding recruitment success of fish and shellfish requires process oriented studies of zooplankton, ichthyoplankton, hydrography, and climate. Multivariate models which include variables like ocean temperature, seasonal timing of larval food production, spawning stock biomass, larval drift, species interactions (cannibalism), for each individual species in focus should prove to increase the ability to predict recruitment for fish and shellfish.

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Appendix 1. Arithmetic mean with 1 standard error (SE) of sea temperature (MTEMP) and salinity (MSAL) by year and section. N = number of samples.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
				MTEMP					
1950	4	1.64	0.92	4	2.06	0.54	2	2.99	0.14
1952	6	2.45	0.70	3	2.70	0.19	3	2.03	0.28
1953	6	3.00	0.64	5	3.25	0.30	5	3.26	0.40
1954	4	2.82	0.25	4	2.89	0.19	5	2.32	0.33
1955	5	2.95	0.37	3	2.79	0.05	3	1.80	0.56
1956	3	2.96	0.05	2	2.37	0.56	4	2.08	0.55
1957	4	3.05	0.54	2	2.96	0.11	4	1.68	0.24
1958	4	2.81	0.78	3	2.82	0.43	4	3.03	0.25
1959	5	3.51	0.39	4	3.00	0.21	4	1.90	0.34
1960							2	3.17	0.46
1961	6	3.42	0.66	4	4.46	0.16	2	4.20	0.25
1962	1	4.56					3	2.58	0.48
1963	6	2.50	0.28	15	2.42	0.17	10	2.10	0.25
1964	5	2.84	0.24	5	3.12	0.13	8	2.53	0.25
1966	5	2.78	0.39	6	2.47	0.31	5	2.40	0.27
1968	4	1.45	0.79	5	2.61	0.27	8	1.45	0.29
1969	6	1.17	0.05	8	1.10	0.15	5	0.21	0.17
1970	5	1.15	0.34	5	1.61	0.08	15	1.17	0.23
1971	7	2.48	0.23	6	2.38	0.13	10	1.35	0.30
1972	6	0.91	0.40	4	1.35	0.03	8	0.92	0.13
1973	5	1.23	0.05	5	1.97	0.17	5	1.43	0.13
1974	5	1.40	0.74	5	2.54	0.18	5	2.58	0.23
1975	6	2.27	0.09	6	2.47	0.15	4	1.85	0.54
1976	6	1.52	0.59	6	2.01	0.18	5	1.82	0.33
1977	4	3.16	0.14	6	3.42	0.14	4	3.74	0.56
1978	6	1.17	0.52	6	2.10	0.08	5	2.60	0.15
1979	7	1.94	0.58	6	3.51	0.05	6	3.16	0.28
1980	3	2.04	0.19	4	2.49	0.06	5	2.41	0.11
1981	5	1.79	0.09	4	2.10	0.10	5	1.45	0.15
1982	2	2.18	0.48	5	2.43	0.23	4	0.76	0.43
1983	3	1.54	0.10	4	1.47	0.12			
1984	5	1.82	0.28	3	1.71	0.14	4	1.51	0.27
				MSAL					
1950	4	33.81	0.17	4	33.65	0.12	2	33.61	0.04
1952	5	33.57	0.20	3	33.75	0.06	3	33.24	0.17
1953	6	33.79	0.08	5	33.69	0.12	5	33.37	0.03
1954	4	33.45	0.04	4	33.44	0.02	4	33.18	0.14
1955	5	33.68	0.03	3	33.51	0.09	3	32.87	0.08
1956	3	33.63	0.09	2	33.42	0.07	4	33.36	0.11
1957	4	33.57	0.15	2	33.49	0.13	4	33.30	0.15
1958	4	33.18	0.11	3	33.20	0.09	4	33.07	0.16
1959	5	33.57	0.06	4	33.44	0.11	3	33.09	0.23
1961	6	33.83	0.12	4	33.91	0.09	2	33.55	0.08
1962							3	33.26	0.13
1963	6	33.59	0.08	15	33.66	0.04	10	33.64	0.09
1964	5	33.59	0.06	5	33.51	0.03	8	33.16	0.04
1966	5	33.66	0.07	6	33.50	0.05	5	33.11	0.04
1968	4	33.32	0.25	5	33.36	0.02	8	33.16	0.11
1969	6	33.59	0.02	8	33.30	0.07	5	32.69	0.11
1970	5	33.30	0.04	5	33.16	0.02	15	33.00	0.06

Appendix 1. (Continued). Arithmetic mean with 1 standard error (SE) of sea temperature (MTEMP) and salinity (MSAL) by year and section. N = number of samples.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
				MSAL (cont'd)					
1971	7	33.24	0.09	6	33.04	0.07	10	32.87	0.05
1972	6	33.75	0.09	4	33.56	0.04	8	33.33	0.04
1973	5	33.74	0.04	5	33.58	0.05	5	33.51	0.03
1974	5	33.54	0.16	5	33.58	0.06	5	33.32	0.04
1975	6	33.79	0.08	6	33.60	0.04	4	33.20	0.06
1976	6	33.45	0.10	6	33.37	0.04	5	33.18	0.05
1977	4	33.55	0.02	6	33.40	0.05	4	33.10	0.29
1978	5	33.47	0.15	5	33.31	0.09	5	32.99	0.10
1980	3	33.83	0.03	4	33.74	0.02	5	33.52	0.08
1981	5	33.55	0.03	4	33.42	0.05	5	33.07	0.10
1982	2	33.40	0.07	5	33.12	0.20	4	32.64	0.06
1983	3	33.69	0.03	4	33.35	0.07			
1984	5	33.91	0.08	3	33.79	0.10	4	33.37	0.08

