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Water temperature and wind effects on the abundance of 0-group plaice (*Pleuronectes platessa*) in the Kattegat

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Abstract:

0-group plaice abundance at two sites in the Kattegat has been shown to be higher in years when wind conditions during the larval development period (March-April) were moderate to strong. This finding suggests that drift patterns from spawning to nursery sites depend on wind conditions, and that larval plaice may be food limited in years when wind conditions are calm. This analysis has been updated and the regional coverage expanded to include the abundance of 0-group plaice along the entire Danish Kattegat coast from Skagen to Fornæs. Observations on 0-group meristic variability (number of anal fin rays) in the Kattegat and the Belt Sea, and temperature and salinity (February-May) in the surface, in the discontinuity layer and near the bottom have been included in the analyses. We find that (1) wind has significant influences on the abundance of 0-group plaice along the entire Danish Kattegat coast, (2) meristic variation depends on wind and hydrographic conditions in a manner consistent with a proposed wind-induced advection of eggs and/or larvae from northern areas to southern areas, and (3) spring temperature has comparatively little influence on abundance or meristic variation.

Introduction.

Variability in 0-group plaice abundance at two study sites along the Danish Kattegat coast can be partly explained by wind speed during the egg and larval phases (MacKenzie et al. 1994). These relationships were all positive and highest in the months (March, April) when larvae were most likely in the water column and actively feeding. This pattern suggested that plaice abundance may partly be determined by processes occurring during the egg and larval stages.

One of these processes could be the role of water mass transport on the distribution of eggs and larvae. Since one of the main spawning areas of plaice is located west of Skagen along the Danish coast (Poulsen 1938), water mass movements in the Skagerrak/Kattegat region (Poulsen 1991, Jakobsen et al. 1994) could potentially increase the rate of exchange of plaice eggs and larvae among different areas of the Skagerrak and Kattegat (Poulsen 1938, Pihl 1990). This hypothesis has been supported by the occurrence of higher than average numbers of 0-group plaice in years when there were unusually strong winds (MacKenzie et al. 1994).

In this paper, we update and extend the wind analyses in MacKenzie et al. (1994) to include the entire Danish Kattegat coast, and part of the Belt Sea. Spatial variability in abundance among 6 sampling sites will be compared. In addition we will also use meristic and hydrographic (salinity, temperature) information to support the wind-based results. Our hypothesis is that hydrographic effects on 0-group plaice abundance reflect transport of eggs and/or larvae among areas.

The meristic information that we will use are counts of anal fin rays (Bagge and Nielsen 1993). Meristic characters such as these are partly determined by environmental conditions during development (Lindsey 1988). In plaice, meristic counts become fixed during the larval stage and by the end of metamorphosis (Molander & Molander-Swedmark 1957, Brooks & Johnston 1994). As a result they can sometimes be useful in determining environmental conditions during egg and larval development, and the geographic origins of different plaice populations (Poulsen 1938, Dannevig 1950). In Danish waters, Poulsen (1938) found that plaice in the North Sea, Skagerrak and northern part of the Kattegat have more anal fin rays than those in the southern Kattegat and Belt Sea. Similar results have been found for the Kattegat by Bagge & Nielsen (1993) using samples collected during 1985-1991. We shall investigate how fin ray counts vary with wind and hydrographic conditions in the eastern part of the Kattegat.

We find that (1) wind has significant influences on the abundance of 0-group plaice along the entire Danish Kattegat coast, (2) meristic variation depends on wind and hydrographic conditions in a manner consistent with a proposed wind-induced advection of eggs and/or larvae from northern areas to southern areas, and (3) spring water temperature has comparatively little influence on abundance or meristic variation.

Material and methods

Data sets- plaice. The 0-group data sets and sampling methods are described in detail by Nielsen & Bagge (1985), Bagge & Nielsen (1993) and MacKenzie et al. (1994). MacKenzie et al. (1994) investigated wind effects on plaice abundance at 2 study sites within the Kattegat during the period 1957-1992. These sites were located south of Skagen in the northern part of the Kattegat (area 1; Fig. 1) and in Ålborg Bay in the southern part of the Kattegat (areas 6 and 7, hereafter referred to area 67). In this study, we will also consider wind effects on plaice abundance in the area between these two sites (i. e., areas 2 and 5; Fig. 1).

The meristic data (anal fin rays) are described by Bagge and Nielsen (1993). The data series used in this study comprises the mean number of anal fin rays of ≈ 100 0-group plaice sampled at each study site for several years beginning in 1985.

Wind data. Wind observation sites were located near Skagen, Anholt North, and Gniben (Kattegat southwest; Fig. 1). The wind data set contains observations for the months February - May for the years 1957-1993.

The raw wind time series consists of daily measurements made at noon 0-2 m above the sea surface. The wind indices used, their justification and other details of the data set are described by MacKenzie et al. (1994). These indices are the monthly mean wind speed and the number of days per month when wind speed exceeded 7.5 m s^{-1}. To assess whether 0-group abundance was associated with wind-induced transport of eggs and larvae, we calculated a time series of velocities for the wind vector component oriented along the major north-south axis of the Kattegat. Positive velocity values represent winds originating from the south, and negative values represent winds originating from the north. Hence given the general influence of wind on currents in this region (Poulsen 1991, Matthaus and Franck 1992, Jakobsen et al. 1994), we expect that strong outflows of surface water will likely be associated with large positive wind velocities, and strong inflows of surface water will likely be associated with large negative wind velocities. As an index of the potential for wind-induced larval transport from north to south, we calculated the number of days per month when the velocity component was less than the 25th percentile (i. e., all values < -3.2 m s^{-1}) of the long-term velocity distribution.

Hydrographic data. The data sets include water temperature and salinity recorded at different depths and are compiled in Nautisk- meteorologisk yearbooks of the Danish Meterological Institute. Recording stations are the Skagen Reef lightvessel, the Kattegat southwest lightvessel and the Anholt North lightvessel in the period 1950-1972. The lightvessels were withdrawn in 1972-1973. The data sets after 1975 are based on research vessel survey data (Vagn Olsen pers. com.). The data collected by these vessels have been averaged for three regions of the Kattegat correspon-ding approximately to the former locations of the lightvessel positions (Skagen Rev - Kattegat North: 57° 40'-57° 50' ; Anholt North - Kattegat Middle: 56° 45'-57 20' ;

Kattegat southwest - Kattegat South: 55° 55'- 56° 45').

The temperature and salinity data from the lightvessels were daily observations recorded from the surface to the bottom in 5 m intervals. The survey data are mean temperature and mean salinity recorded at different depths. In the present paper the depths 0, 15 and 35 m were used and the months are the same as those used in the wind data sets (February - May). The surface measurements indicate the relative magnitude of outflow of brackish water from the Baltic Sea (Poulsen 1938), and the bottom observations indicate the presence of inflows of North Sea/Skagerrak water (Poulsen 1938). The 15 m depth corresponds approximately to the depth of the summer thermocline in the Kattegat (Poulsen 1991, Heilmann et al. 1994).

