

**2. Status for the project entitled:  
Investigations on the artificial reef effect on fish from  
marine wind turbine park at Horns Reef.**

January 2002.  
Contract Ref: Ordre Nr. 69.(11-06-01)  
Our ref: 2002-132-1

**2.1. Description of the program during the first year: 2001/2002 Baseline study.**

The KFG research gillnets, which had not been tested in conditions such as those around Horns Reef, needed to be tested and modified accordingly. A preliminary 2-day survey was therefore carried out.

A reference site was established prior to the first project survey.

Due to timing of the start of the project and delay to test the performance of the gillnets in this site prior to the survey, the first project survey, was conducted in the autumn during September. The spring survey will have to be conducted in 2002 before deployment of the wind turbines, which are scheduled to start on March 18.

**Survey 1:** September 2001. A commercial vessel was chartered for this purpose and two trained HFI personnel assisted with the fishery.

**Conditions:** A total of 8 fishing days are required. The ship and crew were on stand-by for a period of 30 days, to ensure 8 complete fishing days.

**Requirements:** Communication between the responsible TAP and project responsible during the fishing survey was maintained to ensure the catch obtained would be sufficient to provide adequate data for the statistical analysis.

Cooperation with BioConsult A/S ensured that bottom fauna sampling coincided with the September fishery and were taken at the same stations as the fishery. The development of bottom fauna prior to and after the deployment of the wind turbine park can be compared to the diet in the fish assemblages found. Fish stomach analyses are not planned before 2003, after the deployment of the wind turbine park.

**Fishing:** Three wind turbine stations and the reference site were fished with gillnets. A total of 24 gillnets were planned for each station. Fishing traps were tried out for comparison with performance of the KFG gillnets.

**Samples for the laboratory:** Otoliths and frozen fish for aging.

**Survey 2:** This will take place during February/March 2002, just before the wind turbines are deployed. Same conditions, requirements and fishing details as for Survey 1.

## 2.2. Purpose of the project

The objectives of this investigation are:

- to study fish attraction relative to single wind turbine structures and to the wind turbine park
- to study the potential fish production enhancement of single wind turbine structures and of the wind turbine park

The first project year is the baseline study and will be based on data from 2 fishing surveys, an early spring and late summer survey.

## 2.3. Status for the project.

*The fishing.*

The fishing vessel RI 423 was hired for the gillnet fishing.

In cooperation with the local fisheries organisations, the boundaries of the reference area were chosen. The criteria for the choice of reference site were that it should be:

- at a sufficient distance as not to be impacted by the wind turbine site
- same depth as wind turbine site, or within the range
- similar fish assemblages as in the wind turbine site (from anecdotal information from the fisheries organisations on the fishing patterns and type of fish or mussels fished in the two areas)

The position of the reference site is as follows:

55°31'0 N 07°43'0 E, 55°32'0 N 07°43'0 E, 55°31'0 N 07°44'0 E, 55°32'0 N 07°44'0 E.

The multi-mesh gillnets called KFG was developed by DIFRES and consists of 12 gillnets of different mesh size ranging from 6.6 to 117 mm knot to knot (KFG-12). This gillnet was developed towards catching all sizes and types of marine fish in a coastal environment (Eigaard et al. 2000). The mesh-size and thread diameter is shown in Table 1.

Each mesh panel is 6 m long, mounted on a buoyancy line and lead line, with a hanging ratio of 0.3. The mesh panels are randomly distributed in each KFG-12 with around 0.5 m space in between. The net is around 1.5 m in height. From the catches in the preliminary survey it was apparent that all mesh sizes should be maintained. Thus each KFG-12 is around 80 m in total length.

The preliminary survey HR01-1 was conducted in August in the general area of Horns Rev. Six fishing stations were performed each with one KFG-12 gillnet consisting of 12 mesh panels.

**Table 1.** The knot to knot mesh size thread diameter of the different mesh sizes constituting KFG-12 research gillnets.

