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Stress influence of offshore wind farms on the reproduction of the viviparous eelpout (*Zoarces viviparus*)

Karen-Christine Oehninger-Storvoll

Marine Coastal Development

Innlevert:	Mai 2013
Hovedveileder:	Gunilla Rosenqvist, IBI
Medveileder:	Olivia Langhamer, IBI

Norges teknisk-naturvitenskapelige universitet
Institutt for biologi

Content

Abstract

Rising need for renewable energy has led to an increase in installation of renewable marine energy installations (MREI). These installations range from wave and tidal energy conversions to offshore wind turbines. In this study effects on the reproduction of the fish species viviparous eelpout (*Zoarces viviparous*) caused by offshore wind power in the Baltic has been tested. During two field seasons (October 2011 and 2012) pregnant females from Lillgrund wind farm (Latitude 55°, longitude 12°.) with Bredgrund as a control location have been caught. Length (TL), total weight, gonads and liver have been measured. Total number of fry, length of fry, sex ratio and survival has also been recorded for this study. Results show that females from the wind farm are in better shape and have more and larger fry compared to a control location. This study also shows how year can influence all these traits which make it important to have data from more years and localities in further studies when judging the influence of wind farms.

Sammendrag

Økende behov for fornybar energi har skapt en økning av installasjoner for fornybar marin energi. Disse installasjonene varierer fra bølge- og tidevannskraft til offshore vindkraft. Påvirkning av offshore vindkraft på fiskearten ålekvabbe (*Zoarces viviparus*) i Østersjøen har blitt undersøkt i denne studien. I løpet av to feltsesonger (oktober 2011 og 2012) ble gravide hunnfisk fanget ved Lillgrund vindkraftpark (Breddegrad 55°, lengdegrad 12°.), samt ved en kontrollokaliten Bredgrund. Fiskens lengde (TL), totalvekt, gonade- og levervekt ble målt samt antall yngel, lengde på yngel, kjønnsfordeling og yngelens overlevelse ble registrert. Resultatene viser at hunner fra vindkraftparken er i bedre kondisjon og har fler samt større yngel enn i kontrollokaliteten. Denne studien viser også hvordan år kan påvirke alle disse trekkene og hvordan det gjør det viktig å ha data fra flere år samt lokaliteter i fremtidige studier når påvirkninger av vindkraft skal bedømmes.

Acknowledgement

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Viviparous eelpout (*Zoarces viviparus*)

(Photo: Irvin Kilde, *nkml.no*)

Introduction

A rising need for renewable energy leads to an increase in installation of renewable marine energy installations (MREI). These range from wave and tidal energy conversions to offshore wind turbines (Inger et al. 2009). Of the MREI's is wind power the furthest evolved, but development of wave and tidal energy conversion devices are expected to increase in the near future (Inger et al. 2009). Marine environments are looked at as a relatively untapped energy source. MREI's are therefore believed to produce a significant proportion of our energy in the future (Inger et al. 2009). In theory is the marine environment a source that can meet the total global demand for power. Offshore renewable energy is likely to play a major part in the development of energy producing technologies (Pelc and Fujita 2002). Other users of land areas, as well as aesthetic concerns, are often a reason for conflict and competition for onshore wind farms (Taylor 2004). This, together with the better wind conditions offshore, has resulted in strong increase in the development of offshore wind farms (Michel et al. 2007). When looking at the demand for renewable energy around the globe it is likely that countries with large properties of offshore coastal water will turn these areas over to production of marine renewable energy (Inger et al. 2009). It is, however, important to consider the impacts renewable energy installations might have on the local environment, despite that advantages on a global scale are no longer in doubt (Inger et al. 2009). Areas that are looked at as the most interesting for MREI's are often also sites that are already experiencing a high degree of environmental stress (Halpern et al. 2008).