Statistical methods- Plaice abundance estimates were natural log transformed before analysis because abundance estimates of fish populations tend to be logarithmically distributed (Hennemuth et al. 1980). All statistical analyses are based on the detection of associations between plaice abundance and abiotic variables. To detect such associations, we constructed scatterplots and calculated linear correlation coefficients between pairs of selected variables. Due to the large number of correlations conducted, significance levels for correlation coefficients, r, were assessed at the 1% probability level, instead of the 5% level.

Results

Enrivonmental conditions (wind, temperature and salinity):

Since interannual variability in the wind time series has been described earlier by MacKenzie et al. (1994), only a short summary is given here. The Skagen area is more exposed and generally has a higher frequency of strong winds than either Anholt North or Kattegat SW. The freqency of strong winds in the Kattegat SW has been below the mean in the early-mid 1980's.

Mean monthly water temperatures for Skagen at 0, 15 and 35 m depth typically rise from ≈ 2° in February to ≈ 9° in May at the surface, and from ≈ 3.7° to ≈7° at 15 m (Fig. 2). Mean monthly temperatures at the bottom (35 m) showed less interannual variability (range: ≈ 5 - 6.2°).

The vertical distribution of salinity showed a pattern typical for this geographic area. Surface salinity was lower and more variable than at the other two depths, and was lower in late spring than in late winter (Fig. 2).

Abundance of 0-group plaice

Interannual variability in 0-group abundance increases from Skagen (area 1) to Fornæs (area 67). The coefficients of variation (CV = 100 * st. dev./mean) for each site are shown below:

area 1	area 2	area 5	area 67	Belt Sea
43.23	44.31	67.45	92.06	61.83

Abundances at all sites tended to be positively inter-correlated, and those at neighboring sites tended to be most highly correlated (Table 1). This pattern was most significant for abundances at areas 67 and 5 ($P < 0.01$), and area 67 and the Belt Sea ($P < 0.10$), whereas sites separated by larger distances tended to vary independently of each other (Fig. 3).

Our earlier analyses showed a significant positive association between plaice abundance and the number of days when the wind exceeded 7.5 m/sec during April and May (MacKenzie et al. 1994). Similar results are seen in the present analysis for the updated data set for areas 1 and 67, and for the entire Danish Kattegat coast (Table 2, Fig. 4). The combined sample sites from Skagen to Fornæs showed significant positive correlations for March, April and May, and were most significant in April and May ($r = 0.5072$, $P = 0.0069$ and $r = 0.5007$, $P = 0.0078$; Table 2).

The mean wind speed in the extended and updated data sets showed significant positive associations with plaice variability in May for the entire Kattegat, and during April and May for the southern part of the Kattegat (area 67; Table 3, Fig. 5). The tally index of days when longshore wind velocity was less than the critical value of -3.2 m/s also had a significant positive effect on 0-group abundance, particularly at area 67. Here, plaice abundance covaried ($r = 0.52$; $P = 0.0056$) with the wind index for April at Kattegat SW (Fig. 6).

There were few significant associations between either water temperature or salinity and plaice abundance (Table 4). The main exception involved area 67. At this site, abundance was positively correlated with the surface salinity measured at Skagen during March (Fig. 7). In addition, plaice abundance at this site was negatively correlated with the bottom salinity at Skagen during the same month (Fig. 7). Temperature had no significant influence on abundance at any site, except for area 2 where abundance and bottom temperature during the months of February and March at Kattegat SW were positively correlated (Table 4).

Meristic variation

The number of anal fin rays varied among years and sites in the range ca. 51-55 with a standard deviation of ca. 2 within each site and year (Table 5; Fig. 8). Areas 67 and the Belt Sea showed more interannual variability (range ≈ 51-55) than areas 1 and 25 (range ≈ 54-55).

This variability was independent of both the surface and 15 m temperature during February-March at the recording station nearest to the plaice sampling site (Fig. 9). However, scatterplots showed that while fin ray counts were stable for areas 1 and 25 across a 6 degree surface temperature range, they were more variable for area

67 and the Belt Sea, despite a smaller range in temperatures at these sites. Hence in some years, meristic counts in area 67 resembled those in areas 1, 2 and 5, whereas in other years, they resembled those observed in the Belt Sea (Fig. 9).

This observation suggested that meristic variation in area 67 and the Belt Sea depended on hydrographic input of eggs or larvae from northern areas. We tested this hypothesis by comparing the fin ray counts in the different areas with the occurrence of wind conditions most likely to advect eggs and larvae along the north - south axis of Kattegat. This comparison showed that fin ray counts increased significantly ($r = 0.95$; $P < 0.01$ at area 67 and $r = 0.88$; $P < 0.01$ in the Belt Sea) in years when the Skagen wind site recorded strong longshore winds from north to south (i.e., number of days when longshore wind was greater than -3.2 m/s) during the months of April (area 67) and March (Belt Sea).

The corollary to this hypothesis is that if meristic variation at area 67 and in the Belt Sea depended on wind-induced transport, differences in meristic variation along the entire Danish Kattegat coast within each year should also be related to wind conditions. For these comparisons we plotted the annual difference in mean fin ray count between (1) the northern Kattegat (areas 1, 2 and 5) and the Belt Sea, and (2) the northern Kattegat (areas 1, 2 and 5) and area 67 versus our threshold longshore wind velocity tally for the month and site that had the strongest association with meristic variation in the Belt Sea or at area 67. In the first comparisons, the month and wind site used was March and Skagen, and in the second comparison, the month and wind site used was April and Skagen (see paragraph above for correlation indices). As expected, these comparisons showed that fin ray counts throughout the Danish part of Kattegat and Belt Sea region tended to be most similar ($0.01 < P < 0.05$) in years when wind conditions were most likely to advect water masses containing eggs and/or larvae from north to south (Fig. 10).

Discussion.

Our results demonstrate the existence of statistically significant associations between wind conditions and the abundance, distribution and meristic variation of 0-group plaice in the Kattegat and Belt Sea. Wind conditions mediate water mass exchange through the Skagerrak/Kattegat frontal region and along the main axis of the Kattegat (Poulsen 1991, Jakobsen et al. 1994, Heilmann et al. 1994). This appears to facilitate a transport of plaice eggs and larvae among areas (Poulsen 1938, Pihl 1990; Figs. 4, 7, 10).

Our findings are based principally on exploratory data analysis methods coupled with a general understanding of plaice ecology and Kattegat/Skagerrak hydrography. This approach has allowed us to identify some consistent features involving interactions between wind, hydrography and one of the biotic components of the Kattegat/Skagerrak ecosystem. First, we found that 0-group abundance at different sites south of Skagen was higher in years when wind conditions are strong. This covariance was strongest for winds recorded during March and April, which generally overlaps the period when eggs and larvae are most likely to be in the water column (Poulsen 1938, Pihl 1990, Ulmestrand 1992). This abundance-wind relationship was particularly apparent for the southernmost site in the Kattegat for winds in the north-to-south direction (Fig. 6, 7). These patterns are consistent with the idea that the plaice population west and north of Skagen (Poulsen 1938) is a likely source of eggs and larvae for more southerly areas.