Appendix 2. Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
PLVOL									
1950	8	2.40	0.18	7	2.70	0.12	3	2.79	0.13
1952	4	2.99	0.16	3	2.79	0.13	3	2.59	0.44
1953	7	3.10	0.10	4	2.79	0.42	4	2.90	0.15
1954	6	2.72	0.31	7	3.11	0.08	6	2.44	0.29
1955	8	2.82	0.20	5	3.19	0.20	3	3.06	0.08
1956	3	2.98	0.47	3	2.99	0.45	6	2.58	0.43
1957	5	2.61	0.66	3	3.48	0.12	5	2.29	0.42
1958	4	3.13	0.23	5	2.85	0.37	5	2.47	0.33
1959	5	3.36	0.13	3	3.37	0.06	6	1.95	0.50
1960	2	2.19	0.48	2	3.62	0.32	2	2.40	0.09
1961	6	3.07	0.19	4	3.41	0.16	3	3.30	0.10
1963	12	2.58	0.16	26	2.61	0.11	13	2.10	0.14
1964	6	2.75	0.21	6	2.44	0.24	8	1.88	0.34
1966	7	2.33	0.14	8	2.84	0.11	5	2.23	0.28
1968	6	2.92	0.16	7	2.90	0.26	9	2.02	0.26
1969	6	2.12	0.15	8	2.47	0.18	5	2.33	0.22
1970	6	1.88	0.42	7	2.55	0.16	15	1.77	0.20
1971	8	2.69	0.14	7	2.80	0.09	10	1.68	0.19
1972	7	2.04	0.20	7	2.22	0.20	9	1.35	0.21
1973	5	2.39	0.11	5	2.71	0.34	5	2.15	0.39
1974	7	2.92	0.12	6	2.45	0.14	5	2.33	0.15
1975	6	2.57	0.23	6	3.26	0.09	4	2.59	0.29
1976	6	2.56	0.27	6	2.31	0.11	5	2.43	0.12
1977	4	2.62	0.20	6	2.46	0.24	5	3.13	0.12
1978	6	2.31	0.28	6	2.59	0.21	5	2.55	0.19
1979	7	2.57	0.09	6	2.89	0.06	6	2.50	0.20
1980	5	2.57	0.38	5	3.17	0.13	5	3.06	0.13
1981	5	2.03	0.37	5	2.27	0.26	5	2.37	0.15
1982	2	2.85	0.26	5	3.19	0.12	5	2.97	0.20
1983	4	2.32	0.21	4	2.69	0.14			
1984	5	3.09	0.16	5	2.85	0.19	4	3.00	0.17
AGLA									
1956	3	2.87	0.44	3	3.15	0.47	3	3.62	0.15
1957	2	3.01	0.17	2	3.70	0.30	1	3.74	
1958	2	3.08	0.80	1	3.74		1	3.53	
1961	6	3.10	0.26	4	3.68	0.11	3	3.20	0.18
1963	12	3.04	0.20	20	3.12	0.07	6	3.17	0.18
1964	6	2.27	0.43	6	2.28	0.27	5	2.13	0.59
1966	7	1.72	0.42	7	2.79	0.18	5	2.18	0.33
1970							14	0.91	0.27
1971							10	1.08	0.27
1972	7	1.69	0.36	7	2.03	0.47	9	0.79	0.37
1973							5	1.82	0.58
1974							5	1.79	0.29
1975							5	1.76	0.36
1976	1	0.60					5	1.47	0.13
1977	3	1.36	0.68	5	1.93	0.35	5	2.26	0.21
1978	6	1.42	0.49	6	2.21	0.32	5	2.41	0.21

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
				AGLA (Continued)					
1979	7	1.61	0.46	6	2.51	0.17	5	1.80	0.46
1980	5	2.10	0.62	5	3.13	0.12	5	2.84	0.20
1981	5	1.60	0.54	5	2.15	0.51	5	2.00	0.30
1982	2	2.93	0.36	5	3.25	0.11	5	2.87	0.23
1983	4	1.36	0.13	4	2.86	0.14			
				WAGLA					
1956	3	2.87	0.43	3	3.14	0.47	3	3.62	0.15
1957	2	3.00	0.17	2	3.72	0.32	1	3.74	
1958	2	3.23	0.66	1	3.74		1	3.53	
1961	6	2.97	0.33	4	3.67	0.11	3	3.20	0.18
1964	6	2.21	0.40	6	2.27	0.27	5	2.13	0.59
1966	6	1.95	0.34	7	2.77	0.18	5	2.18	0.33
1970							4	1.87	0.55
1971							4	1.45	0.26
1972	7	1.14	0.49	6	2.29	0.44	4	1.03	0.42
1973							1	3.12	
1974							4	2.02	0.23
1976							5	1.47	0.13
1978	5	1.48	0.52	6	2.19	0.32	5	2.41	0.21
1979	7	1.50	0.44	6	2.51	0.17	5	1.80	0.46
1980	5	2.09	0.62	5	3.12	0.12	5	2.84	0.20
1981	5	1.60	0.54	5	2.15	0.51	5	2.00	0.30
1982	2	2.93	0.36	5	3.25	0.11	5	2.87	0.23
1983	2	0.72	0.72	1	3.13				
				RAGLA					
1956	3	0.74	0.74	3	0.65	0.65	3	0	
1957	2	0.73	0.73	2	0		1	0	
1958	2	0		1	0		1	0	
1961	6	0.66	0.44	4	0.53	0.53	3	0	
1964	6	1.20	0.57	6	0.54	0.26	5	0	
1966	6	1.04	0.47	7	0.77	0.38	5	0.19	0.19
1970							4	0.25	0.25
1971							4	0	
1972	7	1.38	0.24	6	0.98	0.27	4	0	
1973							1	0	
1974							4	0	
1976							5	0	
1978	5	1.32	0.46	6	0.88	0.33	5	0	
1979	7	0.59	0.35	6	0		5	0	
1980	5	0.66	0.32	5	0.25	0.25	5	0	
1981	5	0.25	0.19	5	0.06	0.06	5	0.14	0.14
1982	2	1.01	0.31	5	0		5	0	
1983	2	1.36	0.08	1	1.18				
				COP					
1956	3	0.52	0.52	3	2.92	0.59	3	0	
1957	2	0.15	0.15	2	3.09	0.12	1	3.24	