MREI have the potential to be both detrimental and beneficial to the environment but the knowledge still remains limited. To be able to fully understand the full biodiversity impact there is an urgent need for multi- and interdisciplinary. There are a number of factors that must be considered, but one of the key decisions facing policy makers is what sites are most suitable, and, depending upon these sites, if they are to be designed either to minimize negative impacts on the environment or to facilitate ecosystem restoration (Inger et al. 2009). Disagreements around wind farms considering the stress it may cause on both species and ecosystem have made it a controversial topic with a need for more research. The concerns about the potential negative impacts MREI's may have on biodiversity are; habitat loss, collisions, noise disturbance, electromagnetic fields and increased risk for settling of invasive species (Inger et al. 2009, Snyder and Kaiser 2009). In addition there are concerns about the safety of leisure boats when sailing through wind farms and the aesthetics of the wind park (Snyder and Kaiser 2009). Loss of accessible fishing areas is a concern for the fishing industry (Inger et al. 2009).

The discussion around offshore wind farms also have a positive angle and the same aspects as above can be approached with positive eyes. At the same time as MREI may result in some habitat loss, the installations may act as *de facto* artificial reefs and thereby increase the diversity (Langhamer 2012, Snyder and Kaiser 2009). The negative effect of the artificial reefs is that they may attract invasive species or alter the species composition by giving better conditions for new or other species than before (Inger et al. 2009). There has been observed an increased biomass around MREI's, but it is unknown whether this actually is new biomass or just biomass redistributed from surrounding locations (Bohnsack, 1989).

Wind parks as well as other MREI can work as marine-protected areas as they become no-trawling zones. In wind parks and near other MREI there is an increased risk for collision and gear entanglement, and therefore can many gear types not be used. Trawling is known to do much harm and have permanent effects on benthic communities (Kaiser et al. 2005). By lowering the pressure from towed-bottom fishing gear, the benthic biota as well as fish stocks can be improved. Marine-protected areas can also act as a source providing surrounding areas with spill over effects of juvenile and adult fish (Inger et al. 2009, Roberts et al. 2005). Because MREI potentially can create additional habitat, attract marine organisms and create protected areas, it seems possible that the overall effects on marine fauna will to be positive (Casini et al. 2008).

The controversies between negative and positive thoughts about wind farms have shown the importance of more studies. One way of investigating the impact is to use biomarkers or bioindicators (vanGestel and vanBrummelen 1996). Biomarkers or indicators are a species or group of species used to monitor the health or changes of an environment or ecosystem.

The function, population, or status of these species can reveal what degree of ecosystem or environmental integrity is present. One example of a group of biomarkers or bioindicators is copepods and other small water crustaceans present in many water bodies. Such organisms can be monitored for changes (biochemical, physiological, or behavioral) that may indicate a problem within their ecosystem (vanGestel and vanBrummelen 1996).

The benthic fish species viviparous eelpout (*Zoarces viviparous*) has by the Oslo and Paris Conventions (OSPAR) and the Baltic Marine Environment Protection Commission (HELCOM) been suggested as a sentinel species used as biomarker or bioindicator in the North and Baltic Seas (OSPAR, 2007; OSPAR, 2008). Eelpout has been shown to show many characters that are requested in a sentinel species. Eelpout is, with a few seasonal exceptions, a stationary species and this behavior makes them most useful to monitor effects caused by varying types of pollution and disturbance. The fact that eelpout is an ovoviviparous species makes it possible to study reproductive success on an individual level. Disorders in eelpout fry that are thought to have a connection with the fry development during pregnancy can often be linked to the health of the mother. This makes it possible to see a direct consequence of effects on the health of the whole population caused by exposure of contaminants and environmental stress (Gercken et al. 2006, Hedman et al. 2011).

Aim

Eelpout has been used in many earlier reproductive success studies and is therefore a good choice as a bioindicator. This species is also recommended by the International Council for the Exploration of the Sea (ICES), OSPAR Commision and HELCOM (Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area) for use in marine monitoring programmes of biological effects (Hedman et al. 2011)

In this study I aim to investigate if there is a difference in the fecundity and fertility of eelpout (*Zoarces viviparous*) from Lillgrund wind farm, Sweden, compared to a control site, Bredgrund, Sweden.

Prediction

The fry and pregnant females from the wind farm will be of better quality than individuals from the reference site/control area.

Materials and methods

Study site

Lillgrund wind park

In october 2007 Lillgrund wind farm (Latitude 55°, longitude 12°.) opened in the southern part of Sweden. It is located near Malmö, 5 km south from the Öresund Bridge, and 11.3 km offshore. The park is owned by Vattenfall AB and 2007 it was the world's third largest offshore wind park. It contains 48 offshore wind turbines that produce 360 GWh each year (Vattenfall 2013). The size of the park is 6 km^2, depth ranges between 4-8 m. A detailed biological baseline-study has been conducted by the Swedish Board of Fisheries before, during and after construction of the wind park (Bergström et al. 2010).