This idea is also supported by evidence of geographic variation in meristic characters (Fig. 8; Bagge & Nielsen 1993). The number of anal fin rays was larger and less variable in the northern areas than in the southern areas. This trend (see also Bagge & Nielsen 1993) is consistent with the geographic distribution of meristic variability reported by Poulsen (1938), and the proposed advection of eggs or larvae from northern areas towards the south. Moreover, the magnitude of meristic variation between sites is itself associated with wind conditions similar to those which are significantly associated with variability in 0-group abundance (Fig. 4-6). Hence variability in plaice meristic variation in Kattegat is more likely to be associated with the wind-related transport of eggs and larvae among sites, than with a direct effect of local temperatures or salinities on egg and larval development (e. g., Molander & Molander-Swedmark 1957, Brooks & Johnston 1994) in different areas.

We found no evidence that strong winds were negatively associated with 0-group abundance. All significant relationships involving wind which we have observed have a positive sign. Had there been no influence of wind on 0-group plaice abundance, we would have expected by chance to have found a very small number of significant correlations ($P < 0.01$), with half being positive and half being negative. However, all of our significant wind-abundance relationships are positive. The apparent influence of wind is therefore probably due to a real effect of wind on hydrography and larval transport, and not due to falsely rejecting the null hypothesis of no wind effect (Type I statistical error; Sokal & Rohlf 1981, p. 159).

The physical oceanographic mechanisms linking wind variation to water mass transport cannot be identified from our analyses. This will require more detailed physical oceanographic investigations (e. g., Jakobsen et al. 1994), and a better description of the vertical distribution of plaice eggs and larvae. When this information become available, it may be possible to develop better indices of transport which could improve our attempts to explain interannual variability in 0-group plaice abundance.

Spring water temperature had relatively little effect on either abundance or meristic variation of 0-group plaice. This contrasts with findings in other areas (e. g., van der Veer et al. 1990, Pihl 1990), and with earlier work in this area (Nielsen and Bagge 1985). However the negative relationships found in other areas have been attributed to the influence of winter bottom temperatures on abundance of 0-group predators (e. g., shrimps, crabs; Pihl 1990, van der Veer et al. 1990). Our analyses excluded consideration of winter temperatures, so it is possible that in Danish areas of the Kattegat and in the Belt Sea, the effect of winter temperature on 0-group abundance may be similar as in other regions. In addition, we have not directly considered how wind conditions affect water temperature in larval and 0-group habitats. Hence some of the influences of wind which we have described may be partly due to interrelationships between wind and temperature. Identifying the effect of temperature may therefore require more sophisticated analytical methods than those which we have used here (e. g., partial correlations and path analyses).

In summary, plaice abundance, distribution and meristic variation in Danish part of the Kattegat, and in the Belt Sea appear to be sensitive to variations in wind conditions during the egg and larval stages. The proposed mechanism likely involves transport of these stages from northerly spawning sites to more southerly areas.

Acknowledgements

We thank O. Vagn Olsen (Danish Institute for Fisheries Reseach) for obtaining hydrographic data for us.

Table 1 . The correlation (r) between the abundance of the investigated areas.

	Area 1	Area 2	Area 5	Area 67	The Beletsea
Area 1	1.00				
Area 2	.4608*	1.00			
Area 5	.4187*	.3820	1.00		
Area 67	.3274	.0520	.7130**	1.00	
The Beltsea	.3002	.0100	.2285	.7373*	1.00

* significant on 5% level.
** significant on 1% level.

Table 2 . Monthly correlations between 0-group plaice abundance at different sites in the Kattegat and number wind days with winds >7.5.

sampling site	windstation	month	Pearson r	P
1	skag	April	.6788	.0005
67	Kat.sw	March	.5120	.0063
67	Kat.sw	April	.5773	.0016
67	Anholt	Mai	.5632	.0027
Danish Kattegat	Skag	April	.5072	.0069
Danish Kattegat	Skag	Mai	.5007	.0078

Table 3 . Monthly correlation between the mean wind velocity and abundance at different sample sites in the Kattegat.

sample sites	wind station	month	corr	P
67	Skagen	Mai	.49079	.0093
67	KattegatSW	April	.67771	.0001
Danish Kattegat	Skagen	Mai	.5930	.0011
Danish Kattegat	Anholt	Mai	.58889	.0016

Table 4 .Monthly correlation. between the temperatur and salinity and abundance (1957-1992) of the 0-group paice.

Samle site	windsta-tion	month	debth	temp salinity	Pearson r	P
2	Kat.sw	Feb.	35	temp	.55855	.0085
67	Skag	March	0	sali	.52751	.0081
67	Skag	March	35	sali	-.5456	.0058

Table 5 .Mean anal fin rays (standard deviation) of 0-group plaice in different sites in the Kattegat.

	Area 1	Area 2+5	Area 6+7	Beltsea
1985	54.92 (1.87)	54.42 (2.10)	54.47 (2.19)	
1987	55.01 (2.07)	54.71 (2.14)		
1988	54.62 (2.19)	54.28 (2.10)	52.18 (1.94)	51.86 (2.66)
1989	55.13 (2.02)	54.93 (2.11)	54.00 (2.53)	53.33 (2.57)
1990	55.11 (1.98)	55.01 (1.91)	54.96 (2.05)	54.02 (2.16)
1991		55.16 (2.82)	54.45 (2.94)	51.91 (2.63)
1992	55.27 (2.06)	55.00 (2.04)	53.90 (2.35)	53.06 (1.92)
1993	54.01 (2.46)	53.97 (2.39)	51.33 (2.04)	51.88 (2.33)

List of Figures:

Figure 1. Map of Kattegat showing sites where 0-group plaice have been sampled and positions of wind and hydrography stations. The arrow indicates the axis of the longshore wind component used in analyses (see text for details).

Figure 2. Mean and standard deviation of monthly temperature and salinity at Skagen during the period 1957-1993 at depths 0, 15 and 35 m.

Figure 3. Between-site comparisons of 0-group plaice abundance at different sites in the Kattegat and Belt Sea. See also Table 1.

Figure 4. Abundance of 0-group plaice at two sites in the Kattegat, and along the Danish coast of Kattegat, relative to the number of days when wind speed exceeded 7.5 m/s. Top left panel: wind days during April at Skagen and abundance in area 1. Top right panel: wind days during April at Kattegat SW and abundance in area 67. Lower panel: wind days during April at Skagen and mean abundance along Danish Kattegat coast (areas 1-7). Numbers on panels indicate sampling years.