Mesh nr.	Mesh size (mm)	Thread diameter (mm)
1	6.5	0.09
2	8.5	0.09
3	11.0	0.09
4	14.3	0.12
5	18.6	0.14
6	24.2	0.15
7	31.4	0.17
8	40.9	0.20
9	53.1	0.24
10	69.0	0.28
11	89.8	0.34
12	116.7	0.40

The first base-line survey HR01-2 was conducted during September. Each of three wind turbine positions (M55, M58 and M95) and the reference area were fished over 4 fishing days with 6 gillnets at each position. Because one fishing day was excluded from this study due to the turn of weather, M95 and the reference area were fished during 3 days. Table 2 gives an overview of the positions and total number of gillnets (=samples) fished during the survey.

**Table 2.** Position and number of gillnets deployed at each position during the first baseline fishing survey (HR01-2)

Position	Gillnets deployed (samples)
M55	24
M58	24
M95	18
Reference	18
<b>TOTAL</b>	<b>84</b>

#### *Co-ordination with other groups*

The bottom fauna sampling conducted by BioConsult A/S coincided with the September fishery, and all the caught fish were frozen and are stored at the laboratory in Charlottenlund. No stomach analysis were planned or budgeted for in the baseline study, but the samples will be stored in case they should be required at a later date.

### *Data analysis*

There was not enough time to compute the catch data in the DIFRES Fishery database for the analysis, so the following analyses are based on the overall data sets computed in an ordinary spreadsheet (quality checked data). The data is being computed in the database during January.

The species abundance and composition in the wind turbine and reference site were compared using the Primer (Clarke, 1993) and (SigmaStat).

Univariate analyses of abundance and diversity. The species diversity was calculated with the Shannon-Wiener ( $H'$ ) index using the Primer and tested for differences using student's t-test.

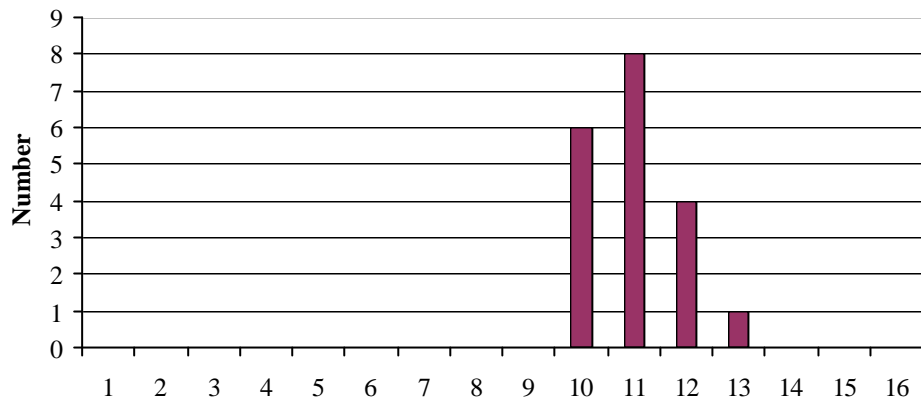
Multivariate analyses of community structure. A cluster analysis (dendrogram) and a nonmetric multi-dimensional scaling (MDS) ordination were the two methods applied to describe similarity in the fish community between the wind turbine and reference site. The Bray-Curtis coefficient based on abundance of the individual species was used to estimate similarity between sites. In the MDS ordination a stress value is given. A value  $<0.2$  gives a useful 2-dimensional ordination which can be interpreted, whereas values between 0.2 and 0.3 should be treated with caution, especially as it approaches 0.3 (Clarke & Warwick, 1994). The statistical differences in the community structure between sites based on single species was tested using student's t-test and the average contribution of each species to the measured dissimilarity between groups was identified and estimated using Simper procedure in the Primer (Clarke & Warwick, 1994).