Bredgrund

Bredgrund (Latitude 55°, longitude 12°.) used as a control location lies about 8 km south of Lillgrund. Here the depth ranges between 6-9 m and the size of the area is also about 6 km^2. Bredgrund was chosen as a control area by The Swedish Board of Fisheries because of its similar conditions to Lillgrund (Bergström et al. 2010). The species composition and environment is similar between Bredgrund and Lillgrund (Bergström et al. 2010).

Study species

Eelpout

The viviparous eelpout (*Zoarces viviparus*) is an ovoviviparous, bottom dwelling and stationary species which gives birth to developed fry after about 5 months of pregnancy (Gercken et al. 2006, Muus 2012). Eelpout was chosen because of its abundance in both locations, Lillgrund and Bredgrund (Bergström et al. 2010). This species is found between kelp and sea weed down to 40 m depth and can also be found in harbours and brackish water near estuaries (Muus 2012). They are found in marine conditions (35 psu) as well as brackish water with salinity down to 5 psu (Pethon 2005). They grow up to 50 cm length, but seldom reach more than 30 cm, and the females become larger than the males. The eelpout normally lives 4-5 years, but 9 year old individuals have been found (Muus 2012, Pethon 2005). The abundance of the species stretches between the English Channel and the North Sea, along the Norwegian coast and all the way up to the White Sea. In Sweden they are found around the coasts of Bohuslän and up to Norrbotten. They become sexually mature at the age of 2 years, 15-20 cm, and fertilisation happens between August-September. The larva then evolves 3-4 weeks inside the eggs before they hatch and evolve further inside the ovary. The female gives birth to living fry 5-6 months later. The fry measures 3.5-5.5 cm at birth and are transparent, but morphologically alike the adult individuals. The female can give birth to between 20-400 fry (Pethon 2005), and the sex ratio has been reported to be 50/50 (Strand et al. 2004). There is no parental care after birth (Muus 2012, Pethon 2005).

The presence of abnormal development of larvae in eelpout broods is used as a biomarker of reduced reproductive success and the eelpouts is looked at as a non-specific, biological indicator of impaired fish reproduction (Hedman et al. 2011, Strand et al. 2004).

Field work

The field work was conducted during two seasons, October 2011 and 2012, and consisted of fyke net fishing at Lillgrund windpark and control area Bredgrund. We used 10 stations on each location. The stations used on both locations are the one chosen by The Swedish Board of Fisheries for studies connected to Lillgrund wind farm (figure 1).