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
				COP (Continued)					
1958	2	4	0.54	1	2.92		1	1.18	
1961	6	2.55	0.71	4	2.23	0.64	3	2.46	0.18
1963	12	1.27	0.33	20	1.47	0.16	6	0.3	0.22
1964	6	2.35	0.4	6	1.68	0.29	5	1.42	0.61
1966	7	0.29	0.25	7	0.91	0.51	5	0.67	0.67
1970							14	0.6	0.25
1971							10	0.18	0.12
1972	7	1.47	0.72	7	2.24	0.52	9	1.09	0.45
1973							5	1.01	0.48
1974							5	0.71	0.6
1975							5	0.84	0.84
1976	1	0					5	0	
1977	3	0.44	0.24	5	0.28	0.28	5	0.17	0.17
1978	6	0.87	0.48	6	1.13	0.41	5	1.33	0.63
1979	7	1.87	0.63	6	2.49	0.41	5	1.6	0.65
1980	5	0.19	0.19	5	2.49	0.44	5	3.05	0.36
1981	5	0.94	0.6	5	0		5	2.18	0.55
1982	1	2.55		4	2.53	0.87	5	1.68	0.97
1983	4	3.20	0.34	4	3.30	0.14			
				CALFI					
1956	3	0.33	0.33	3	2.46	0.21	3	0	
1957	2	0		2	2.73	0.43	1	3.17	
1958	2	2.99	0.91	1	2.43		1	0.90	
1961	6	0.91	0.70	4	0.58	0.58	3	1.63	0.2
1963	12	0.67	0.28	20	0.83	0.19	6	0	0
1964	6	1.51	0.41	6	1.60	0.30	5	1.10	0.55
1966	7	0.10	0.10	7	0.47	0.38	5	0.06	0.06
1970							12	0.46	0.24
1971							10	0.13	0.1
1972	7	1.29	0.72	7	2.02	0.51	9	0.41	0.24
1973							4	0	
1974							3	0	
1975							4	0	
1976	1	0		4	0		5	0	
1977							4	0	
1978	6	0		6	0.17	0.12	5	0	
1979	7	0.54	0.44	6	0.73	0.41	5	0.50	0.32
1982				4	1.58	0.94	5	0	
1983	4	0		4	0				
				CALHY					
1956	3	0.48	0.48	3	1.92	0.69	3	0	
1957	2	0.15	0.15	2	2.61	0.25	1	2.36	
1958	2	3.84	0.40	1	2.72		1	0.90	
1961	6	2.53	0.7	4	2.01	0.66	3	2.38	0.18
1963	12	0.84	0.32	20	0.98	0.18	6	0.21	0.21
1964	6	1.33	0.44	6	0.82	0.28	5	0.71	0.44

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
CALHY (Continued)									
1966	7	0.19	0.15	7	0.37	0.37	5	0.34	0.34
1970							12	0.40	0.27
1971							10	0.08	0.08
1972	7	1.04	0.55	7	1.57	0.43	9	0.90	0.36
1973							4	0	
1974							3	0	
1975							4	0	
1976	1	0					5	0	
1977				4	0		4	0	
1978	6	0.87	0.48	6	1.07	0.42	5	0.67	0.42
1979	7	1.86	0.63	6	2.48	0.41	5	1.60	0.65
1982				4	2.40	0.81	5	1.68	0.97
1983	4	3.20	0.34	4	3.30	0.14			
EUCH									
1956	3	0		3	2.23	0.88			
1957	2	0		2	0		1	0.78	
1958	2	1.54	1.54	1	1.56		1	0	
1961	6	0.49	0.49	4	0.17	0.17	2	0.66	0.18
1963	12	0.23	0.18	20	0.47	0.14	6	0.18	0.11
1964	6	2.15	0.37	6	0.10	0.06	5	1.09	0.63
1966	7	0.27	0.23	6	0.92	0.59	5	0.67	0.67
1970							14	0.19	0.17
1971							10	0	0
1972	7	1.02	0.62	7	0.40	0.28	9	0.76	0.44
1973							5	0	
1974							5	0.60	0.60
1975							5	0.81	0.81
1976	1	0					5	0	
1977				4	0		4	0	
1978	6	0		6	0		5	0.66	0.66
1979	7	0		6	0		5	0.10	0.10
1982	2	0		5	0		5	0	
1983	4	0		4	0				
HYPER									
1956	3	1.24	0.50	3	1.68	0.58	3	0.57	0.27
1957	2	0.82	0.22	2	0.57	0.57	1	1.57	
1958	2	1.82	0.78	1	0		1	0.30	
1961	6	0.97	0.31	4	0.88	0.36	3	1.41	0.11
1963	12	1.47	0.28	20	1.04	0.19	6	1.19	0.49
1964	6	1.58	0.39	6	0.71	0.22	5	1.60	0.47
1966	7	1.07	0.18	7	0.94	0.10	5	1.54	0.42
1970							14	0.98	0.16
1971							10	1.03	0.15
1972	7	1.13	0.27	7	1.93	0.18	9	0.87	0.32
1973							5	1.25	0.36
1974							5	1.37	0.38

