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REPORT

Report no.: 2005.050	ISSN 0800-3416	Grading: Open

Title:
Detailed seabed information in Integrated Coastal Zone Planning and Management - AquaReg Pilot study, Norway

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County: Nord-Trøndelag	Commune: Fosnes
Map-sheet name (M=1:250.000) Namsos	Map-sheet no. and -name (M=1:50.000) 1624 II (Nord-Flatanger), 1724 III (Jøa)
Deposit name and grid-reference:	Number of pages: 36 Price (NOK): 295,- Map enclosures: 0

Fieldwork carried out:	Date of report: 15th July 2005	Project no.: 308800	Person responsible: Reidulv Bøe

Summary:
Integrated coastal zone planning and management (ICZPM) requires adequate knowledge on the marine coastal systems. In this pilot project, the use of detailed seabed information (depths, sediment and bottom types, seabed structures and processes) translated to thematic maps as a tool for ICZPM has been tested and evaluated.

Based on data collected in an earlier project (HASUT) and from local sources, ten thematic maps were made:
1 – Depth; 2 – Slope; 3 - Seafloor sediments and natural habitats; 4 - Strength of bottom currents interpreted from bottom morphology and sediment types; 5 - Accumulation basins and areas with risk of oxygen deficiency; 6 - Anchoring conditions – interpreted from bottom type and depth; 7 - Seafloor sediments and biological diversity; 8 - Fish habitats and spawning areas; 9 - Fishing activity and aquaculture sites; 10 - Fosnes Municipality area plan - sea.

A first version of the maps were presented to a wide range of end-users at a dedicated workshop, and used in a test phase by a local community (Fosnes). The workshop presentation was done using Internet-based GIS tools, allowing users to test functionality and evaluate content. For the testing in the Fosnes community, customized GIS files which could be incorporated into their own systems were provided. Based on feedback from the end users, the maps were improved and finalized, and made publicly available on a dedicated section of the marine knowledge and information system www.mareano.no. This system integrates written documentation, illustrations and map services from a wide range of sources, focusing at end user needs.

Recommendations from the pilot study particularly addresses the need of detailed seabed information, the need for translating specialist information to thematic maps useful for end users using suitable tools, and the need for increased communication and experience transfer between ICZPM stakeholders and scientists.

Keywords: Marine geology	Fish farming	Marine biological diversity
Marine maps	Coastal zone planning	Fish habitats
Sediments	Sediment-trap	Anchoring conditions

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APPENDIX

1 INTRODUCTION

Under sub-contract to the AquaReg project, NGU has translated detailed spatial seabed information from the HASUT- project (depths, sediment and bottom types, seabed structures and processes) to thematic maps for planning purposes in the coastal zone. Several HASUT sub-projects were involved in the collection and distribution of the marine GIS-datasets (Andersen 2004, Andresen 2004a, b, Longva et al. 2003, Sandberg 2004, Sandnes 2004). Examples of information collected are: fishing- and spawning areas, marine biological diversity and fish farming sites. The data follow the national SOSI-standard, and are available through the databases www.statkart.no/arealis and www.mareano.no.
The maps are intended to be models/examples for other marine areas. The web site is developed to give easy access to relevant data and to help guiding non-geologists to make use of geological information in their work.

The background information was collected in Fosnes municipality in Nord-Trøndelag County in a former project; HASUT (Aquaculture/Area/Coordination and Development in the region of Trøndelag). Several sub-projects dealing with a wide spectre of topics were involved: Aqua culture site quality, the establishing of datasets relevant for Coastal Zone Management, production of detailed maps of the sea floor and of marine biological diversity. Information was used across sub-projects, and fishermen, fish-farmers, consultants, bureaucrats, municipalities and scientists worked together to obtain a good result. The same participants cooperated in the AquaReg pilot study, where they attended a workshop in Fosnes, giving valuable input on the contents of the maps and the functionality on the web system.

NGU would like to thank all of the participants of this work. This includes the help and support from partners in the AquaReg projects, Geir Tevasvold, Jørn Ekrem, Eivind Thronæs, Jan Brødreskift and Oisin Naughton. A special thank goes to the mayor of Fosnes municipality, Kristen Dille, and adviser Kjell Tranås, Innovation Office of Midtre Namdal, for the cooperation, hospitality and enthusiasm in connection with the work.

2 AQUAREG PILOT STUDY – FOSNES

AquaReg is a cooperation between the regions Galicia (Spain), Border, Midland and Western (BMW) Ireland and Trøndelag, focusing on the development of aquaculture and coastal fisheries. The present work has been done as a sub-project to the AquaReg programme, an EU-programme in INTERREG IIIC partly financed by EU and partly by Sør- and Nord-Trøndelag County Councils. More information is available on www.aquareg.com.

