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Estimating abundances of 0-group western Baltic cod by using pound net fisheries

Quantitative Erfassung von Jungdorschen mit Bundgarnen

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Abstract

Nearshore 0-group western Baltic cod are frequently caught as bycatch in the commercial pound net fishery. Pound net fishermen from the Danish Isle of Funen and Lolland and the German Isle of Fehmarn have recorded their catches of small cod between September and December 2008. Abundance patterns were analysed, particularly concerning the influence of abiotic factors (hydrography, meteorology) and the differences between sampling sites. Catch per unit effort (CPUE) differed by site and location, whereas CPUE were highest at Lolland. Correlation between catch and wind/currents were generally weak. However, wind directions and current speeds seem to affect the catch rates. Finally an algorithm was developed to calculate a recruitment index for western Baltic cod recruitment success based on previous analyses.

Kurzfassung

Bundgarnfischer vor Fünen, Lolland und Fehmarn protokollierten von September bis Dezember 2008 den Beifang an Jungdorschen. Die Häufigkeitsmuster dieser Fänge wurden analysiert, insbesondere hinsichtlich des Einflusses von Umweltfaktoren wie Wind, Strömung und Temperatur. Die Einheitsfänge (CPUE) variierten per Station und Region, wobei besonders große Fänge vor Lolland erzielt wurden. Korrelationen der Fänge mit Wind- und Strömungsbedingungen waren generell recht schwach. Allerdings schienen Windrichtung und Strömungsstärke die Fänge zu beeinflussen. Auf der Grundlage der vorgestellten Ergebnisse wurde abschließend ein Verfahren zur Etablierung eines neuen Rekrutierungsindexes für den Dorsch der westlichen Ostsee entwickelt.

Introduction

Cod is one of the most important fish species in the Baltic fisheries. The fishery management distinguishes between a western Baltic (Belt Sea, ICES SD 22-24) and an eastern Baltic cod stock (ICES SD 25-32) (ICES, 2009). Both stocks are separated by spawning area and spawning season, although some exchange between the areas exists (Bleil and Oeberst 2002; Nissling and Westin 1997).

Cod eggs and early juvenile stages are found in the pelagic zone. Their distribution, settling locations and finally survival, especially for the eastern Baltic cod depend on currents and wind-induced drifts (Hinrichsen et al. 2008). However, although many study has focused on the egg and early larval stages, little is known about the spatial and temporal distribution of juvenile Baltic cod after settling.

The distribution of pelagic stages is influenced by currents, whereas it is assumed that post-settled juvenile cod are more aggregated and concentrated in shallow coastal waters. Grant and Brown (1998) found that juvenile cod of Newfoundland remained localized, not moving further than a few hundred meters for several weeks after settling from pelagic habit. Methven and Schneider (1998) found the highest densities of post-settled age 0 cod at depths of 4 to 7 m in coastal Newfoundland. Similar observations were reported by German commercial fishermen.

Due to high fishing effort, the spawning stock biomass of western Baltic cod stock is dominated by first and second time spawners. This increases the importance of good recruitment estimates for the prediction of stock abundance in fishery management (Oeberst and Bleil 2003).

Methods to improve the knowledge of the recruitment and the strength of the new year-class in the western Baltic cod stock have been investigated. While recent approaches were based on fecundity estimates (Bleil and Oeberst 2003), data presented in this study are obtained using traditional coastal eel traps (pound net) (Figure 1).

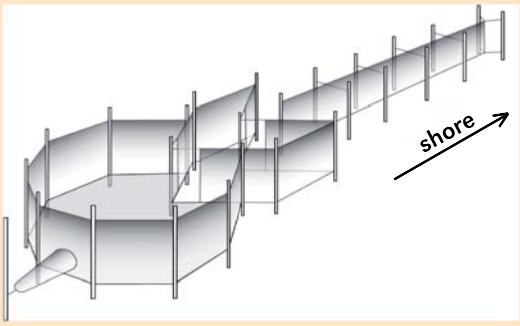

Figure 1: Pound net – fish trap construction. The construction is orthogonally oriented to the coast line. Nets are fixed with pickets. A long leading net guides fish to swim away from the coast into a court (pound) by passing a forecourt. Finally fishes are trapped in a bow net.

Abbildung 1: Bundgarn. Die Reusenanlage wird senkrecht zur Küste aufgestellt, wobei Pfähle zur Verankerung dienen. Ein langes Leitwehr führt die Fische in die Reusenanlage. Dort passieren sie zunächst einen Vor- und Haupthof bevor sie in einen Reusensack gelangen.

Based on this sampling method, we present analyses of catch patterns of juvenile cod in pound nets, in the light of the question on the influence of abiotic factors (hydrography, meteorology) and the differences between sampling sites. These analyses will be the basis for further sampling and the development of a recruitment index for western Baltic cod.

Material and methods

Catch

Sources of data

The study areas are located in the western Baltic Sea, ICES SD 22. These areas are close to the main spawning areas of the western cod stock (Figure 2) (Oeberst 2000) and are assumed to provide suitable habitat for 0-group cod.