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
HYPER									
1975							5	1.64	0.56
1976	1	1.83					5	1.17	0.26
1977	3	1.13	0.51	5	1.43	0.49	5	0.68	0.26
1978	6	0.90	0.34	6	0.92	0.07	5	0.94	0.35
1979	7	1.24	0.32	6	1.54	0.37	5	0.80	0.10
1980	5	1.37	0.15	5	2.47	0.32	5	2.43	0.13
1981	5	0.87	0.35	5	2.26	0.27	5	2.43	0.17
1982	2	1.36	0.08	5	1.70	0.38	5	1.93	0.25
1983	4	2.49	0.24	4	2.25	0.20			
EUP									
1956	3	0.16	0.16	3	0.91	0.59	3	0	
1957	2	0.71	0.41	2	2.12	0.06	1	1.76	
1958	2	1.49	1.49	1	0.90		1	1.18	
1961	6	1.09	0.50	4	1.54	0.71	3	2.08	0.67
1963	12	0.9	0.21	20	1.15	0.13	6	0.38	0.23
1964	6	1.28	0.44	6	0.74	0.29	5	0.96	0.56
1966	7	0.19	0.10	6	0.63	0.44	5	0.34	0.34
1970							14	0.21	0.09
1971							10	0.15	0.15
1972	7	0.45	0.27	7	0.67	0.21	9	0.54	0.28
1973							5	0.45	0.27
1974							5	0.52	0.32
1975							5	0.68	0.36
1976	1	0					5	0	
1977	3	0		5	0.24	0.24	5	0.10	0.10
1978	6	0		6	0.46	0.25	5	0.51	0.51
1979	7	0.74	0.24	6	1.63	0.4	5	0.50	0.34
1980	5	0		5	0.25	0.25	5	1.08	0.3
1981	5	0.39	0.19	5	0.35	0.22	5	0.85	0.24
1982	2	0.35	0.35	5	0.36	0.24	5	0.33	0.26
1983	4	0.23	0.23	4	0.82	0.09			
LIMA									
1956	3	1.85	1.07	3	3.55	0.33	3	3.29	0.79
1957	2	0.75	0.75	2	2.82	0.27	1	3.26	
1958	2	2.26	0.25	1	3.05				
1961	6	0.63	0.38	4	0.51	0.29	3	0.23	0.23
1963	12	1.41	0.31	20	1.31	0.13	6	0.97	0.39
1964	6	1.54	0.49	6	1.53	0.28	5	0.86	0.30
1966	7	0.53	0.33	7	1.59	0.29	5	0.72	0.45
1970							14	0.57	0.17
1971							10	0.18	0.10
1972	7	0.96	0.39	7	2.23	0.31	9	0.91	0.33
1973							5	0.76	0.35
1974							5	1.00	0.42
1975							5	0.58	0.43
1976	1	0					5	1.07	0.39
1977	3	0.53	0.53	5	0.19	0.12	5	0.34	0.17

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

		Section 1			Section 2			Section 3	
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
					LIMA (Continued)				
1978	6	0.53	0.27	6	0.57	0.37	5	0.57	0.5
1979	7	0.67	0.33	6	2.01	0.36	5	1.42	0.41
1980	5	0.71	0.44	5	3.27	0.3	5	3.21	0.15
1981	5	0		5	2.29	0.35	5	2.91	0.15
1982	2	0.48	0.48	5	2.67	0.26	5	2.08	0.55
1983	4	1.64	0.63	4	2.18	0.45			
					LIMR				
1956	3	1.61	1.16	3	3.51	0.33	3	3.03	0.69
1957	2	0.75	0.75	2	2.82	0.28	1	3.26	
1958	2	1.25	1.25	1	2.85				
1961	5	0.25	0.16	4	0.46	0.27	3	0.16	0.16
1963	12	1.39	0.31	20	1.3	0.13	6	0.96	0.39
1964	6	1.47	0.51	6	1.53	0.28	5	0.80	0.33
1966	7	0.44	0.34	7	1.58	0.29	5	0.60	0.45
1970							14	0.54	0.17
1971							10	0.11	0.08
1972	7	0.65	0.33	7	1.84	0.21	9	0.85	0.34
1973							5	0.76	0.35
1974							5	1	0.42
1975							3	0	
1976	1	0	.				2	0	
1977	2	0		3	0		2	0	
1978	6	0.43	0.22	6	0.50	0.32	5	0.55	0.47
1979	7	0.39	0.26	6	1.17	0.22	5	1.22	0.39
1980	5	0.52	0.34	5	2.62	0.18	5	2.32	0.21
1981	5	0		5	2.08	0.37	5	2.61	0.10
1982	2	0.42	0.42	5	2.03	0.38	5	1.74	0.44
1983	4	1.52	0.56	4	1.73	0.59			
					LIMH				
1956	3	1.15	0.83	3	1.64	0.60	3	2.86	0.95
1957	2	0		2	0.39	0.39	1	0	
1958	2	1.00	1.00	1	2.66		1	0	
1961	5	0.54	0.46	4	0.17	0.17	3	0	
1963	12	0.30	0.19	20	0.06	0.05	6	0.13	0.13
1964	6	0.52	0.37	6	0.05	0.05	5	0.06	0.06
1966	7	0.09	0.09	7	0.29	0.12	5	0.17	0.17
1970							14	0.08	0.04
1971							10	0.07	0.07
1972	7	0.66	0.35	7	1.80	0.45	9	0.31	0.17
1973							5	0	
1974							5	0	
1975							3	0	
1976	1	0					2	0	
1977	2	0		3	0		2	0	
1978	6	0.34	0.22	6	0.43	0.30	5	0.39	0.39
1979	7	0.28	0.28	6	1.89	0.42	5	0.66	0.46
1980	5	0.38	0.38	5	2.97	0.52	5	3.13	0.16