2.1 Objectives of the pilot study

The objective of the pilot study is to test how spatial information on depths, sediment and bottom types, seabed structures and processes) can be translated to thematic maps for planning purposes in the coastal zone, for aquaculture and fishery activities, and for environmental care.

2.2 Organizing and activity

The planning of the project started in December 2004, whereas the actual project work started in January 2005. A preliminary version of the maps were presented and evaluated at a workshop in Fosnes in April 2005, and the final maps are now distributed on www.mareano.no.

Table 1. NGU participants in the pilot study.

Kari H. Bachke Andresen	**Biologist (leader of the project)**
Oddvar Longva	**Marine geologist**
Aave Lepland	**Data engineer**
Terje Thorsnes	**Marine geologist**

The Norwegian AquaReg pilot study has two sub-projects; this study, based on detailed marine maps, and a study performed by Fosen County Council. The Fosen County Council study deals more with combining different kinds of available maps with documents, for instance from Directories and fish farms. More information can be obtained at www.fosen.net. Many organisations and participants have given information and added knowledge to this study (Tables 1 and 2).

Table 2. Organisations and participants who have provided information and knowledge to the study.

Per A. Andersen	**Project leader of HASUT- Site Quality Project.**
Otto Sandnes	**Aqua Kompetanse A/S– working for HASUT - Site Quality Project.**
Knut Staven	**Marine Harvest A/S.**
Kjell Tranås	**Fosnes municipality/Innovation office of Midtre-Namdal, member of the group, HASUT - Establishing datasets relevant for CZM and Mapping Marine biological diversity.**
Kristen Dille	**Mayor of Fosnes municipality.**
Erlend Skutberg	**The County Governor in Nord-Trøndelag, member of the group, HASUT - Establishing datasets relevant for CZM.**
Kristian Julien	**The County Governor in Nord-Trøndelag, GIS-responsible for mapping marine biological diversity.**
Sissel Holien	**Nord-Trøndelag County Council, member of the group, HASUT- Establishing datasets relevant for CZM.**
Jan Henrik Sandberg	**Researcher, Norwegian Institute for Water Research (NIVA), project leader of the HASUT-project until summer 2004.**
Åge Ugseth	**Fisherman, Fosnes, important informant for fishing areas and marine biological diversity.**
Ole Christensen	**Geological Survey of Norway, identifying and making maps of the sea-floor around Fosnes for the HASUT- project.**
Jørn Ekrem	**Nord-Trøndelag County Council, participating in the coordination the HASUT-project.**

Major pilot project activities are listed in Table 3.

Table 3. Major pilot activities.

Meetings

- **Information meeting/workshop. Coastal Zone Management, Trondheim, 2 nd of March 2005.**
- **Meeting with the Spanish and Irish partners in the AquaReg project, Geological Survey of Norway, Trondheim, 2 nd of March 2005.**

Workshops

- **Development of marine maps in the most well-mapped marine mapped areas of Norway - Fosnes Municipality, Jøa Gjestegård, April 14 th 2005.**

Lectures

- **Lepland, A. 2005: Fosnes-AquaReg on Internett. Workshop, Fosnes, April 14 th 2005.**
- **Andresen, K.H.B. 2005: The importance of detailed marine maps for development and planning in the coastal zone - an example from several HASUT-projects in Fosnes Municipality. Information meeting/workshop Coastal Zone Management, Trondheim, 2nd March 2005.**
- **Longva, O. 2005: Ny teknologi for marin kartlegging - muligheter for framtida. Annual meeting for the fish farmers organization in Trøndelag, March 7th 2005.**
- **Longva, O. 2005: Presentation of marine maps. Workshop, Fosnes, April 14 th 2005.**
- **Andresen, K.H.B. 2005: Presentation of marine maps. Workshop, Fosnes, April 14 th 2005.**
- **Longva, O., Andresen, K.H.B., Lepland. AA., Thorsnes, T. & Christensen, O. 2005: Thematic maps in coastal management. The GeoHab2005 meeting in Sidney, B.C., Canada, May 4th-8th 2005.**

Articles

- **Kartprosjekt vekker EU-interesse. Trønderavisa, April 13th 2005.**
- **Fagfolket ble imponert. Namdalsavisa, April 19th 2005.**
- **Articles in, Fiskaren, August 2005 (in prep).**
- **Sandberg J. H., Thorsnes T., Bekkby, T., Longva O., Christensen O., Andresen K.H.B. & Lepland A. 2005: Future perspectives for ICZPM in relation to aquaculture. EAS Special Publication 2005 (in prep.).**

Info-folders

- **Presentasjon av AquaReg pilotstudiet – Norge – Fosnes (English/Norwegian)**

2.3 Economy

The total budget for the pilot study is 47 500 Euro. NGUs financial contribution to the study amounts to 23 750 Euro, i.e. 50 % of the total project costs.