The sampling was initiated within the framework of JOIFISH ("Joint data collection between the fishing sector and the scientific community in the Baltic Sea"), a project in support of the Common Fisheries Policy (call for tenders FISH/2006/15-Lot8). Samples were carried out by Danish and German fishermen on a voluntary basis from September to December 2008. However, sampling periods differed for each site and catch durations were not constant (Table 1), ranging from 24 to 168 hours. Pound nets were used to catch cod (Figure 1). The pound nets differed by the length of the leader net and the numbers of fishing traps. Cod were sorted

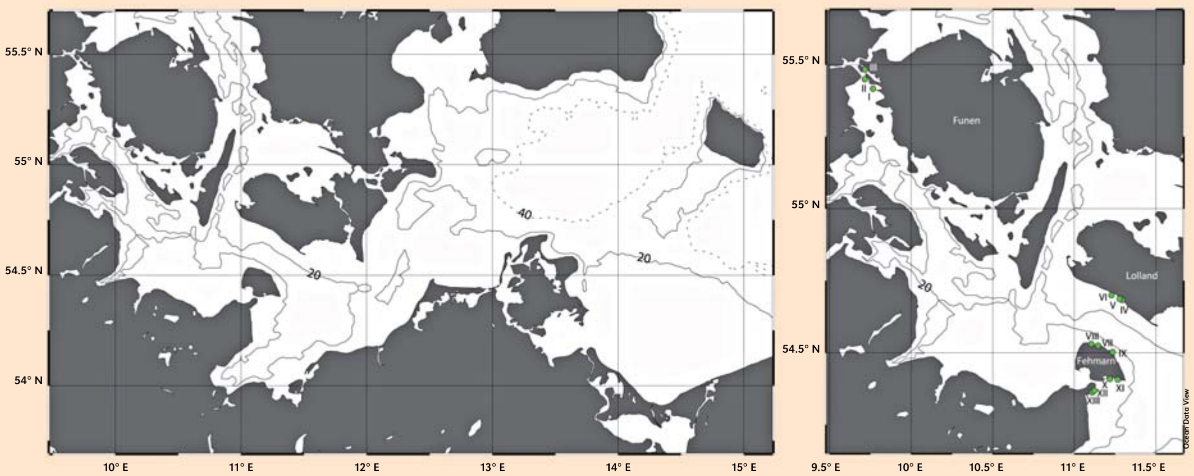

Figure 2: Left: Western Baltic Sea, Right: Sampling sites of cod recruits in pound net fishery. Sites I-III were located at northwestern coast of Funen Island , next to the Little Belt. Sites IV-VI were located at the southwestern coast of Lolland. Sites from Fehmarn (VII-XIII) are grouped in sites at northern Fehmarn (sites VII-X), southeastern Fehmarn (site XI) and southern Fehmarn (sites XII-XIII).

Abbildung 2: Links: westliche Ostsee; Rechts: Standorte der verwendeten Bundgarne. Stationen I-III lagen an der nordwestlichen Küste von Funen, die Stationen IV-VI an der südwestlichen Küste von Lolland. Die Stationen um Fehmarn herum wurden unterteilt in Nord-Fehmarn (VII-X), Südost-Fehmarn (XI) und Süd-Fehmarn (XII-XIII).

by length into three different size classes (0-20 cm; 20-38 cm; > 38 cm = minimum landing size). The amount of cod per haul and size group was estimated by fishermen in numbers per size group (0-20 cm and 20-38 cm) and as weight per size group 3 (> 38 cm). The data were noted in standardized protocols, whereas data on other fish species, like eel were not recorded. After counting, small cod were released or sampled for further investigations. Samples (approx. 1 kg per sample) were frozen at -20 °C and analysed at the institute for Baltic Sea Fisheries Rostock (OSF) or at the National Institute of Aquatic Resources in Charlottenlund (DTU-Aqua). The analyses of these samples were conducted for every fish and included length measurement, total weight and otolith sampling. Otoliths were collected for age determination in accordance to ensure that fish in the smallest size category belong to the 0-group.

Analyses

Catch

To standardize catch in numbers, the catch per unit effort (CPUE) was calculated based on the time of deployment of the net. Therefore, catch in numbers per 6 and 24 hours was calculated, whereas samples without details about catch duration were disregarded. Catch development and catch-catch duration relationships were analysed for all sample areas using catch per 24 hours data. Catch per 6 hours-intervall was used for analyses concerning wind and current-catch relationships.

Since size groups of cod were estimated by fishermen, length frequencies of laboratory samples were analysed to determine the accuracy of the estimate. Reading otoliths and therefore age determination of cod brought to the laboratory was not possible, since distinguishing of false rings and annuli was not feasible.

Therefore, medians of frequency distributions were used to estimate the mean daily growth (DG) of the total sampling period via linear regression. Based on estimated DG, length frequency distributions of laboratory samples were shifted and summarized to a hypothetical length distribution at closest mid month date (15. September 2008; 15. October 2008; 15. November 2008; 15. December 2008).

Medians of each mid-month length distribution were used to determine specific growth rate for length per day according to Hawkins et al. (1985)(Formula 1).

Formula 1:

$$GL = (ln\, L_2 - ln\, L_1) \cdot t^{-1} \cdot 100$$

L_1 and L_2 = subsequent medians of mid-month length frequency distributions. t = time in days.

Abiotic data

Water temperature at Fehmarn, (Figure 1) was recorded every hour with a HOBO PRO V2 water temperature logger for almost the entire sampling period (12. September to 06. December 2008).