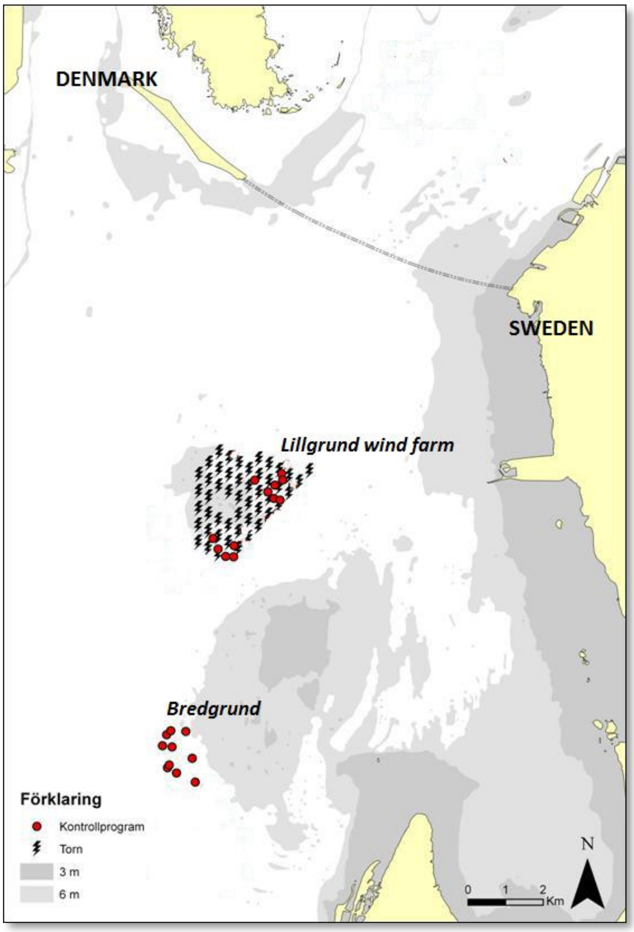

Figure 1: The study sites Lillgrund wind farm and control area Bredgrund (Latitude 55°, longitude 12°.). Red dots show the stations used during the field work and the black flashes show the turbines.

On each station 2-3 joined fyke nets (40-60 in total) were placed, left during the night and collected during the morning. The nets were emptied daily (with exceptions due to bad weather) and put back immediately after being emptied. All stations and both locations were fished on the same day until enough individuals had been collected.

To carry out the analysis for this study pregnant eelpout in the length group 20-30cm (total length) were used from each location. During the two field seasons 50 and 26 pregnant eelpout were caught in Lillgrund (wind farm) and 50 and 17 pregnant eelpout in Bredgrund in 2011 and 2012 respectively. The fish were kept alive in barrels in the sea until the delivery date to the laboratory.

Laboratory work

The fish were delivered to Toxicon AB in containers with 100l (app.) of sea water after the fishing was done. During delivery the fish were kept in tanks with aquaria pumps to keep the water aerated. The lab work took 2 days in 2011 and 2012. Total length (mm) as well as weight measures of the whole female, the liver and gonads (all in gram) were registered. The fry classification included numbers of alive and dead fry as well as sex ratio.

The measuring was done by killing the female by decapitation and then immediately dissect her. The clutches from each female was put on separate glasses with a lid. The clutches were sedated one at the time with aerated mineral water (Ramlösa) and then counted, measured and divided into size classes as well as registered as dead or alive (Sjölin 2010).

The fry was sexed a few weeks later after being fixated with Bouin's solution (Sigma) and the procedure was done by Toxicon AB. This was done according to Larsson *et al.* (2000). The fry were cut open on the ventral side and the gonads were examined in a stereomicroscope (40 x magnifications). Single, big gonads were classified as ovaries, while small, pairwise gonads were classified as male gonads (Larsson et al. 2000).

Ethical permit

Ethical permissions for fishing with fish traps was given by the Swedish Board of Fisheries (Ref. nr. 23-2231-11) and permission for handling the fish in the laboratory is granted Toxicon AB by Jordbruksverket (D nr. 181-09).

Statistical methods

All statistical analyses were done using R version 2.14.1 (Team 2012) with support of RStudio version 0.97.173 (RStudio 2012).

Female length analyzes were done using the package lme4 (Bates et al. 2012). To analyze number of fry compared to female size the packages MASS and plyr were used with location and year as explanatory variables (Venables and Ripley 2002, Wickham 2011).

Year and location have been defined as factors in all of the computations.

Akaike information criterion (AIC) has been considered when calculating the best choice for one of the models, to fit and weight them based on their AIC. ($AIC = - \ln L + p$, where L is the likelihood for an estimated model with p parameters.). For three models of the models the adjusted squared R-values have been considered to decide which choices are the best.

The calculation of the mass of the gonads seen as a proportion of the total body mass is called the gonadosomatic index (GSI). It has been defined as ((gonad weight/body weight) x 100). Weight measures are in gram. GSI is used as a tool to measure sexual maturity (Bulow et al. 1978).

For hepatosomatic index (HSI) the values were calculated as follows ((liver weight/body weight) x 100). All weight measures are in gram. HSI can be used to obtain information regarding the metabolic state in fish (Crupkin et al. 1988).

Results

The model to explain length at Lillgrund and Bredgrund has been choosen by adjusted R-squared value (0.013 vs 0.99) (table 1). Lengths for female eelpout (*Zoarces viviparus*) vary between Lillgrund and Bredgrund, females are shorter in Lillgrund (table 1). The fish are shorter in both locations in 2012 compared to 2011 (table 1).