Figure 5. Left panel: Mean abundance of 0-group plaice along the Danish coast of Kattegat (areas 1-7), relative to the mean wind speed during May at Skagen. Right panel: abundance of 0-group plaice in the southern Kattegat (area 67) relative to the mean wind speed during April at Kattegat SW. Numbers on panels indicate sampling years.

Figure 6. Abundance of 0-group plaice in area 67 relative to the number of days in April when the longshore wind velocity component at Kattegat SW was less than the longterm 25th percentile (i. e., number of days per month when wind < -3.2 m s^{-1}; see Materials and Methods for details). The regression line is significant ($r = 0.52$; $P = 0.0056$). Numbers on panel indicate samping years.

Figure 7. The abundance of 0-group plaice relative to interannual variability in March salinity at Skagen. Left panel: surface salinity; right panel: bottom salinity. Numbers on panels indicate sampling years.

Figure 8. Interannual variability in the number of anal fin rays in 0-group plaice at 3 areas in the Kattegat and Belt Sea. Kattegat north refers to the areas 1, 2 and 5.

Figure 9. Number of anal fin rays in 0-group plaice relative to the mean water temperature during February and March recorded at the station closest to the plaice sampling site. Left panel: surface temperature; right panel: 15 m temperature.

Figure 10. Association between longshore wind velocity and meristic variation in 0-group plaice in the Kattegat and Belt Sea. The numbers on the panels are years of sampling. Left panel: wind velocity during March at Skagen and the difference in fin ray counts between areas 1, 2 and 5 and the Belt Sea ($r = 0.84$; $0.01 < P < 0.05$); right panel: wind velocity during April at Skagen and the difference in fin ray counts between areas 1, 2 and 5, and area 67 ($r = 0.87$; $0.01 < P < 0.05$).

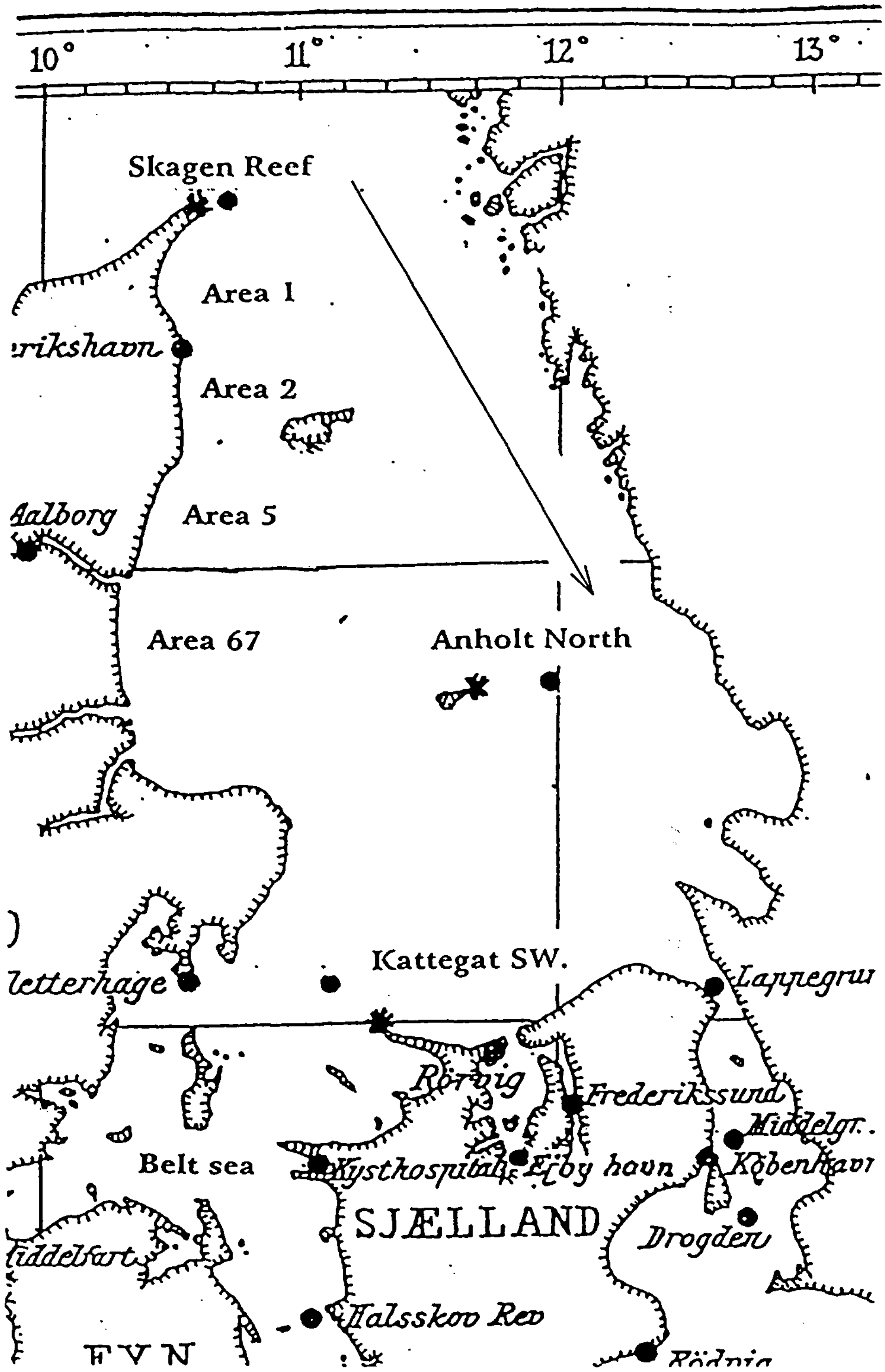
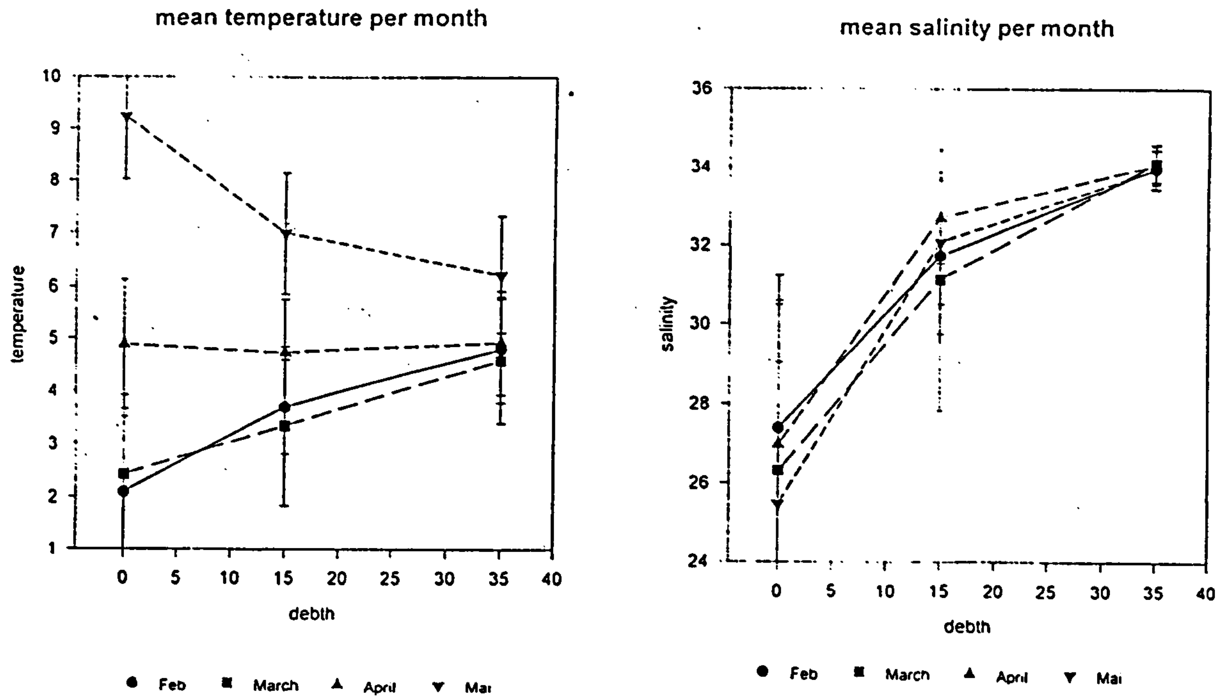