Air temperature data were obtained from Deutschen Wetterdienst (DWD, http://www.dwd.de) for DWD-station 10055 (Fehmarn). This data series contains 24 h values of minimum, maximum and average temperature 2 m above bottom.

The air and water temperature, as well as temperature changes and its possible effects on the catch rates were analysed. It was assumed, that temperature anomalies (i.e. warmer than normal and colder than normal) may affect catch rates. Therefore, deviations from temperature trend (DTT) were calculated, for both, air and water temperature. DTT-values of previous days were assigned to CPUE-values of juvenile cod (see above) from Fehmarn according to catch duration.

Fishermen recorded wind speed (in bft) and wind direction during heaving the nets. However, no information was given for the catch period itself (often several days; Table 1). Therefore, wind and water current data for all sampling sites were obtained from the operational hydrodynamical model of the Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency, BSH,http://www.bsh.de).

Three wind stations were chosen, one per island, since it was assumed that wind directions and strength are similar at these sites.

Based on the assumption that currents are area specific, two additional stations were used (southern and southeastern Fehmarn) in current analyses. Current and wind data were averaged per 6 h interval. Unlike wind directions current data were only available in X, Y and Z-direction [m·s^{-1}]. Therefore averaged and untreated current direction values were converted in degrees, using formula 2 and 3. Current speeds were computed using formula 4, based on averaged X- and Y-values. Z-values were not considered, since obtained data belonged to surface, and all Z-values were almost equal to zero.

To analyze the quality of averaged data (especially errors due to averaging of directions; e.g. averaging 360° and 20° results in 190°), 6 h-averaged and untreated values of wind/current directions and wind/current speeds were compared. Additionally 6 h-averaged wind direction data from BSH were compared with 6 h data from WetterOnline Meteorologische Dienstleistungen GmbH (http://www.wetteronline.de) using linear regression.

The dominance of different wind/current directions and speeds was analysed, as well as their effects on the catch of juvenile cod. Therefore, 6 h catch values were attributed to the corresponding 6 h-wind /current data.

Formula 2:

$$current\ direction\ [°] = arctan2(Y, X) - \frac{\pi}{2}$$

Formula 3:

$$current\ direction\ [°] = 360 - arctan2(Y, X) - \frac{\pi}{2}$$
$$(if\ x < 0\ \&\ y > 0)$$

Formula 4:

$$current\ direction\ [m \cdot s^{-1}] = \sqrt{x^2 + y^2}$$

Table 1: Sampling periods and catch durations for each site. Periods are colored, catch durations are given in hours at heaving days. Dates of laboratory sampling are illustrated in the outermost column. Question marks indicate samplings with unknown catch durations (those catches are not used in the analyses).

Tabelle 1: Beprobungszeitraum und Fangintervalle für jeden Fangort. Die Zeiträume sind farblich dargestellt, die Fangdauer in vollen Stunden angegeben. Zeitpunkt und Umfang der Laborproben sind in der rechten Spalte aufgeführt. "Fragezeichen" symbolsieren Fänge mit unbekannter Fangdauer. Diese Fänge wurden bei den Analysen nicht verwendet.

Date	Funen			Lolland			Fehmarn							frozen samples (n)
							north				south	southeast		
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
2008-09-11														
2008-09-12											24	24	24	
2008-09-13														
2008-09-14											48	48	48	
2008-09-15											24			
2008-09-16											24	48	48	
2008-09-17														
2008-09-18														
2008-09-19											72	72	72	
2008-09-20														
2008-09-21												48	48	37
2008-09-22							96		72		72			
2008-09-23											24	48	48	
2008-09-24											24	24	24	
2008-09-25							72		72		24			
2008-09-26							24		24		24	48	48	
2008-09-27														
2008-09-28												48	48	
2008-09-29							72		72	24	72			
2008-09-30												48	48	52
2008-10-01							48	48	48	48	48			
2008-10-02														
2008-10-03							48	48	48		48	72	72	
2008-10-04										48				
2008-10-05				?	?	?								
2008-10-06				24	24	24	72	72	72		72	72	72	39
2008-10-07				24	24	24				48				21
2008-10-08				24	24	24					48	48	48	
2008-10-09				24	24	24					24			
2008-10-10						24	96	96	96	48	24	48	48	23
2008-10-11				48	48	24								
2008-10-12											48			
2008-10-13	?	?	?	48	48	48	72	72	72	48	24	72	72	
2008-10-14														
2008-10-15														
2008-10-16							72	72	72		72	72	72	
2008-10-17				96	96	96						24	24	25
2008-10-18	120	120	120							24				
2008-10-19				48	48	48					72	48	48	
2008-10-20	48	48					96	96	96		24			71
2008-10-21				48	48	48					24	48	48	
2008-10-22			96	24	24	24				24				
2008-10-23	72	72		24	24	24					48	48	48	
2008-10-24				24	24	24	96	96	96		24			
2008-10-25				24	24	24				24				