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

		Section 1			Section 2			Section 3	
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
				LIMH (Continued)					
1981	5	0		5	1.64	0.34	5	2.46	0.30
1982	2	0.24	0.24	5	2.04	0.48	5	1.58	0.66
1983	4	1.17	0.68	4	1.96	0.38			
				CLIO					
1956	3	1.41	0.43	3	1.93	0.1	3	1.85	0.43
1957	2	2.04	0.06	2	0.69	0.69	1	1.04	
1958	2	1.54	0.37	1	1.34		1	0.70	
1961	6	0.82	0.28	4	0.55	0.32	3	0.70	0.11
1963	12	1.14	0.06	20	1.33	0.06	6	1.13	0.18
1964	6	1.21	0.16	6	1.05	0.11	5	0.79	0.15
1966	7	1.33	0.28	7	0.49	0.1	5	0.71	0.11
1970							14	0.58	0.13
1971							10	0.69	0.21
1972	7	1.3	0.19	7	1.15	0.14	9	0.76	0.14
1973							5	0.94	0.13
1974							5	0.97	0.31
1975							5	1.05	0.12
1976	1	0.48					5	1.44	0.14
1977	3	0.64	0.26	5	0.62	0.12	5	0.83	0.23
1978	6	1.28	0.25	6	1.19	0.23	5	1.56	0.15
1979	7	1.10	0.13	6	1.26	0.31	5	1.50	0.26
1980	5	1.30	0.39	5	2.14	0.19	5	1.86	0.18
1981	5	1.24	0.10	5	1.60	0.20	5	1.31	0.27
1982	2	0.94	0.34	5	1.76	0.19	5	1.78	0.18
1983	4	1.06	0.12	4	1.05	0.15			
				CHAE					
1956	3	0		3	1.73	0.42	3	0	
1957	2	0		2	1.15	0.19	1	0	
1958	2	1.73	1.73	1	1.49		1	0	
1961	6	0.61	0.50	4	0.75	0.50	3	1.02	0.13
1963	12	0.34	0.22	20	0.34	0.09	6	0.05	0.05
1964	6	0.91	0.3	6	1.82	0.19	5	1.26	0.58
1966	7	0.17	0.17	7	0.09	0.06	5	0	
1970							14	0.38	0.17
1971							10	0.56	0.18
1972	7	1	0.52	7	1.18	0.34	9	0.83	0.38
1973							5	0.27	0.2
1974							5	0.36	0.36
1975							5	0.10	0.10
1976	1	0					5	0.19	0.12
1977	3	0.30	0.17	5	0.56	0.26	5	0.10	0.10
1978	6	0.10	0.10	6	0.05	0.05	5	0.23	0.16
1979	7	0.96	0.38	6	0.90	0.46	5	0.54	0.33
1980	5	0		5	0		5	0.69	0.42
1981	5	0.22	0.22	5	0		5	0.70	0.45
1982	2	0		5	0		5	0.24	0.15
1983	4	0.08	0.08	4	0.49	0.30			

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
				SHR					
1956	3	0.52	0.52	3	1.33	0.56	3	1.12	0.53
1957	2	0.56	0.56	2	2.49	0.27	1	0.78	
1958	2	1.68	0.06	1	0.60		1	0.85	
1961	6	0.95	0.36	4	0.97	0.58	3	0.43	0.22
1963	12	0.98	0.24	20	1.55	0.13	6	1.51	0.19
1964	6	1.46	0.27	6	1.06	0.24	5	1.66	0.15
1966	7	0.46	0.15	7	0.67	0.23	5	0.85	0.33
1970							14	0.8	0.21
1971							10	1.15	0.35
1972	7	1.54	0.38	7	1.98	0.28	9	1.3	0.34
1973							5	1.45	0.3
1974							5	1.97	0.29
1975							5	1.60	0.18
1976	1	0					5	1.14	0.37
1977	3	1.23	0.58	5	0.77	0.36	5	1.28	0.44
1978	6	0.13	0.09	6	0.35	0.22	5	0.46	0.29
1979	7	1.00	0.41	6	0.95	0.28	5	0.32	0.23
1980	5	0.53	0.24	5	1.17	0.30	5	1.34	0.55
1981	5	0.46	0.23	5	0.49	0.30	5	1.09	0.51
1982	2	2.23	0.20	5	2.61	0.27	5	0.85	0.30
				CRAB					
1956	3	1.10	0.65	3	0.93	0.51	3	0	
1957	2	1.61	0.66	2	1.35	0.39	1	0.78	
1958	2	0		1	0		1	1.46	
1961	6	1.10	0.27	4	0.5	0.31	3	0.58	0.29
1963	12	1.86	0.33	20	0.8	0.15	6	0.13	0.09
1964	6	2.16	0.45	6	0.82	0.08	5	1.23	0.25
1966	7	1.64	0.31	7	0.22	0.11	5	0.55	0.4
1970							14	0.59	0.21
1971							10	1.33	0.28
1972	7	2.14	0.51	7	1.31	0.2	9	1.51	0.39
1973							5	1.76	0.69
1974							5	1.04	0.32
1975							5	0.97	0.32
1976	1	0					5	0.22	0.13
1977	3	2.04	1.02	5	0		5	0	
1978	6	0.74	0.42	6	0.27	0.13	5	0.47	0.29
1979	7	0.91	0.51	6	0.33	0.33	5	0	
1980	5	1.06	0.47	5	0.33	0.33	5	0	
1981	5	0.54	0.37	5	0		5	0.57	0.35
1982	2	1.38	1.38	5	0.51	0.20	5	1.27	0.45
1983	4	1.52	0.21	4	0.15	0.15			
				GONA					
1956	3	0.44	0.44	3	0.69	0.47	3	0.23	0.23
1957	2	0.24	0.24	2	0.65	0.35	1	1.32	
1958	2	0.52	0.52	1	0.7		1	0	
1961	6	0.56	0.20	4	0.62	0.33	3	1.10	0.20