Table 1: Female eelpout (*Zoarces viviparus*) length in Lillgrund (wind farm) and Bredgrund (control) during 2011 and 2012. Females from Bredgrund are shorter than females from Lillgrund. Females from both locations are shorter in 2012 than the year before. This model has been chosen on behalf of the adjusted R-squared values. Degree of freedom: 140

	Estimate	St.error	p-value	z-value
Lillgrund (Intercept)	261.796	3.045	<0.001	85.971
Bredgrund	256.304	3.045	0.1637	-1.400
Year 2012	-7.787	4.268	0.0702	-1.825

Between 2011 and 2012 there is a difference in weight for both locations (figure 2). The females differed in weight between the two locations with smaller females from Bredgrund both years (figure 2).

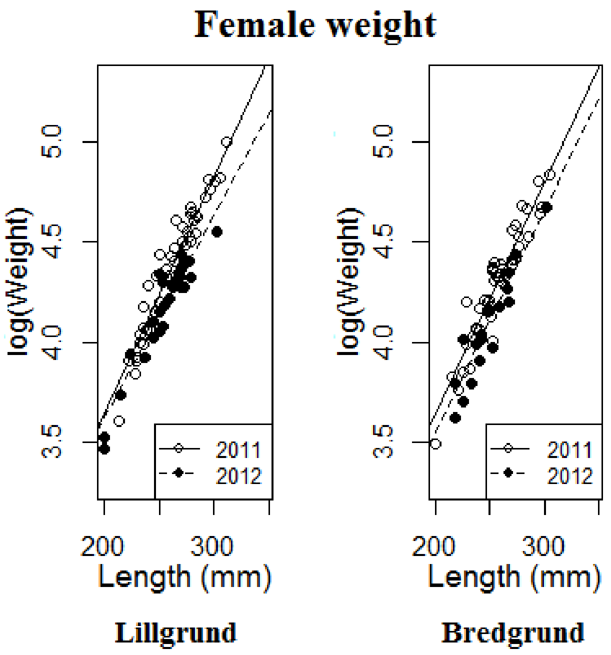

Figure 2: Female eelpout (*Zoarces viviparus*) weight (log) compared to length for 2011 and 2012. Data from both Lillgrund (wind farm) and Bredgrund (control). White dots show data from 2011 and black dots show data from 2012 for both locations.

Calculating ΔAIC gives a value of 3.5 and location as a factor has therefor been removed from the model explaining number of fry compared to size of female eelpout shown in table 2. There are significantly fewer fry compared to female size in 2012 than 2011. There is also a tendency towards fewer fry when looking at the interaction between MTlength Bredgrund and 2012 (table 2).

Table 2: Number of fry compared to size of female eelpout (*Zoarces viviparous*) for 2011 and 2012 at Lillgrund wind farm and control Bredgrund. MTlength is defined as the residuals of the linear model consisting of female length (on log scale) as predictor variable and year and location as explanatory variables. Degree of freedom: 136.

	Estimate	Std. error	p-value	z-value
MTlength Lillgrund 2011	4.063976	0.024728	<0.001	164.347
MTlength Bredgrund 2011	0.012394	0.001073	<0.001	11.552
Year 2012	3.603979	0.040584	<0.001	-9.679

MTlength Bredgrund: 2012	-0.005381	0.002096	0.0102	-2.567

In 2012 there are significantly fewer fry per clutch than in 2011 (table 3). The adjusted R-squared values for the different models tested showed that location does not affect the number of fry per clutch and has therefore been excluded from the model. Adjusted R-squared values from the summary tables had small differences and were 0.8823, 0.8829 and 0.8835 respectively (not shown). The model used here was the simplest model considered and with highest adjusted R-squared value.

Table 3: Number of eelpout (*Zoarces viviparus*) fry per clutch from both Lillgrund (wind farm) and Bredgrund (control). A significant difference in number of fry per clutch is seen between the two years, with fewer fry in 2011. Degree of freedom: 141.

	Estimate	Std.error	p-value	t-value
Year 2011 (Intercept)	60.560	1.981	<0.001	30.574
Year 2012	37.209	3.021	<<0.001	-6.464

Histograms of raw data showing clutch size show some variation between locations and years, but tend to show a distribution with bigger clutch sizes in 2011 (figure 3). Big difference in number of pregnant females from Bredgrund in 2011 and 2012 (50 and 17 respectively) will affect the total number of clutches and therefor affect the distribution of clutch sizes.