Date	Funen			Lolland			Fehmarn							frozen samples (n)
							north				south	southeast		
	I	II	III	IV	V	VI	VI	VIII	IX	X	XI	XII	XIII	
2008-10-26											48	72	72	
2008-10-27	96	96	120	48	48	48								
2008-10-28							96	96	96		48	48	48	
2008-10-29	48	48		48	48	48					24	24	24	
2008-10-30										24				
2008-10-31	48	48	96	48	48	48	72	72	72		48	48	48	33
2008-11-01														
2008-11-02							48	48			48	48	48	
2008-11-03	72	72	72	72	72	72				24				
2008-11-04							48	48	96	24	48	48	48	
2008-11-05												24	24	
2008-11-06			72	72	72	72								
2008-11-07							72	72	72		72	48	48	26
2008-11-08	120	120		48	48	48				24				
2008-11-09														
2008-11-10	48	48												
2008-11-11			144	72	72	72				24	96	96	96	
2008-11-12							120	120	120					
2008-11-13										24		48	48	
2008-11-14				72	72	72					72			
2008-11-15														
2008-11-16							96		96			72	72	
2008-11-17				72	72	72				24	72			
2008-11-18											24			
2008-11-19														
2008-11-20												96	96	40
2008-11-21					96	96			120	24	48			
2008-11-22					24	24								
2008-11-23											48	72	72	
2008-11-24														
2008-11-25									96	24	48			
2008-11-26														
2008-11-27														
2008-11-28									72		72		120	
2008-11-29										24				
2008-11-30														
2008-12-01														
2008-12-02														
2008-12-03														
2008-12-04														
2008-12-05													168	
2008-12-06										24				36
2008-12-07														
2008-12-08											96			22
2008-12-09														
2008-12-10														
2008-12-11										24	96			80

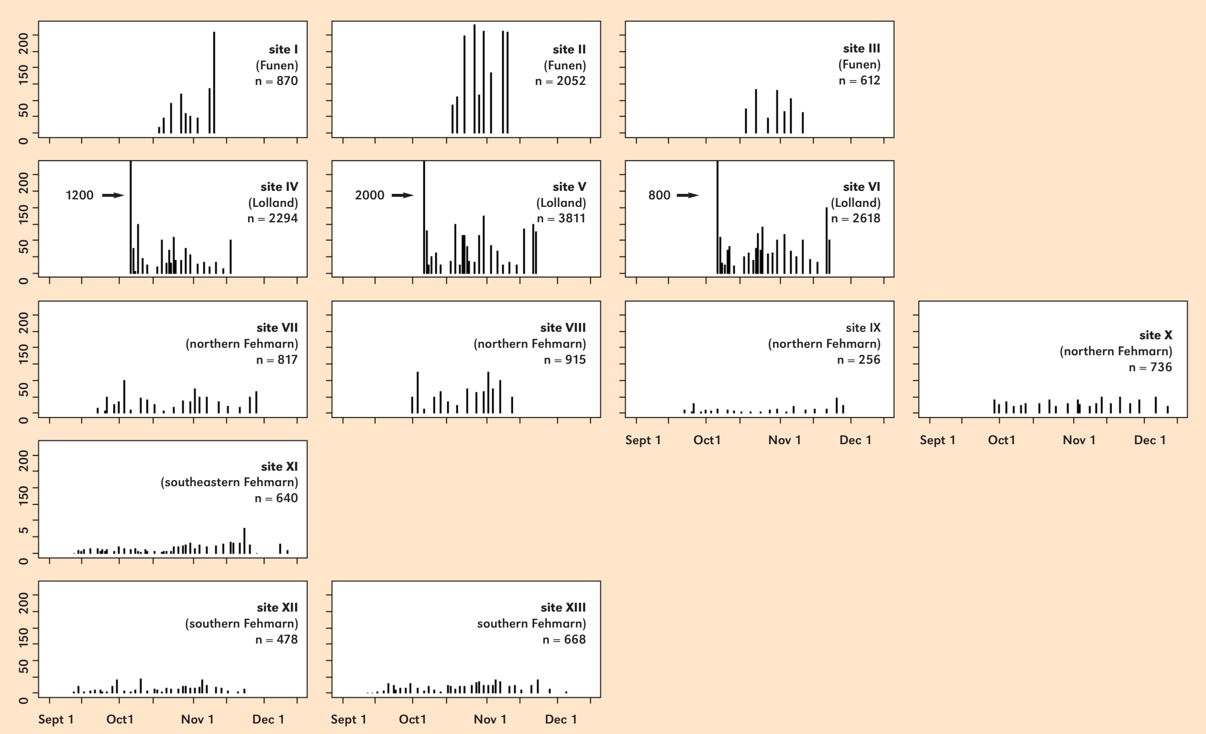

Figure 3: Temporal development of catch per unit effort (24 h), for each sampling site. Plots from different areas are organized in rows. From top: Funen, Lolland, northern Fehmarn, southeastern Fehmarn, southern Fehmarn. First catches from Lolland exceed the limit of the y-axis. These values are given as numbers.

Abbildung 3: Zeitliche Entwicklung der auf 24 Stunden genormten Fänge (CPUE), dargestellt für jede Fangstation (site). Die Grafiken sind nach Fangregion in Reihen unterteilt: Erste Reihe Funen; zweite Reihe Lolland; dritte Reihe Nordfehmarn; Vierte Reihe Südost-Fehmarn; Fünfte Reihe Süd-Fehmarn.