## **2.4. Results**

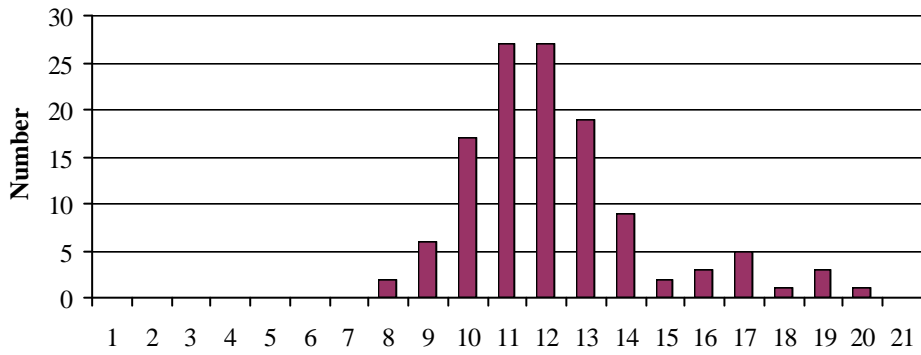
### *The preliminary survey HR01-1*

The catch results of the preliminary survey HR01-1 are given in Table 3. A total of 186 fish distributed in 14 species were caught in this preliminary survey. The most predominant fish species in the catches were whiting and plaice. On the basis of 6 gillnets (=samples) an average of 22.7 and 3.3 whiting and plaice were caught with a variability of 80% and 35% respectively. The length distribution of the 3 most common species in the catches is given in Fig. 1.

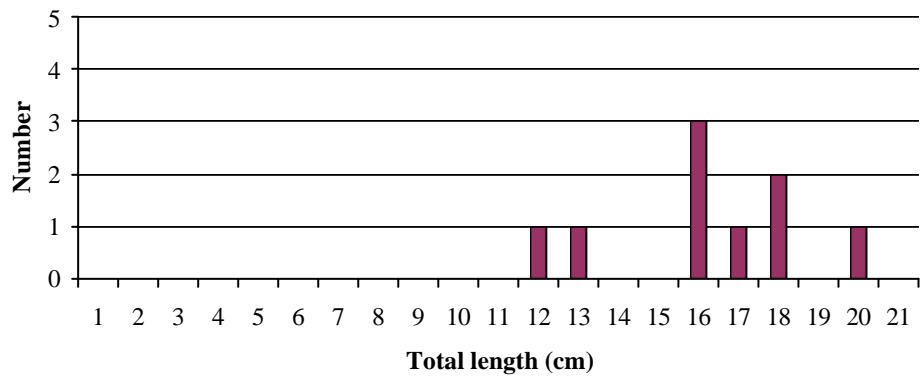
### Plaice



### Whiting



### Sandeel



**Fig. 1.** Length distribution of the three most commonly caught species, plaice, whiting and sandeel in the preliminary survey HR01-1.

*The first project survey HR01-2*

A total of 801 fish distributed in 21 species were caught in 84 gillnets during the first project survey. Since the wind turbines are not yet in place, the data from these three wind turbine positions is merged and compared to catches from the reference area.

The catch results of the first project survey HR01-2 constituting part of the baseline study are given in Table 4. Note that each data comprises of the total from 3 KFG-12 catches and not a single KFG-12. In general a higher catch per unit effort (CPUE per KFG-12) of fish was obtained in the reference area as compared to the wind turbine area. This is especially evident for whiting and dab and plaice, whereas slightly higher CPUE for sandeel is observed in the wind turbine area.

A slightly higher number of species were caught in the wind turbine site (Fig 2) as compared to the reference site (Fig. 3). This was due to singular or sporadic catches of species such as sprat, horse mackerel, dragonet, flounder, cat shark or sand goby.