10°
11°
12°
13°
Skagen Reef
Area 1
rikshavn
Area 2
Aalborg
Area 5
Area 67
Anholt North
Kattegat SW.
letterhage
Lappegru
Rørvig
Frederikssund
Middelgr.
Belt sea
Kysthospital
Esby havn
København
SJÆLLAND
Drogden
iddelfart
Halsskov Rev
FYN

Fig. 1


mean temperature per month
temperature
10
9
8
7
6
5
4
3
2
1
0
5
10
15
20
25
30
35
40
debth
Feb
March
April
Mai
mean salinity per month
salinity
36
34
32
30
28
26
24
0
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15
20
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March
April
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Fig. 2

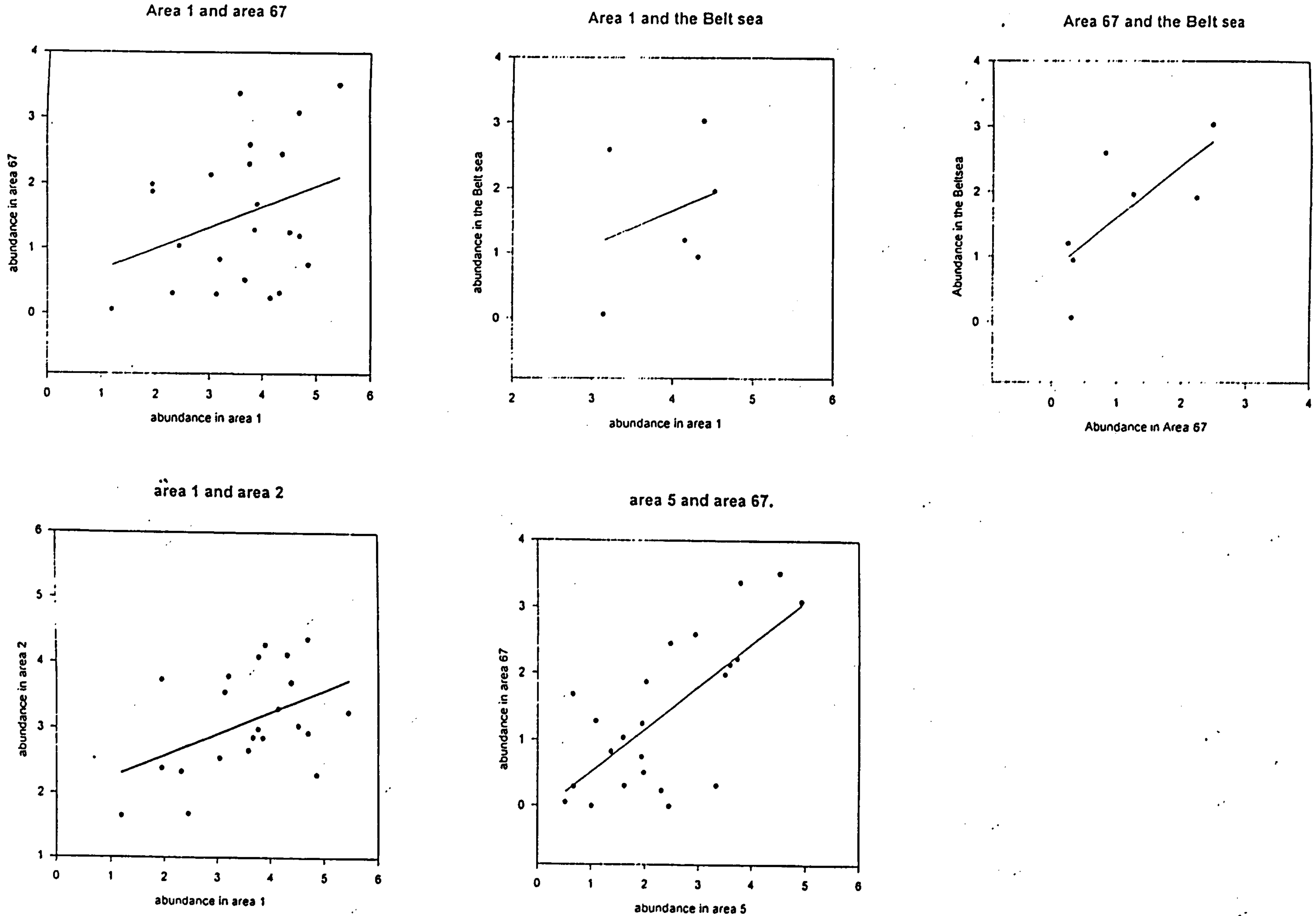
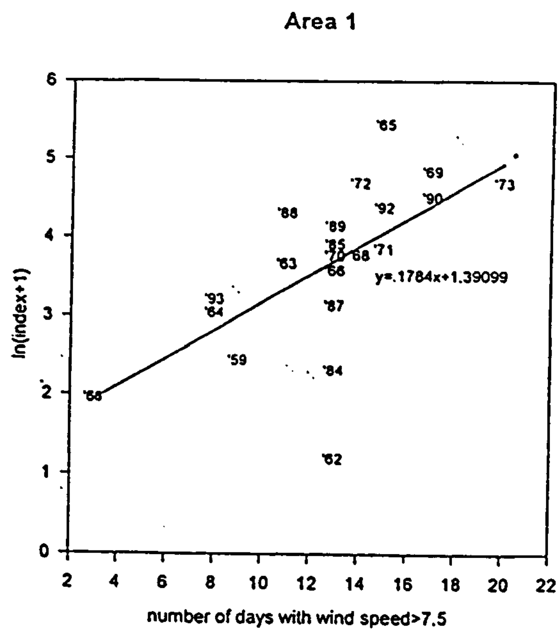
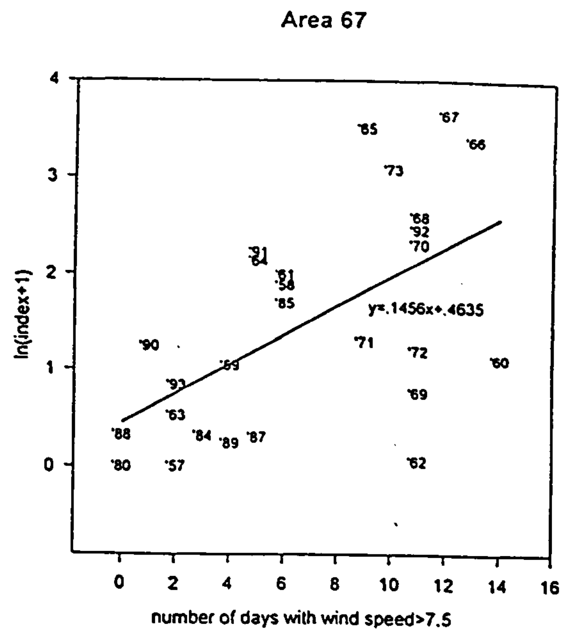