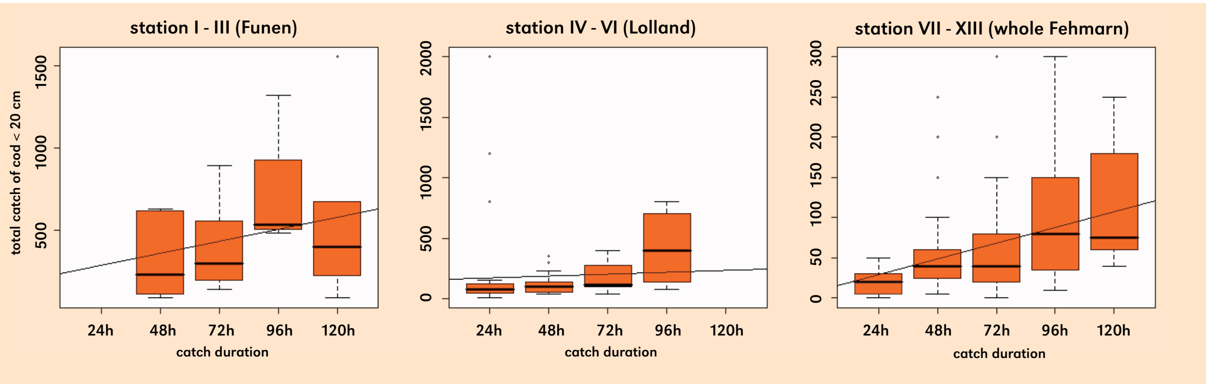

Figure 4: Total catch-catch duration relationships. Catches with a longer catch duration than 120 h occurred in maximum once per location and are not shown.

Abbildung 4: Verhältnis von Fangmenge zu Fangdauer. Fänge mit einer Fangdauer von mehr als 120 Stunden traten nur einmal auf und sind daher nicht dargestellt.

Results

Catch

A total of 12007 juvenile cod (< 20 cm) were caught at Funen, 16355 at Lolland and 10660 at Fehmarn. Maximum catches of size class 1 occurred at the beginning of the sampling period at all sites of Lolland (Figure 3), reaching up to 2000 individuals per 24 h (CPUE). Regardless these assumed but well supported outliers, average CPUE of Lolland and Funen were significantly higher than those from Fehmarn despite fewer numbers of sites and shorter sampling periods. In general, the temporal development of CPUE differed by sites (Figure 3) without showing a trend.

The number of small cod increases with longer catch durations (Figure 4), while results of linear regression do not support the hypothesis of 1:1 relationship (e.g. doubled numbers in catch by doubling the catch durations). Results from Funen and Fehmarn indicate that catch durations longer than 96 h do not provide significant increase of catches.

Length frequencies (Figure 5) show that laboratory samples included small size (< 20 cm) as well as mid-size (20-38 cm) cod (88 %; 12 %), while the latter fraction increased with time. The length distributions show no clear modes or maxima due to low sample sizes. Nevertheless, an increase of length (median) with time was found for monthly summarized length data. The trend of length-median per sample date represents mean daily growth (DG) based on the start of the sampling period (Figure 6).

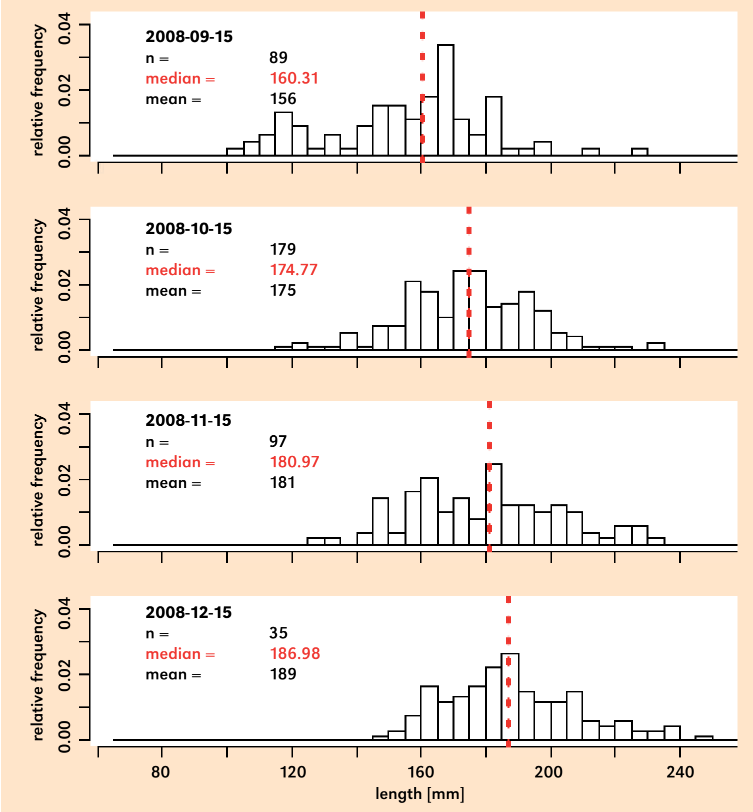

Figure 5: Length frequency distribution for juvenile cod caught at Fehmarn, estimated for the middle of each month. The median as dotted red line.