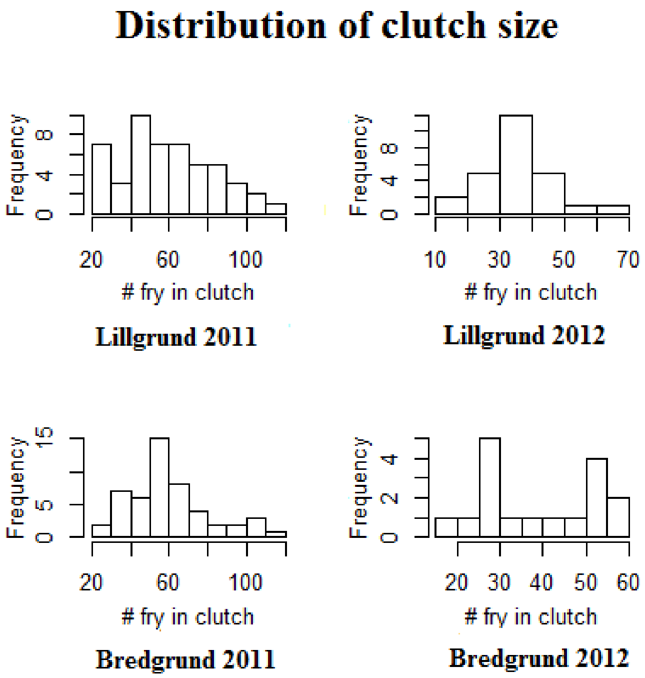

Figure 3: Distribution of eelpout (*Zoarces viviparus*) clutch sizes for both years (2011 and 2012) and both locations (Lillgrund (wind farm) and Bredgrund (control)). Note that scales vary between locations and year due to different sample size of adult females.

Survival of fry is lower in Bredgrund than Lillgrund (table 4). For 2012 there is survival lower for both locations compared to 2011. (Note that numbers in table 4 are on logit scale).

Table 4: Number of dead eelpout (*Zoarces viviparus*) fry per clutch. Data from both Lillgrund wind farm and control location Bredgrund. Significantly higher survival in Lillgrund wind farm compared to control location Bredgrund can be seen from these results. In 2012 there was lower survival in both locations. Numbers are on logit scale.

	Estimate	Std.error	p-value	z-value
Lillgrund (Intercept)	4.6314	0.1866	<0.001	24.820
Bredgrund	3.5520	0.1100	<<0.001	-4.983
Year 2012	-2.2615	0.2206	<0.001	-10.252
Bredgrund: Year 2012	1.0203	0.2807	<0.001	3.635

Gonado somatic index (GSI) values show that size of gonads compared to weight of females are significantly lower for Bredgrund are lower than for Lillgrund (table 5). Values from 2012 are also significantly lower than for 2011 for both locations.

Table 5: Gonado somatic index (GSI) for female eelpout (*Zoarces viviparus*) for 2011 and 2012 at Lillgrund wind farm and control location Bredgrund. Values are significantly lower for Bredgrund compared to Lillgrund in both 2011 and 2012. Values for Lillgrund are lower in 2012 than in 2011. GSI=((gonad weight/body weight) x 100). Degree of freedom: 134. Intercept (Lillgrund 2011) is not shown.

	Estimate	Std.error	p-value	t-value
Bredgrund 2011	$-2.531e^{+02}$	$2.534e^{+03}$	<0.001	-3.786
Year 2012	$-1.770e^{+00}$	$1.870e^{+00}$	<0.001	-3.879
Length	$-9.830e^{+00}$	$1.469e^{+01}$	0.00954	-2.611
Locality:Year	$1.258e^{+00}$	$1.260e^{+00}$	<0.001	3.788
Locality:Length	$9.428e^{+00}$	$9.977e^{+00}$	0.00474	2.849
Year:Length	$4.889e^{-03}$	$7.303e^{-03}$	0.00950	2.613
Locality:Length:Year	$-4.687e^{-03}$	$4.961e^{-03}$	0.00473	-2.850

Hepatic somatic index values show that liver size compared to female weight is slightly higher in Bredgrund compared to Lillgrund (table 6). The values are significantly lower for 2012 than 2011. Adjusted R-squared values from the summary tables differed greatly for the rejected model and the model chosen. The values were 0.095 and 0.62 respectively.