Area 1 and area 67
abundance in area 67
abundance in area 1
Area 1 and the Belt sea
abundance in the Belt sea
abundance in area 1
Area 67 and the Belt sea
Abundance in the Beltsea
Abundance in Area 67
area 1 and area 2
abundance in area 2
abundance in area 1
area 5 and area 67.
abundance in area 67
abundance in area 5

Fig. 3


Area 1
ln(index+1)
number of days with wind speed>7.5
y=.1784x+1.39099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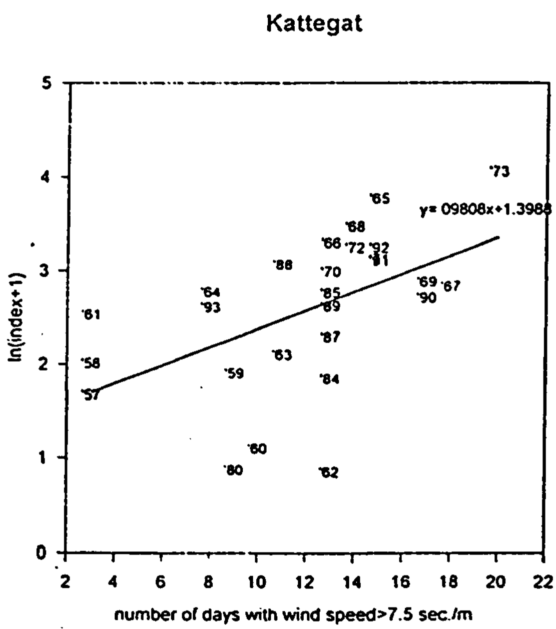
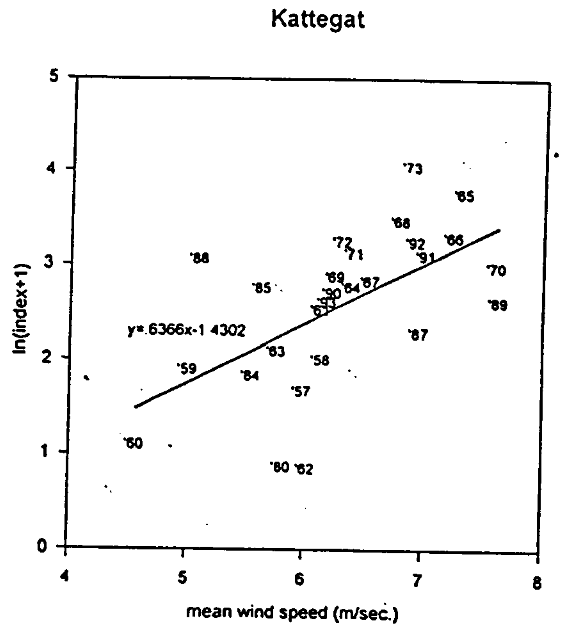

Kattegat
ln(index+1)
number of days with wind speed>7.5 sec./m
y= 09808x+1.3988

Fig. 4


Kattegat
y=.6366x-1.4302
ln(index+1)
mean wind speed (m/sec.)

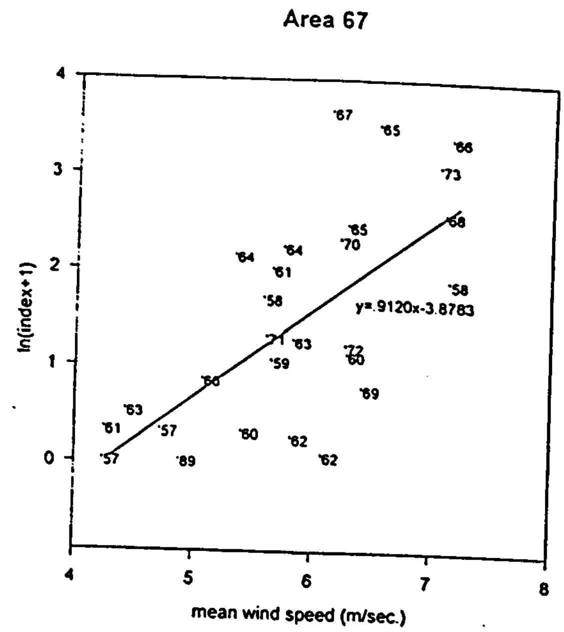
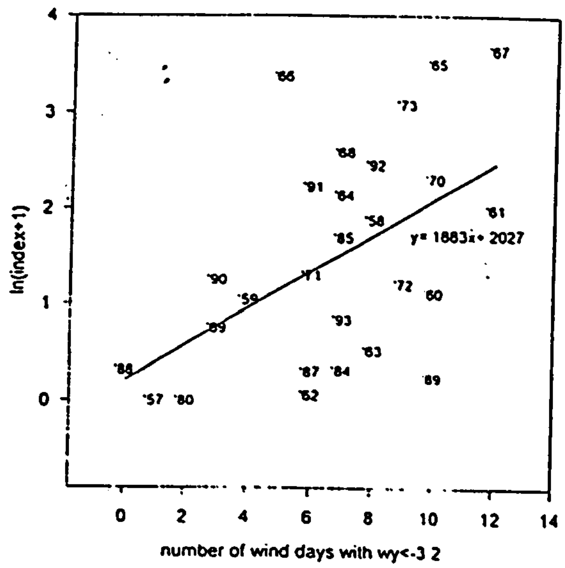

Area 67
y=.9120x-3.8783
ln(index+1)
mean wind speed (m/sec.)