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
GONA (Continued)									
1963	12	0.72	0.16	20	0.69	0.11	6	0.60	0.32
1964	6	0.38	0.14	6	0.9	0.23	5	0.52	0.23
1966	7	0.16	0.12	8	0.3	0.1	5	0.26	0.26
1970							14	0.04	0.03
1972	7	0.04	0.04	7	0.31	0.1	9	0.32	0.16
1973							5	0.16	0.1
1974							5	0.35	0.21
1975							5	0.18	0.18
1976	1	0					5	0.62	0.23
1977	3	0.16	0.16	5	0.17	0.17	5	0.45	0.32
1978	6	0.10	0.06	6	0.32	0.16	5	0.44	0.27
1979	7	0.04	0.04	6	0.21	0.10	5	0.14	0.14
1980	5	0.47	0.47	5	1.46	0.22	5	0.97	0.34
1981	5	0		5	0.17	0.17	5	0.45	0.28
1982	2	0.52	0.52	5	0.93	0.36	5	0.28	0.28
1983	4	0		4	0.15	0.09			
COD									
1950	8	0.84	0.21	7	1.05	0.28	3	1.20	0.03
1952	6	0.20	0.13	4	0.62	0.21	3	0.38	0.25
1953	11	0.51	0.15	6	0.85	0.31	6	0.18	0.11
1954	6	0.79	0.11	7	0.57	0.09	6	0.10	0.06
1955	8	0.62	0.12	6	0.55	0.09	3	0.30	0.17
1956	3	0.23	0.23	3	0.30	0.17	6	0.31	0.1
1957	5	1.47	0.40	3	1.45	0.34	5	0.38	0.19
1958	4	0.69	0.26	5	0.24	0.15	5	0.62	0.21
1959	5	0.54	0.15	4	0.59	0.26	6	0.38	0.14
1960	2	0.30	0.30	2	1.29	0.25	2	0.30	
1961	6	0.65	0.20	4	0.66	0.16	3	0.10	0.10
1962	1	0					3	0	
1963	13	0.33	0.09	26	0.29	0.07	14	0.31	0.12
1964	6	0.17	0.12	6	0.10	0.06	8	0.18	0.14
1966	7	0.31	0.10	8	0.64	0.09	5	0.06	0.06
1968	6	0.64	0.22	7	0.86	0.20	9	0.07	0.04
1969	6	0.21	0.16	8	0.59	0.15	5	0.12	0.07
1970	6	0.19	0.19	7	0.09	0.06	15	0.11	0.06
1971	8	0.16	0.08	7	0.20	0.11	10	0.33	0.11
1972	7	0.24	0.07	7	0.33	0.13	9	0	
1973	5	0.24	0.11	5	0.19	0.12	5	0.22	0.13
1974	7	0.31	0.09	6	0.10	0.06	5	0.10	0.1
1975	6	0.84	0.10	6	0.31	0.11	5	0.19	0.12
1976	6	0.05	0.05	6	0.33	0.08	5	0.10	0.10
1977	4	0.15	0.09	6	0.13	0.09	5	0.22	0.09
1978	6	0.08	0.08	6	0.10	0.06	5	0.06	0.06
1979	7	0.27	0.14	6	0.26	0.13	6	0.15	0.07
1980	5	0.60	0.19	5	0.52	0.24	5	0.06	0.06
1981	5	0.06	0.06	5	0.18	0.12	5	0.12	0.07
1982	2	0.69	0.21	5	1.15	0.17	5	0.92	0.2
1983	4	0.08	0.08	4	0.72	0.26			
1984	5	0.06	0.06	5	0.62	0.36	4	0.21	0.21