Table 6: Hepatic somatic index (HSI) for female eelpout (*Zoarces viviparus*) in 2011 and 2012 for Lillgrund wind farm and control location Bredgrund . Values are significantly higher for Bredgrund compared to Lillgrund in both 2011 and 2012. For Lillgrund are HSI values also significantly higher in 2012 than 2011. HSI= ((weight of liver/weight of body) x 100). Degree of freedom: 134. Intercept (Lillgrund 2011) is not shown.

	Estimate	Std.error	p-value	t-value
Bredgrund 2011	$2.581e^{+02}$	$1.092e^{+02}$	0.00424	-2.886
Year 2012	$2.006e-^{04}$	$2.214e^{-04}$	<<0.001	-5.858
Length	$-1.760e^{+00}$	$6.470e^{-01}$	<<0.001	-5.446
Locality:Year	$-1.285e^{-01}$	$5.428e^{-02}$	0.00455	2.862
Locality:Length	$1.826e^{-03}$	$1.133e^{-03}$	0.00675	2.731
Year:Length	$8.746e^{-04}$	$3.218e^{-04}$	<<0.001	5.448

Data from this study show a sex ratio for fry of approximately 50/50 for Lillgrund and Bredgrund both years (2011 and 2012) (figure 4). Grey areas show ratio of female fry and white areas ratio of male fry.

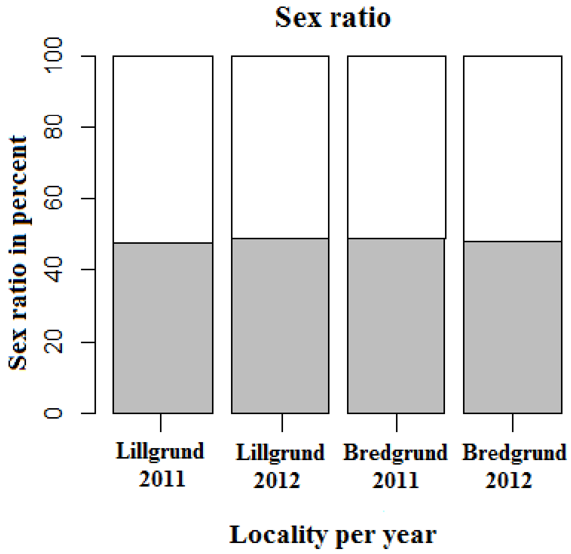

Figure 4: Sex ratio for eelpout (*Zoarces viviparus*) fry from Lillgrund (wind farm) and Bredgrund (control) (2011 and 2012). Grey areas show the portion of female fry and white areas show male fry, when all clutches are combined for each location and year.

Distribution of fry size is about the same for all locations and years (figure 5) with most fry being app. 30 mm long. Fewer females from Bredgrund in 2012 compared to Lillgrund gives a differently divided figure for the locations in 2011.

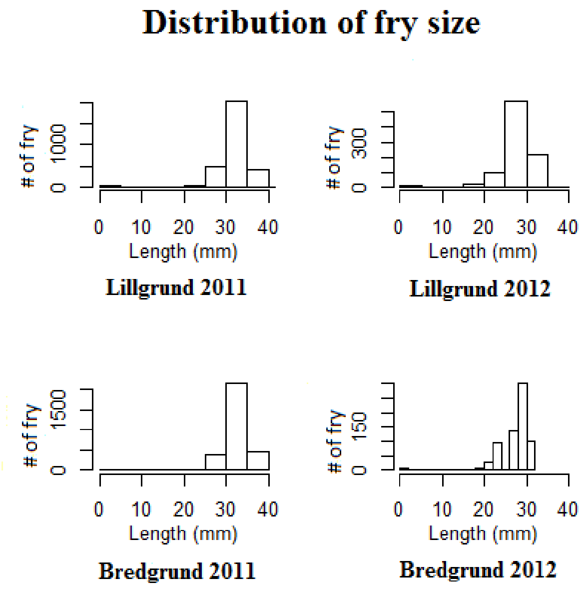

Figure 5: Distribution of eelpout (*Zoarces viviparus*) fry size (mm). Note that dimension and numbers of poles are differently divided for Bredgrund 2012 due to much lower sample size. Number of fry, and therefor number of fry in the length groups, are lower for both locations in 2012.