Fig. 5

area 67


ln(index+1)
number of wind days with wy<-3 2
y= 1883x+ 2027
'87
'65
'66
'73
'68
'92
'70
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'64
'61
'58
'85
'90
'71
'72
'60
'59
'93
'69
'63
'88
'87
'84
'89
'57
'80
'62
0
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2
3
4
0
2
4
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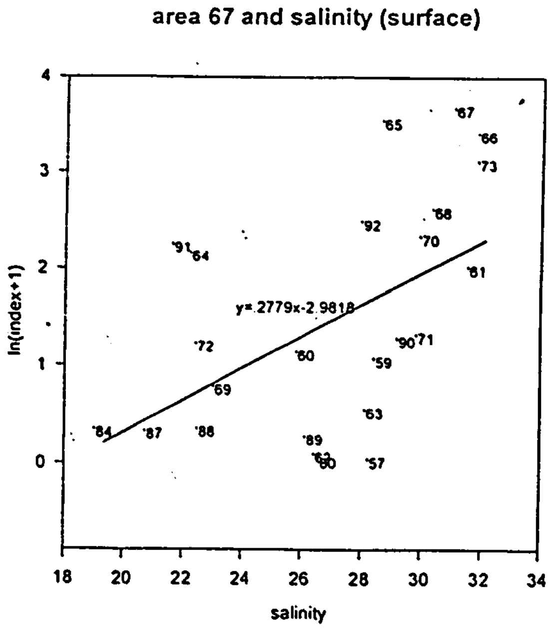
12
14

Fig. 6


area 67 and salinity (surface)
ln(index+1)
salinity
y=.2779x-2.9818
'65
'67
'66
'73
'92
'68
'70
'91
'64
'61
'72
'60
'90
'71
'59
'69
'63
'84
'87
'88
'89
'57
18
20
22
24
26
28
30
32
34
0
1
2
3
4

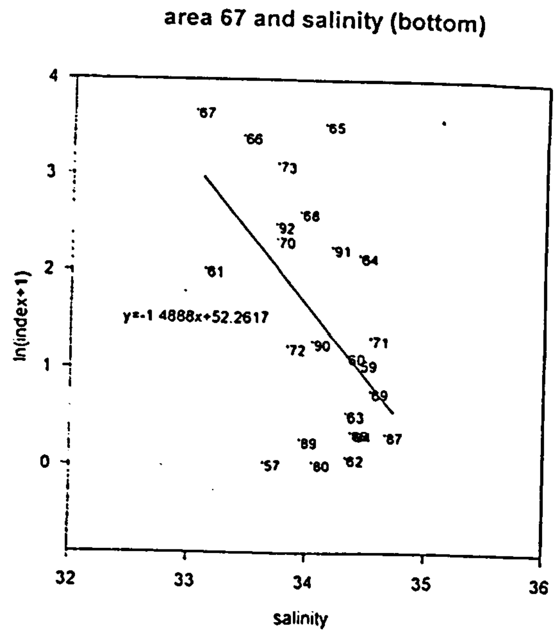

area 67 and salinity (bottom)
ln(index+1)
salinity
y=-1.4888x+52.2617
'67
'66
'65
'73
'68
'92
'70
'91
'64
'61
'71
'72
'90
'59
'69
'63
'87
'89
'57
'80
'62
32
33
34
35
36
0
1
2
3
4

Fig. 7

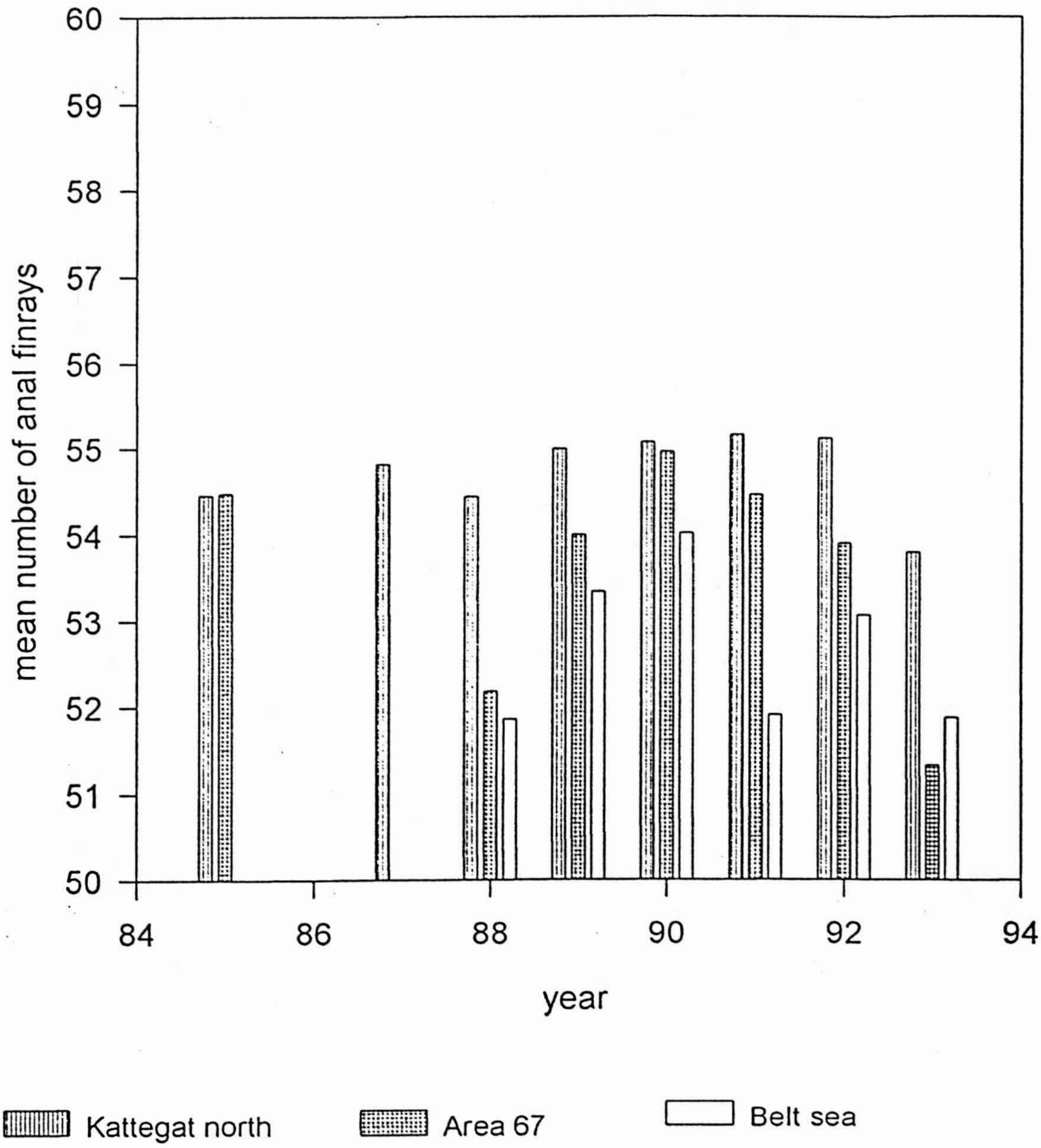
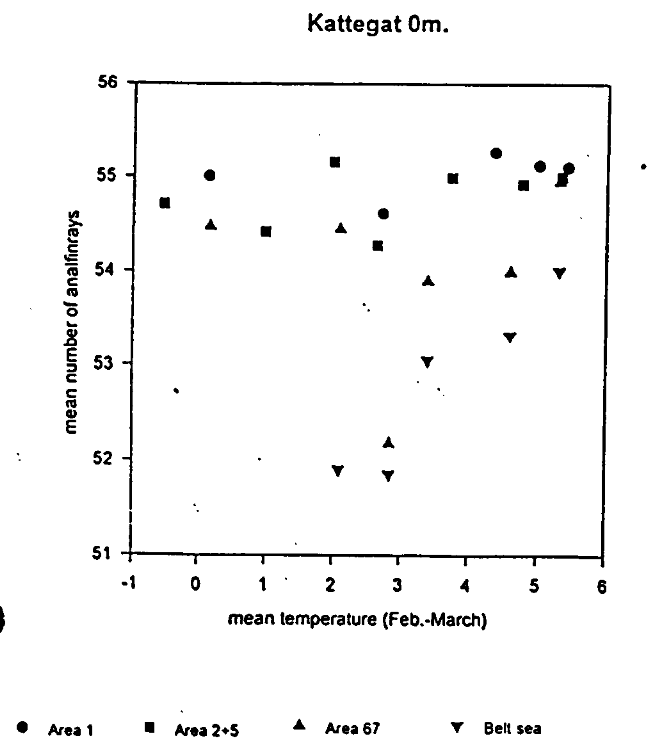