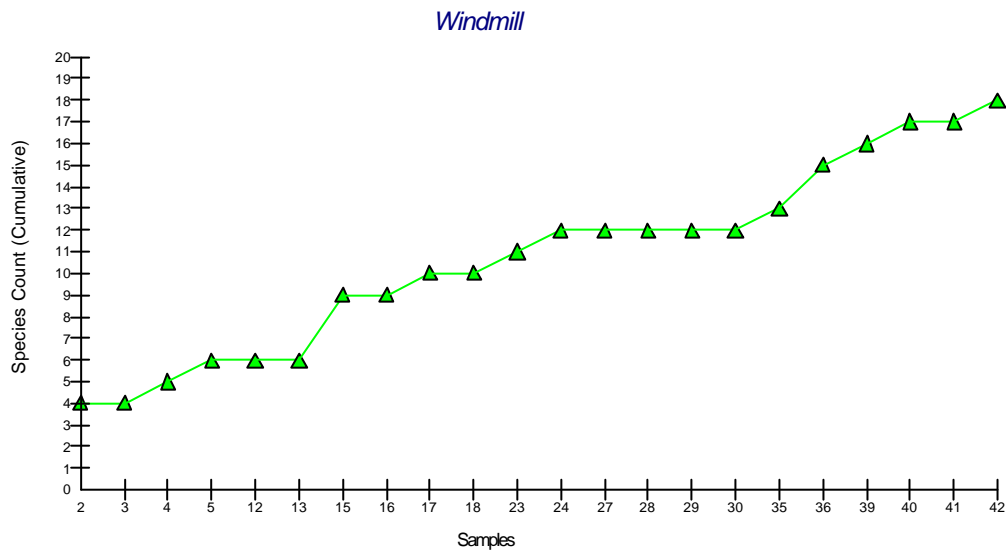


Fig. 2. Cumulative species number at the wind turbine site.

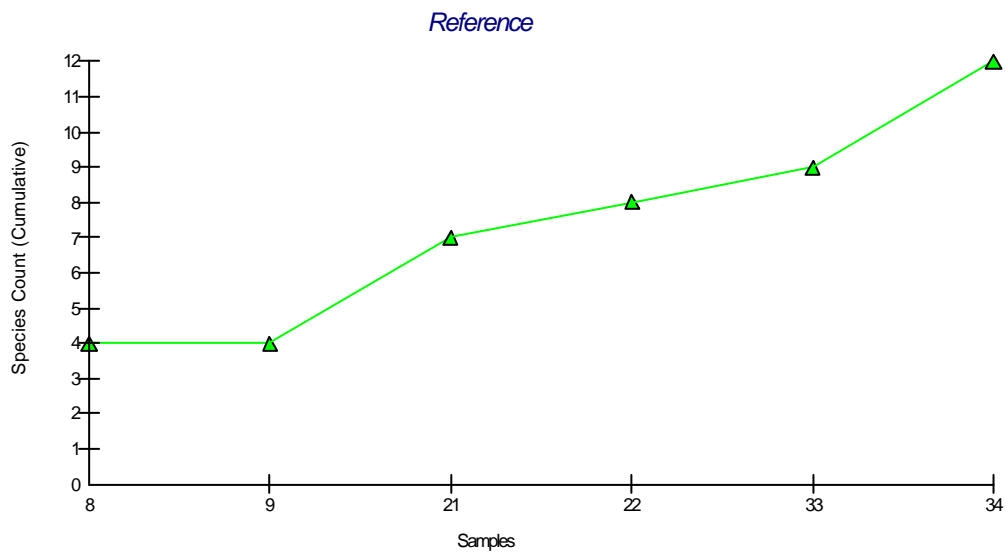


Fig. 3. Cumulative species number at the reference site.

**Table 3. Total catches of different fish species in the different mesh panels during the preliminary survey.**

	Plaice	Sole	Whiting	Sandeel	Sprat	Horsemakereel	Dragonet	Great sandeel	Herring	Megrim	Mackerel	Cod	Dab	Hooknos
6,5			5	2	1	3								
8,5			15	4		5	1							
11		2	57	3	2	4	0	1	2					
14,3		1	19	0	0	1	0	0	0	1				
18,6	2	1	9	0	0	0	0	0	0	0	1	1		
24,2	17	0	9	0	0	0	0	0	0	0	0	1	1	
31,4			5	0	0	0	0	0	0	0	0	0		3
40,9			2	0	0	0	0	0	0	0	0	0		1
53,1			1											1
69														
89,8														1
116,7														
	19	4	122	9	3	13	1	1	2	1	1	2	7	