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
				GHL					
1950	8	0.30	0.11	7	1.31	0.17	3	1.15	0.39
1952	6	0.31	0.22	4	1.28	0.49	3	0.71	0.39
1953	11	0.27	0.12	6	0.61	0.31	6	0.30	0.13
1954	6	1.00	0.31	7	1.72	0.16	6	0.26	0.17
1955	8	0.76	0.23	6	0.86	0.31	3	0.16	0.16
1956	3	0.57	0.42	3	0.65	0.44	6	0.2	0.15
1957	5	0.50	0.26	3	0.73	0.22	5	0.06	0.06
1958	4	0.49	0.4	5	0.81	0.24	5	0.06	0.06
1959	5	0.30	0.16	4	1.10	0.30	6	0	
1960	2	0.24	0.24	2	0.87	0.57	2	0	
1961	6	0.35	0.14	4	0.65	0.32	3	0.36	0.23
1962	1	0					3	0	
1963	13	0.56	0.15	26	0.52	0.08	14	0.24	0.09
1964	6	0.56	0.22	6	0.56	0.21	8	0.15	0.06
1966	7	0.31	0.13	8	0.75	0.11	5	0.29	0.29
1968	6	0.25	0.12	7	1.00	0.23	9	0.05	0.05
1969	6	0.49	0.27	8	1.18	0.27	5	0.36	0.11
1970	6	0.17	0.12	7	0.58	0.2	15	0.04	0.03
1971	8	0.55	0.16	7	0.31	0.17	10	0.14	0.09
1972	7	0		7	0.89	0.25	9	0.31	0.20
1973	5	0.26	0.17	5	1.36	0.27	5	0.52	0.24
1974	7	0.35	0.18	6	0.49	0.16	5	0.10	0.10
1975	6	0.39	0.21	6	0.51	0.19	5	0.06	0.06
1976	6	0.20	0.15	6	0.45	0.07	5	0.62	0.28
1977	4	0.39	0.22	6	0.59	0.24	5	0.24	0.15
1978	6	0.18	0.13	6	0.47	0.16	5	0.28	0.12
1979	7	0		6	0.28	0.10	6	0.05	0.05
1980	5	0.29	0.15	5	1.30	0.27	5	0.73	0.21
1981	5	0.31	0.13	5	0.82	0.36	5	0.69	0.13
1982	2	0.95	0.48	5	1.89	0.26	5	0.52	0.22
1983	4	0.29	0.20	4	1.21	0.18			
1984	5	0.12	0.07	5	0.25	0.16	4	0.33	0.14
				RED					
1950	8	0		7	0		3	0.26	0.14
1952	6	0		4	0		3	0.20	0.20
1953	11	0		6	0.05	0.05	6	0	
1954	6	0		7	0		6	0	
1955	8	0		6	0.05	0.05	3	0	
1956	3	0		3	0		6	0	
1957	5	0		3	0.23	0.23	5	0.06	0.06
1958	4	0.15	0.09	5	0		5	0	
1959	5	0		4	0		6	0	
1960	2	0		2	0		2	0	
1961	6	0		4	0		3	0	
1962	1	0					3	0	
1963	13	0		26	0.01	0.01	14	0.08	0.06
1964	6	0		6	0		8	0	
1966	7	0		8	0		5	0	
1968	6	0		7	0		9	0	

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
				RED (Continued)					
1969	6	0.1	0.06	8	0.22	0.13	5	0.12	0.07
1970	6	0		7	0		15	0	
1971	8	0		7	0		10	0	
1972	7	0		7	0		9	0.07	0.07
1973	5	0		5	0.12	0.07	5	0	
1974	7	0		6	0		5	0	
1975	6	0		6	0		5	0.06	0.06
1976	6	0		6	0		5	0	
1977	4	0		6	0		5	0	
1978	6	0		6	0		5	0	
1979	7	0		6	0		6	0.05	0.05
1980	5	0		5	0		5	0	
1981	5	0		5	0		5	0	
1982	2	0		5	0		5	0	
1983	4	0		4	0				
1984	5	0		5	0		4	0	
				PLA					
1950	8	0.06	0.06	7	0.47	0.18	3	0.10	0.10
1952	6	0.24	0.16	4	0.65	0.43	3	0	
1953	11	0.36	0.16	6	0.72	0.27	6	0.20	0.13
1954	6	0.87	0.25	7	1.25	0.13	6	0.10	0.06
1955	8	0.44	0.19	6	0.51	0.13	3	0.30	
1956	3	0.43	0.30	3	0.61	0.31	6	0	
1957	5	0.23	0.16	3	0.59	0.32	5	0.14	0.14
1958	4	0.5	0.12	5	0.72	0.12	5	0.12	0.07
1959	5	0.79	0.31	4	1.26	0.28	6	0	
1960	2	0.30	0.30	2	1.41	0.3	2	0	
1961	6	0.41	0.19	4	0.31	0.19	3	0.20	0.20
1962	1	0					3	0	
1963	13	0.71	0.18	26	0.46	0.10	14	0.29	0.12
1964	6	0.73	0.18	6	1.11	0.16	8	0.1	0.07
1966	7	0.85	0.35	8	0.95	0.15	5	0.41	0.34
1968	6	0.18	0.11	7	0.58	0.28	9	0	
1969	6	0.15	0.1	8	0.49	0.24	5	0.28	0.17
1970	6	0.08	0.08	7	0.42	0.21	15	0.02	0.02
1971	8	0.88	0.2	7	0.95	0.11	10	0.15	0.08
1972	7	0.20	0.07	7	0.09	0.06	9	0	
1973	5	0.14	0.14	5	0.28	0.21	5	0.20	0.14
1974	7	0.61	0.21	6	0.67	0.11	5	0	
1975	6	0.86	0.23	6	0.4	0.17	5	0	
1976	6	0.33	0.21	6	0.5	0.2	5	0.30	0.16
1977	4	0.08	0.08	6	0.28	0.1	5	0.18	0.07
1978	6	0		6	0		5	0	
1979	7	0.29	0.15	6	0.38	0.14	6	0	
1980	5	0.88	0.36	5	1.15	0.39	5	0.16	0.16
1981	5	0.40	0.25	5	0.34	0.14	5	0.10	0.10
1982	2	0.90	0.05	5	1.78	0.24	5	0.06	0.06
1983	4	0		4	0				
1984	5	0.06	0.06	5	0.62	0.27	4	0.08	0.08