60
59
58
57
56
55
54
53
52
51
50
mean number of anal finrays
84
86
88
90
92
94
year
Kattegat north
Area 67
Belt sea

Fig. 8


Kattegat 0m.
56
55
54
53
52
51
-1
0
1
2
3
4
5
6
mean number of analfinrays
mean temperature (Feb.-March)
Area 1
Area 2+5
Area 67
Belt sea

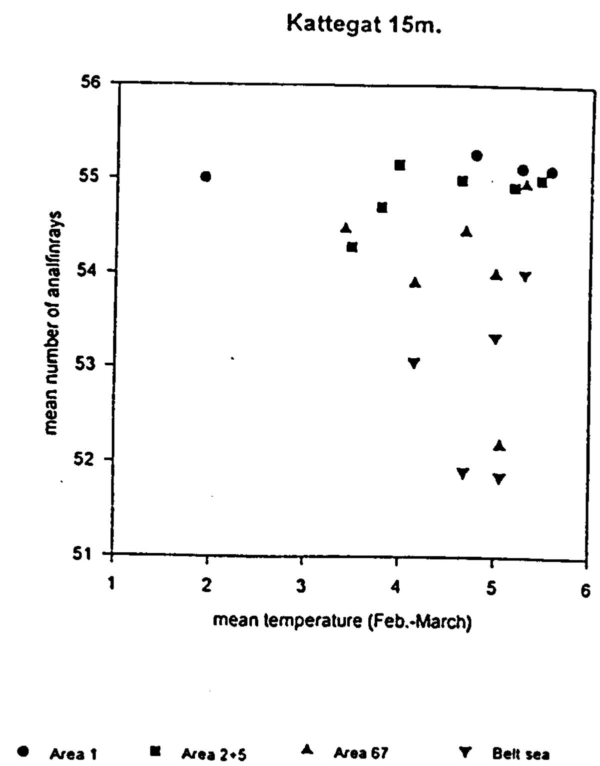
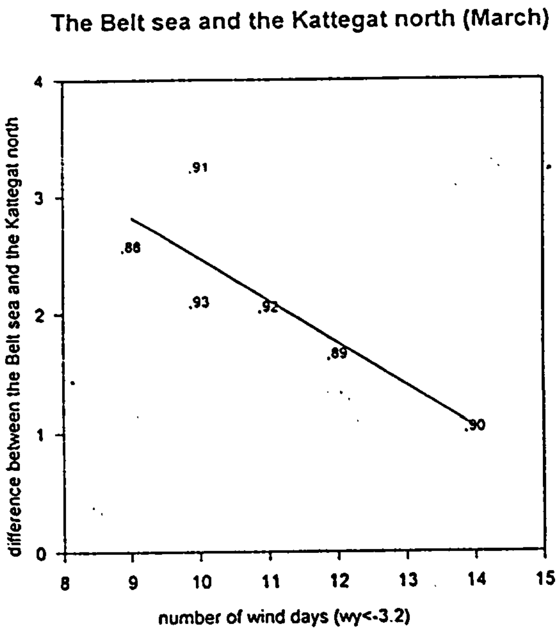

Kattegat 15m.
56
55
54
53
52
51
1
2
3
4
5
6
mean number of analfinrays
mean temperature (Feb.-March)
Area 1
Area 2+5
Area 67
Belt sea

Fig. 9


The Belt sea and the Kattegat north (March)
difference between the Belt sea and the Kattegat north
number of wind days (wy<-3.2)
.91
.88
.93
.92
.89
.90

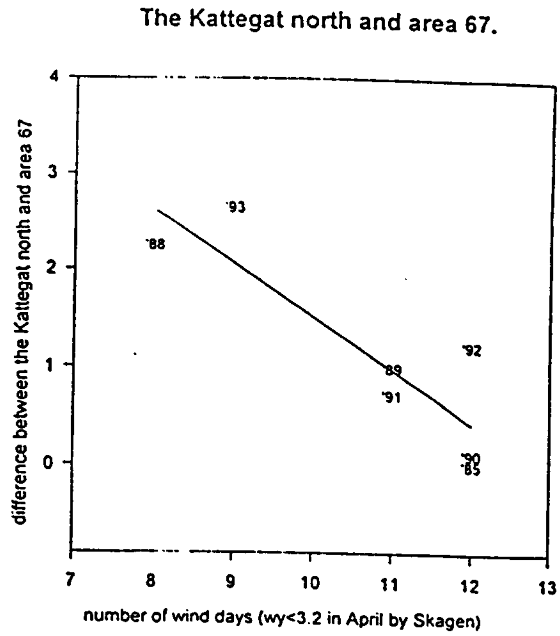

The Kattegat north and area 67.
difference between the Kattegat north and area 67
number of wind days (wy<3.2 in April by Skagen)
'93
'88
'92
'89
'91
'90
'85

Fig. 10

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