**Table 4.**

Total catches of the most commonly occurring species – fish

- crabs

Station nr.	Position	fish									- crabs		
		Whiting	Dab	Sand eel	Hooknose	Plaice	Sole	Horse mackerel	Cod	Turbot	Edible crab	Shore crab	Sw. Crab
	2M55	5	4	0	0	1	4	0	0	0	3	2	167
	3M55	6	4	0	0	1	2	0	0	0	2	0	115
	4M58	18	1	11	0	1	3	0	0	0	4	0	118
	5M58	25	2	12	0	1	1	0	0	0	4	0	118
	8REF	31	5	0	5	2	1	0	0	1	9	0	113
	9REF	52	6	2	8	5	0	0	0	0	4	0	153
	12M95	5	3	0	0	1	1	0	0	0	1	0	97
	13M95	4	5	1	0	0	0	0	0	0	1	0	71
	15M55	8	2	0	1	0	0	1	0	1	1	0	70
	16M55	14	6	1	3	0	1	0	0	0	2	7	167
	17M58	10	0	2	0	0	2	0	0	0	4	0	55
	18M58	14	6	5	1	0	1	1	0	0	4	2	97
	21REF	17	7	1	2	3	2	0	0	0	15	0	176
	22REF	24	16	1	3	5	3	0	0	1	10	0	104
	23M95	5	2	0	3	1	2	0	0	0	1	6	56
	24M95	7	1	1	1	1		0	0	0	0	3	42
	27M55	5	2	2	0	0		0	0	0	6	7	182
	28M55	9	1	2	0	1		0	0	0	4	1	127
	29M58	7	0	0	0	2	1	3	0	1	5	3	92
	30M58	12	1	1	1	0		0	0	0	4	1	86
	33REF	57	6	1	2	0	1	0	1	1	27	4	425
	34REF	80	2	1	0	1	0	0	1	0	25	4	172
	35M95	19	3	3	6	1	0	0	1	0	12	0	190
	36M95	21	2	0	1	0	3	0	0	0	16	0	220
	39M55	13	1	2	1	0	1		1		14	1	262
	40M55	15	2		2	3					16	5	135
	41M58	18	2	1		2					5	3	172
	42M58	15	2	3	2	1	1		1		3	1	161
<b>TOTAL</b>		<b>516</b>	<b>94</b>	<b>53</b>	<b>42</b>	<b>33</b>	<b>30</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>202</b>	<b>50</b>	<b>3943</b>
Total Reference area		261	42	6	20	16	7	0	2	3	90	8	1143
Total Wind turbine area		255	52	47	22	17	23	5	3	2	112	42	2800
Reference/KFG-12		14,5	2,3	0,3	1,1	0,9	0,4	0,0	0,1	0,2	5,0	0,4	63,5
Wind turbine/KFG-12		3,9	0,8	0,7	0,3	0,3	0,3	0,1	0,0	0,0	1,7	0,6	42,4

Univariate indices. It can be seen from Fig. 4 that fish species diversity was not significantly different between the wind turbine and reference sites. This was tested using student's t-test and no significant differences were found.

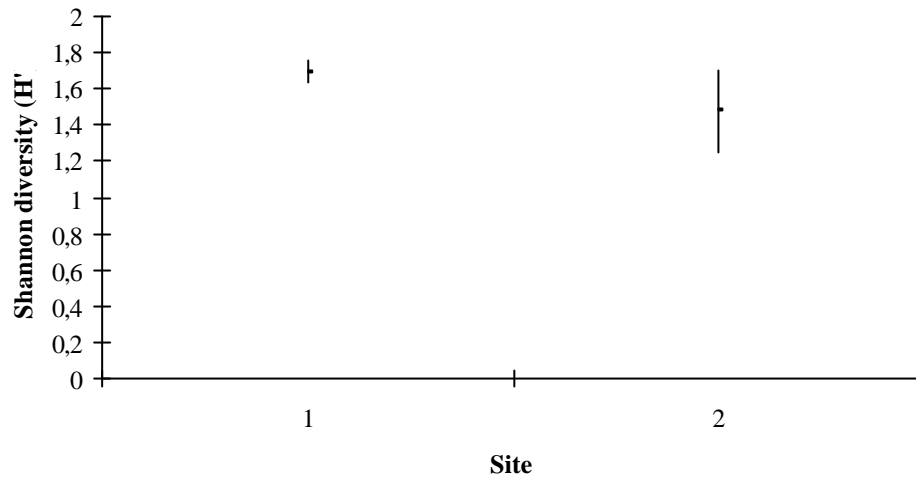


Fig. 4. Means and 95% confidence intervals of Shannon diversity ( $H'$ ) at the wind turbine (1) and reference site (2).