Abbildung 5: Geschätzte Längenfrequenzverteilung von Jungdorschen vor Fehmarn zur Monatsmitte (der Median ist rot gepunkted)

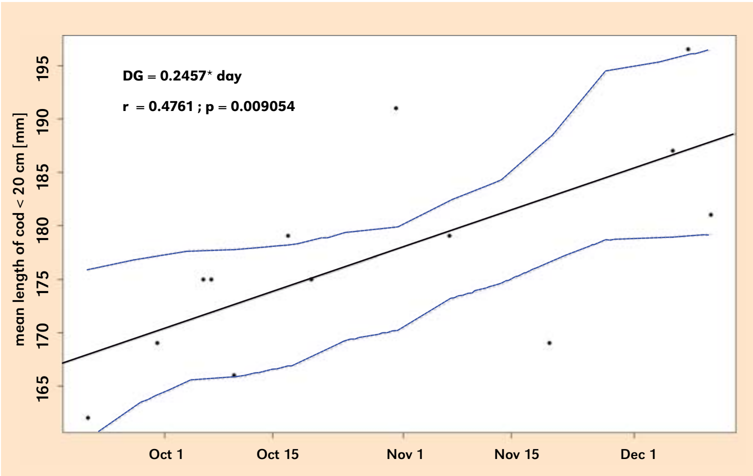

Figure 6: Mean daily growth (DG) of cod (Fehmarn samples only). Estimates are based on the median of length distributions of each sample. Blue lines indicate the confidence interval.

Abbildung 6: Mittleres tägliches Wachstum (DG) von Dorschen. Die Schätzungen basieren auf den Medianen der Längenfrequenzverteilungen der einzelnen Stichproben. Die blauen Linien deuten das Konfidenzintervall an.

Abiotic data

Temperature

With regard to temperature data, both water and air temperature decreased from the beginning to the end of the sampling period. However, deviations from temperature trend (DTT) did not seem to affect catch rates significantly.

Wind

All locations showed more or less similar development patterns concerning wind direction and strength. Furthermore, 6h wind directions from BSH are comparable with untreated BSH data and data obtained from wetteronline.de (linear regression: $r^2 = 0{,}66$).

Catches from Funen appeared to be higher at southwesterly winds (Figure 7). However, due to the short sampling period, information at several wind directions were not available. This applies also to data from Lolland, where high catches occurred especially at westerly directions. Data from Fehmarn represent the longest sampling period and accordingly most wind directions are covered. Here, catches are more equal at all wind direction, whereas slightly higher catches are found at easterly winds. Furthermore, an obvious influence of wind strength on catches was not found (Figure 8).

Currents

All stations have shown quite similar patterns concerning current directions and speeds. Since variability was low, current directions could be separated into two groups, regardless of the locations. The second direction was always the approximate opposite direction (+/- 180°) of the first one. However, directions differed from location to location. Both directions were constant over several hours. However, current directions often alternated several times per day and one direction group was often more frequent than its counterpart. In most cases high current speeds occurred only within these two groups of current directions, showing typical peaks. Current speed-catch relationships are given in Figure 8. CPUE-medians increased with increasing current speeds at Funen, Lolland and Fehmarn, although catches from northern Fehmarn decreased by exceeding a current speed of 0,25 m/s.