Discussion

In this study we found that wind power can have an influence on size of females, number of offspring and condition. Fish from the wind farm had a higher fecundity and were in better condition. This study also shows how year can influence all these traits which make it important to have data from more years and localities when judging the influence of wind farms.

The decrease in length from 2011 to 2012 is very weak and there is no difference between the two localities (table 1). Looking at mass implies that there is a weak effect of locality (Bredgrund < Lillgrund) (figure 2). There is also an effect of year (2012 < 2011). The biggest difference is the dissimilar relationship between mass and length between years.

Female weight (log) seen together with length varies between both locations and years (figure 2). The weight is lower in Bredgrund (control) than Lillgrund, and there is a steeper slope for Bredgrund than Lillgrund for both years. A different relationship between weight and length can be seen between the years.

Difference between the years 2012 and 2011 might, based on observations during field work, be due to different weather and temperature conditions which may have affected when pregnancy occurred and therefore the number of pregnant females we were able to get during field work. The water quality might also affect the fish in a way we don't know today. During field work in 2012 many of the fishes caught in the fyke nets died during the nights the nets were placed in the ocean. This included both eelpout and other species like cod (*Gadhus morhua*). This may however be due to coincidence and conclusions cannot be drawn from these obervations alone.

In 2011 there were significantly fewer fry compared to the length and weight of the mother than in 2012 (table 2). We can also see that there were fewer fry compared to size of females in Lillgrund compared to Bredgrund. There were also significantly more fry per clutch in 2011 than 2012 (table 3). This can be seen in correlation with other results in this study showing that the females were in better condition in 2011 than 2012 (for both locations) (figure 2).

The gonadosomatic index (GSI) is lower for Bredgrund than Lillgrund in 2011 and lower for fish from both locations in 2012 (not significant) (table 5). Weather can have affected when spawning occurred and thereby also have influenced the size of the gonads these two years. GSI is decreasing with female length. With increasing female length is GSI decreasing. The size of the gonads increase towards reproduction and declines following spawning, the size of gonads also correlates with food and growth. This can explain why the GSI is higher in Lillgrund where it can be expected to be better access to resources, but not why increasing length is seen in correlation with decreasing GSI.

High hepatosomatic index (HSI) indicates that a fish is in poor health because the liver size increases with lower condition. The results show that HSI is significantly higher for Lillgrund in 2012 compared to 2011 (table 6). Other results in this study indicate that eelpout from Lillgrund are in better or same condition as the eelpout from Bredgrund and that females from both locations were in better condition than the year before (figure 2), but HSI values for 2012 are higher than the year before only in Bredgrund.

The sex ratio for the eelpout both in the wind farm (Lillgrund) and the control area is approximately 50/50 (figure 4). This is the same as what have been found in earlier studies at 13 sites for up to 4 years (Larsson et al. 2000, Larsson 2002). This points to the fact that offshore wind power in the Baltic does not seem to affect the sex ratio in the new born.

The result that fewer fry survived in 2012 compared to 2011 can also be an effect of weather or water quality (table 4). Even though eelpout tolerate big fluctuations in temperature and salinity, their fry are not as tolerant and will be affected first if the mother is stressed and/or exposed to anoxic conditions. This will just be speculations and assumptions without meteorological data. Higher survival of fry in Lillgrund might have a correlation with females being heavier and longer than females from Bredgrund (control) (table 1, figure 2).

Distribution of size of fry is approximately the same in all the clutches for both locations and years (figure 5). This indicates that size is not affected even though there is variation in number of fry per clutch and number of fry compared to female size.

Conclusion

From the results in this study can we draw the conclusion that wind power does not affect the reproduction of eelpout (*Zoarces viviparous*) in the Baltic in a negative direction. Females are in better shape and have more and larger fry. Still, further research should be done with more wind farms and preferably over longer time to give more accurate data. It can be recommended to carry out other studies with more than one sentinel species to be able to draw more definite conclusion about possible impacts offshore wind power might have.

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