Multivariate analysis was carried out on the data to test for similarity of fish assemblages in the wind turbine and reference site. A two-dimensional MDS plot based on the abundance estimate of the fish assemblages at the reference and wind turbine site shown in Fig. 5 visualises the lack of distinct groups and implies no difference in fish assemblages between the two sites. Those samples closest to each other have the highest similarity, whereas those more distant, the lowest. There are no significant differences in fish assemblages between the wind turbine and reference site in the late summer survey. On the other hand the relatively high stress indicates low similarities between triplicate samples, which may give problems in later identifying possible differences between localities. This analysis needs to be repeated using the single data sets.

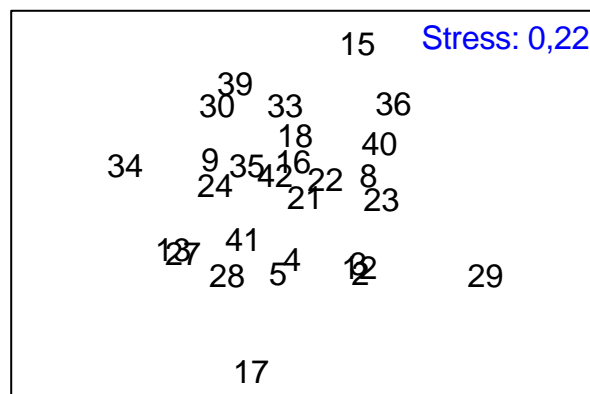


Fig. 5. MDS plot of species abundance at the fishing stations during the first project survey HR01-2. Reference site: 8, 9, 21, 22, 33, 34. The remaining stations are from the wind turbine site.

The lack of grouping of the two sites is further illustrated in the corresponding dendrogram in Fig. 6.

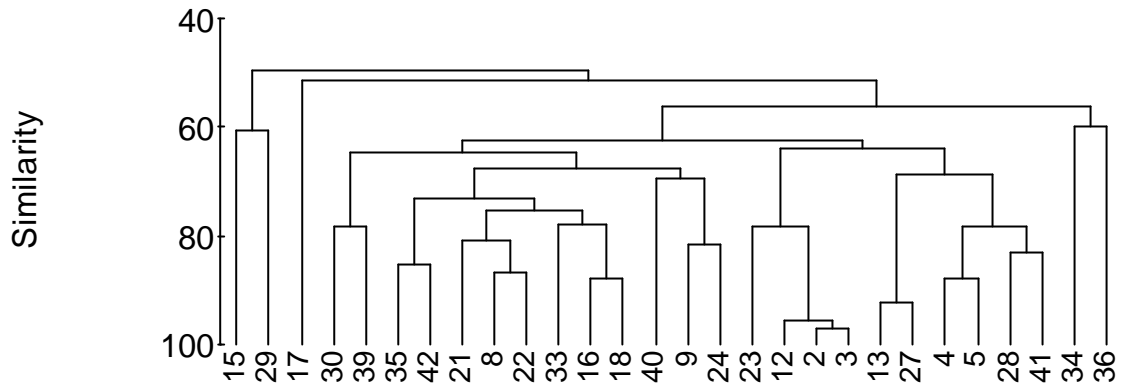


Fig. 6. Dendrogram illustrating the similarity of fish assemblages between stations during the first project survey HR01-2. Reference site: 8, 9, 21, 22, 33, 34. The remaining stations are from the wind turbine site.

The average abundance of the different fish species (based on the triplicate KFG-12 catches) was tested for differences between wind turbine and reference site by comparing the catch per 3 gillnets. Only in the case of dab were there significant differences (t-test,  $p=0,002$ ) in the average catch. The results of this test are tabulated in Table 4.

The length distributions from this survey are not reported as this data is not available at this point. The otoliths will be analysed during 2002.