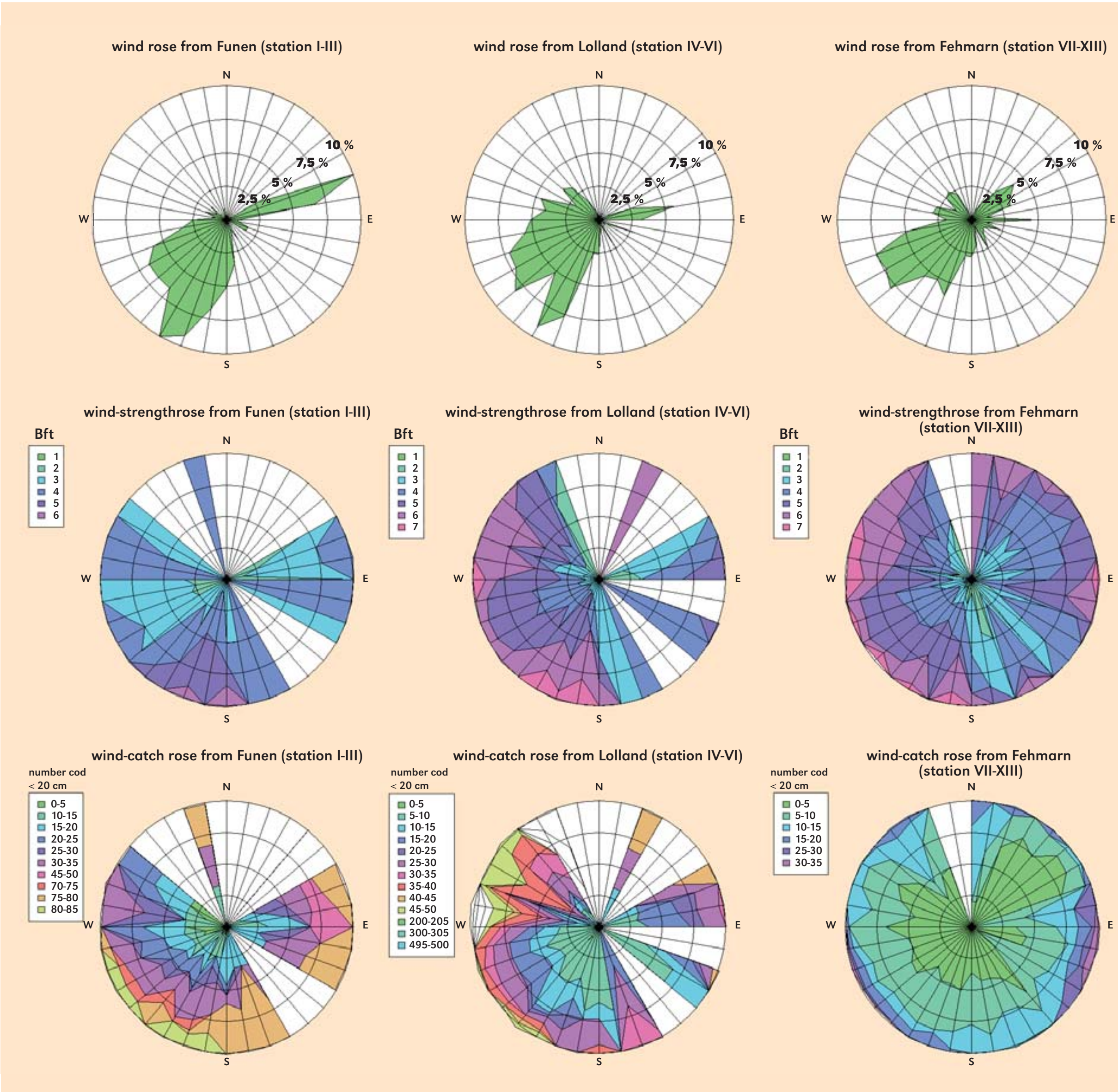

Figure 7: Wind and its influence on the occurrence of juvenile cod. Upper panel: frequencies of wind directions (intervalls:10°); central panel: frequencies of different wind speed (in Bft); lower panel: frequencies of small cod at specific wind directions. Gaps in graphics are caused by less or missing wind directions during sampling periods.

Abbildung 7: Wind und Einfluss des Windes auf den Fang von juvenilen Dorschen. Oben: Häufigkeit der Windrichtung; Mitte Häufigkeit der Windstärken in Abhängigkeit von der Windrichtung; Unten: Häufigkeit juveniler Dorsche in Abhängigkeit von der Windrichtung.

Discussion

In this study, we have investigated catch data of 0-group cod in the western Baltic Sea, which are collected by fishermen by using pound nets along the coast of the Islands of Funen, Lolland and Fehmarn. Catch per unit effort (CPUE in numbers per 24 h) differed by site (i.e. by pound net) and location (Funen, Lolland and Fehmarn), although some adjacent sites have shown a similar range of CPUE. The catches from Lolland and Funen exceeded those from Fehmarn by the factor 3-10. Therefore, it could be assumed that habitat utilization for these areas differed. Gregory et al. (2003) described an increase in recently settled cod abundance with simulated eelgrass and a corresponding decrease in sites where eelgrass has been removed. Borg et al. (1997) pointed out, that during daytime habitat choice of juvenile cod is correlated to vegetation types, whereas *Fucus vesiculosus* was preferred significantly. Hence, further information concerning habitat structure are necessary. In many studies different behaviour of juvenile cod was observed during day and night (Grant and Brown 1998; Methven and Schneider 2004; Borg et al. 1997). However, these behaviour patterns are specific for locations, age and predation pressure (Kamenos et al. 2004). Since different behaviour during day and night could bias averaging catch data into 6h intervals, knowledge about differences in day and night time behaviour (and consequently catch rates) is necessary, but not available for the western Baltic Sea. The temporal development of CPUE of small cod has not shown a clear trend, regardless which site is considered (Figure 3).

Catch increased significantly with longer catch duration, although a 1:1-relation was not found (i.e. total catch was not twice by doubling catch durations. This could be caused by saturation effects or by bad weather conditions, when nets were not heaved. Moreover, Bogstad et al. (1994) stated that cod feeds large numbers of its own species, especially those of age 0 to 2 and reported furthermore inter-cohort cannibalism between 1- to 3- year old cod. Therefore, another possible explanation could be that reduced CPUE of small cod is caused by cannibalism and predation by other species within the pound net. Reducing catch durations or disregarding long catch durations in further analyses should be made to minimize these sources of errors. If this is not possible, diet analyses of midsize (20-38 cm) and sized cod (> 38 cm) should be undertaken to evaluate this potential effect.

Laboratory samples were taken to investigate length-distribution, growth and age composition. Hawkins et al. (1985) characterized specific growth of juvenile demersal cod from the western Scottish coast. Our results of specific growth values (September-October: 0.288; October-November: 0.112; November-December: 0.111) were within the range mentioned in their study (0.0 to 0.6).