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
WOLF									
1950	8	0		7	0.17	0.06	3	0.26	0.14
1952	6	0.05	0.05	4	0.19	0.12	3	0.30	0.17
1953	11	0.05	0.04	6	0.10	0.06	6	0.10	0.06
1954	6	0.20	0.06	7	0.22	0.09	6	0.15	0.07
1955	8	0.17	0.07	6	0.29	0.10	3	0.10	0.10
1956	3	0.26	0.14	3	0.10	0.10	6	0.15	0.07
1957	5	0.19	0.12	3	0.20	0.10	5	0	
1958	4	0.15	0.09	5	0.22	0.09	5	0.06	0.06
1959	5	0.12	0.07	4	0.08	0.08	6	0.05	0.05
1960	2	0		2	0		2	0	
1961	6	0.05	0.05	4	0.08	0.08	3	0	
1962	1	0					3	0	
1963	13	0.14	0.06	26	0.13	0.04	14	0.08	0.04
1964	6	0.17	0.12	6	0.23	0.08	8	0.04	0.04
1966	7	0.18	0.09	8	0.23	0.07	5	0.12	0.07
1968	6	0.52	0.13	7	0.18	0.09	9	0.09	0.06
1969	6	0.05	0.05	8	0.08	0.05	5	0	
1970	6	0		7	0.09	0.06	15	0.02	0.02
1971	8	0.04	0.04	7	0.33	0.09	10	0.03	0.03
1972	7	0.04	0.04	7	0.26	0.08	9	0.09	0.06
1973	5	0.12	0.07	5	0.36	0.12	5	0.12	0.07
1974	7	0.07	0.07	6	0.08	0.08	5	0.10	0.10
1975	6	0.05	0.05	6	0.15	0.07	5	0.18	0.07
1976	6	0.05	0.05	6	0.13	0.09	5	0.19	0.12
1977	4	0.08	0.08	6	0.23	0.11	5	0	
1978	6	0.12	0.12	6	0.13	0.09	5	0.12	0.07
1979	7	0		6	0.05	0.05	6	0.05	0.05
1980	5	0.06	0.06	5	0.96	0.19	5	0.18	0.07
1981	5	0		5	0.25	0.11	5	0.37	0.18
1982	2	0		5	0.76	0.15	5	0.55	0.20
1983	4	0		4	0				
1984	5	0		5	0.19	0.12	4	0	
SAND									
1950	8	0.39	0.11	7	0.22	0.08	3	0	
1952	6	0.16	0.10	4	0.29	0.18	3	0	
1953	11	0.51	0.16	6	0.42	0.28	6	0	
1954	6	0.10	0.06	7	0.04	0.04	6	0.05	0.05
1955	8	0.20	0.09	6	0.17	0.12	3	0	
1956	3	0.36	0.18	3	0		6	0.05	0.05
1957	5	0.24	0.06	3	0		5	0	
1958	4	0.19	0.12	5	0.68	0.28	5	0.16	0.1
1959	5	0.30	0.16	4	0.08	0.08	6	0.16	0.16
1960	2	0.15	0.15	2	0.24	0.24	2	0	
1961	6	0.08	0.08	4	0.08	0.08	3	0	
1962	1	0					3	0.26	0.14
1963	13	0.85	0.23	26	0.25	0.06	14	0.29	0.13
1964	6	0.62	0.29	6	0.10	0.06	8	0.36	0.2
1966	7	1.37	0.23	8	0.62	0.17	5	0.19	0.12
1968	6	0.71	0.26	7	0.61	0.27	8	0.11	0.11

Appendix 2. (Continued). Mean abundance indices [log10(x+1)] with 1 standard error (SE) of different zooplankton taxa by year and section. Abbreviations shown in Table 2. N = number of stations with zooplankton hauls.

	Section 1			Section 2			Section 3		
Year	N	Mean	SE	N	Mean	SE	N	Mean	SE
				SAND (Continued)					
1969	6	0.98	0.32	8	1.36	0.31	5	0.66	0.25
1970	6	0.8	0.35	7	0.65	0.25	15	0.54	0.18
1971	8	0.32	0.12	7	0.37	0.14	10	0.89	0.27
1972	7	1.45	0.12	7	1.13	0.17	9	1.04	0.22
1973	5	1.34	0.17	5	1.29	0.44	5	1.38	0.47
1974	7	0.41	0.18	6	1.22	0.38	5	0.80	0.36
1975	6	1.46	0.17	6	0.85	0.23	5	0.34	0.12
1976	6	0.63	0.26	6	1.62	0.24	5	0.61	0.37
1977	4	0.83	0.32	6	0.13	0.09	5	0.06	0.06
1978	6	0.55	0.15	6	0.53	0.2	5	0.06	0.06
1979	7	0.25	0.17	6	0.13	0.09	6	0	
1980	5	0.55	0.17	5	0.12	0.12	5	0	
1981	5	0.16	0.10	5	0.24	0.11	5	0.12	0.07
1982	2	1.07	0.60	5	1.37	0.42	5	0.87	0.41
1983	4	1.06	0.33	4	0.75	0.26			
1984	5	0.88	0.21	5	1.25	0.39	4	0.27	0.27