Despite efforts to minimise catches of crabs, their abundance is such that high catches are unavoidable. However, their presence in the gillnets was evaluated from visual appraisals of the gear and the condition of the catch, to have low impact on the catch efficiency of the gillnets. The crabs caught during the survey were identified to species and counted. The data is presented in Table 3, but is not included in the above uni- and multivariate analysis. Three species of crabs were caught: edible-, swimming- and shore crab. The occurrence of crabs in the two sites is similar except for that of the edible crabs, where significantly higher numbers were caught in the wind turbine site as compared to the reference site.

## 2.5. Deviations from the program.

The **gillnets** have been modified and manufactured for this project. They were assayed in a two-day preliminary survey at the site and the catches analysed. The results indicated that fishing with the modified KFG-gillnet is possible and the catches are relatively consistent. It was therefore decided to go ahead with the baseline study, which is underway although the following modifications have to be made to the survey design to accommodate the physical properties of the gillnets, the fishing

conditions in the area and to ensure safety for the crew during fishing under these conditions.

- the number of stations at each of the three wind turbines has been reduced from 4 to 3
- the number of gillnets which can be deployed per day has been reduced from 20 to around 12
- fishery will not take place twice daily as planned, but only once daily and during a specific time period to encourage high catches of fish, and low catches of crab.
- the number of mesh sizes has been increased to 12 for each gillnet
- specific conditions for weather during fishery have been specified

These adjustments are not expected to cause problems with regards to the data treatment.

## **2.6. Conclusion**

The newly developed KFG research gillnets were tested in the Horns Reef area in a preliminary survey to examine their performance under these extreme conditions. The catches showed that it would be possible to complete the project since the variation in catches for particular fish species was within reasonable limits. However, the strong currents, exposed conditions and occurrence of huge numbers of crabs made it necessary to alter the original experimental field design to cater for these particular conditions.

The first project survey was conducted during September. All but one of the planned fishing days was performed within two fishing periods. The data is being computed in the Fishery database at DIFRES. The analysis is based on spreadsheet data due to time limitation. The preliminary results show no significant differences between fish assemblages in the two sites, indicating the suitability of the reference site with this respect.

Univariate and multivariate analysis of the catch data from the wind turbine and reference site show no differences between these two sites.

### 3. Budget

#### 4. Activities in 2002.

One fishing survey will be conducted in the spring prior to the deployment of the wind turbines. A mid-year status and full year report will be supplied including fishery data and comparison of reference and non-reference site fishery. This report will comprise the one-year baseline study.

#### Appendix I.

Glossary of fish names appearing in the report.

English	Danish	LATIN
Sprat	Brisling	<i>Sprattus sprattus</i>
Dragonet	Fløjfisk	<i>Callionymus sp.</i>
Megrim	Glashvarre	<i>Lepidorhombus whiffiagonis</i>
Yellow sole	Glastunge	<i>Buglossidium luteum</i>
Cat shark	Rødhaj	<i>Scyliorhinus caniculus</i>
Atlantic horse mackerel	Hestemakrel	<i>Trachurus trachurus</i>
Whiting	Hvilling	<i>Merlangius merlangus</i>
Dab	Ising	<i>Limanda limanda</i>
Great sandeel	Tobiskonge	<i>Hyperoplus lanceolatus</i>
Makerel	Makrel	<i>Scomber scombrus</i>
Hooknose	Panserulk	<i>Agonus cataphractus</i>
Turbot	Pighvar	<i>Psetta maxima, Scophthalmus maximus</i>
Plaice	Rødspætte	<i>Pleuronectes platessa</i>
Herring	Sild	<i>Clupea harenga</i>
Flounder	Skrubbe	<i>Platichthys flesus</i>
	Tangspræl	<i>Pholis gunellus</i>
sole/scaldfish	Tunge/tungehvarre	<i>Solea solea/Arnoglossus laterna</i>
Sandeel	Tobis	<i>Ammodytes marinus</i>
Cod	Torsk	<i>Gadus morhua</i>
Bull head	Ulk	<i>Myoxocephalus scorpius</i>
Sand goby	Sandkutling	<i>Pomatoschistus minutus</i>
Edible crab	Taskekrabber	<i>Cancer pagarus</i>
Shore crab	Strandkrabber	<i>Carcinus maenas</i>
Swimming crab	Svømmekrabber	<i>Ovalipes catharus</i>