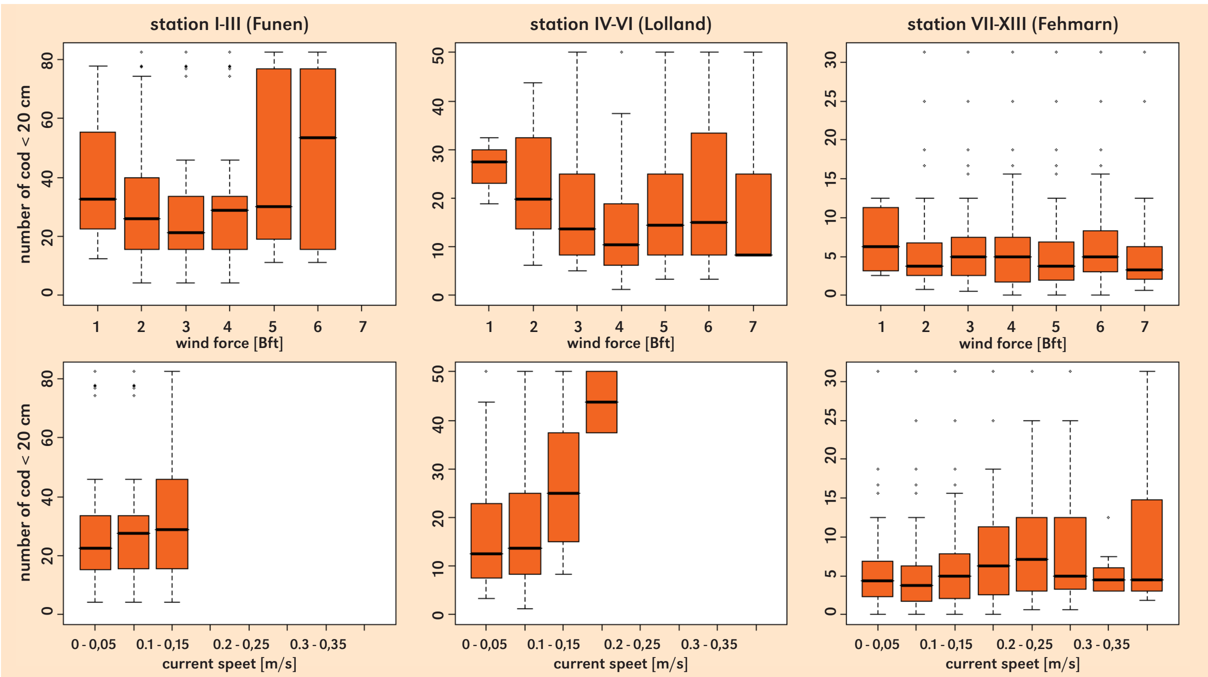

Figure 8: Wind-force catch relationship (upper panel) and current speed-catch relationship (lower panel) for all sampling areas. Missing box plots indicate wind forces or current speeds which did not occrured.

Abbildung 8: Verhältnis von Windstärke (oben) und Strömungsgeschwindigkeit (unten) zur Anzahl gefanger Jungdorsche, dargestellt für jedes Untersuchungsgebiet. Fehlende Boxplots beruhen auf nicht aufgetreteten Windstärken, bzw. Strömungsgeschwindigkeiten.

Furthermore, length frequencies of laboratory samples revealed that the later the season, the more cod from size group 2 (20 to 38 cm) were taken in the samples (due to growth of the cohort). This reveals that a) the range of size groups used for the protocols may not be optimal and do not cover the entire length spectrum over the entire season and b) that numbers per size group given in the protocols do not strictly refer to the predefined size groups. Moreover, fishermen seemed to adapt these size groups to the actual size range of the cohort. To encompass the entire cohort of 0-group cod, it is advisable to extent the size limit of small cod to 25 cm. The separation of 0-group and (small individuals) of age 1 cod in this extended size group 1 (< 25 cm) has to be done using otolith age readings. Compared to previous years, the structure of the otoliths of juvenile cod in 2008 were very difficult to interpret and hence not usable to distinguish age groups. Further investigations, such as the estimation of length at age are needed to calculate the proportion of 0-group cod. However, it has been stated, that the 0-group cod of 2008 represents one of the strongest in the last decade and the 1-group of 2008 the least cohort of the whole the time series (ICES, 2009). Therefore it could be assumed that size group 1 includes only a low proportion of age 1 cod.

Wind directions and strength are known to affect distribution of eggs and larval stages of many marine fish species (Margoñski 2000, Hinrichsen et al. 2008). Furthermore, Nanami and Endo (2007) have shown that occurrence of adult fish of various species within the surf zone is addicted to wind conditions. Our results indicate that wind directions seem to affect catches of small cod. However, catches did not show close correlation to wind strength. Although, wind directions are superimposed by wind strength data and therefore wind strengths might influence wind direction effects on catches. Multiple correlation analyses could improve the understanding of relationships. Such investigations were made by Gibson et al. (1993). They developed a "wind factor", which combines wind directions and wind strengths and relate them to the compass directions of the beach.

As wind conditions, currents can be assumed to affect fish occurrence, particularly since wind can causes currents. Within our study area currents occurred mainly in two groups of directions. Differences concerning effects on catches of both groups were low. Therefore, current directions apparently did not impact catches.
Increasing current speeds were attended by increasing catches. However, strong currents (> 0,3 m/s) were accompanied by low catches. Shore structures influence current speeds and directions. Taking one current station to analyse catches of various sampling stations could distort results.
Based on our results we developed an algorithm to calculate a recruitment index to be potentially used for the assessment of the western Baltic cod. However, we accentuate that this data series started only in 2008 and cannot be used for assessment until the time series has a duration of at least 5 years. Therefore, the algorithm is preliminary and has to be checked and adapted if more data are available (e.g. if variation estimates are available).

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