3 MARINE MAPS

Water depths and bottom types in Fosnes were mapped with equipment that enable measurement of depths for each metre of the seafloor (swath bathymetry) and a resolution of a few centimetres for water depths. The properties and distribution of sediments were mapped by sonar, seismic methods, seabed sampling and photo/video.

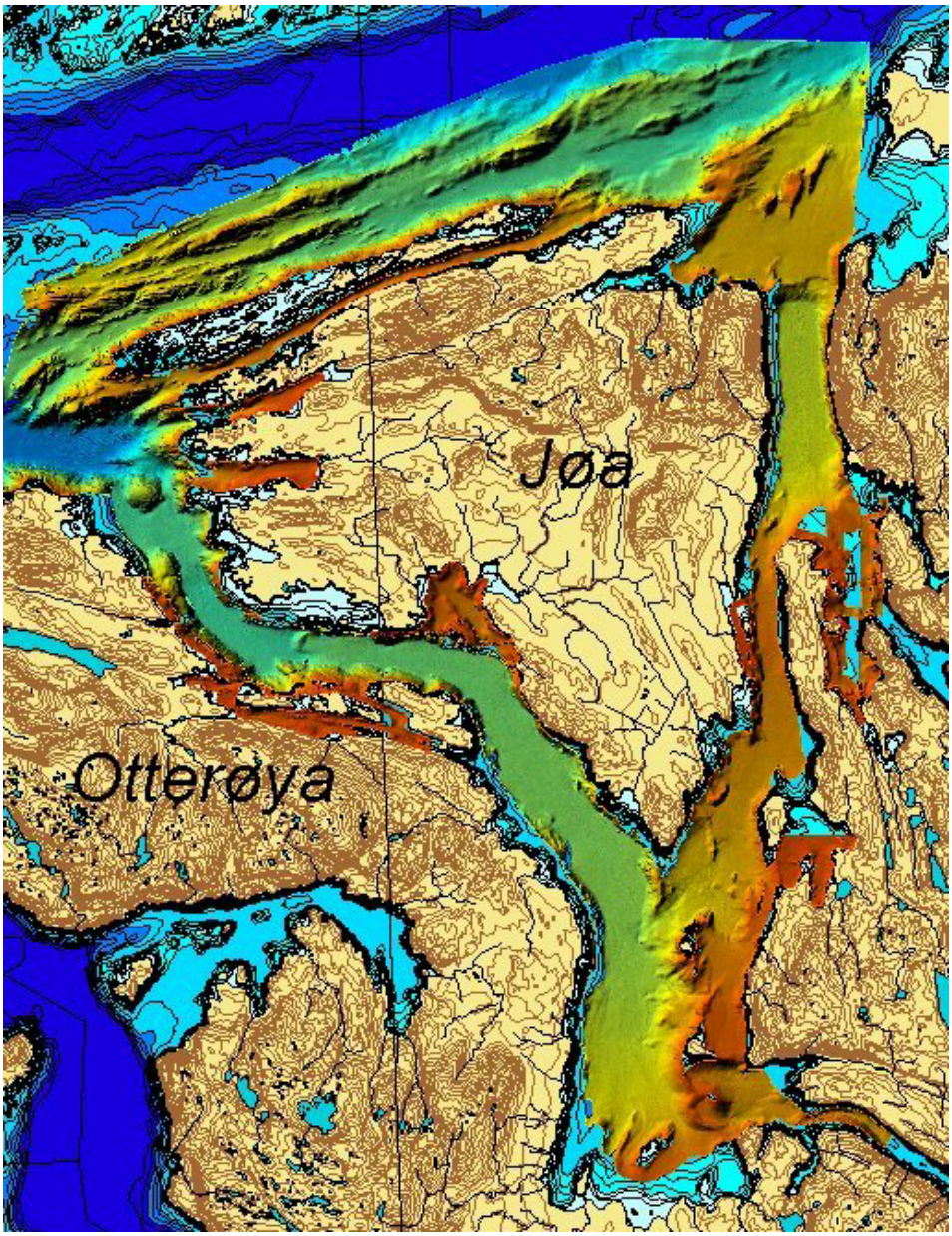


Figure 1. Fosnes Municipality in Nord-Trøndelag county. The topography of the fjord areas (blue is deep and reddish is shallow) is shown as a shaded relief map with an artificial sun in the north.

By collecting data (layer on layer) on seafloor morphology, distribution of sediments and bottom types and species, knowledge is acquired on what characterises the preferred habitats of different species. For example, corals are often found in connection with subaquous cliffs, where nutrient-rich water is forced up along the edges. Pollack is often found in current-rich areas where the supply of nutrients is plentiful. For the fish farming industry, it is important to locate farms in areas where currents remove feed waste and excrements. The terrain formations and sediments tell us which areas will tolerate additional organic input and which areas should be treated with caution. This information is important knowledge for planners.

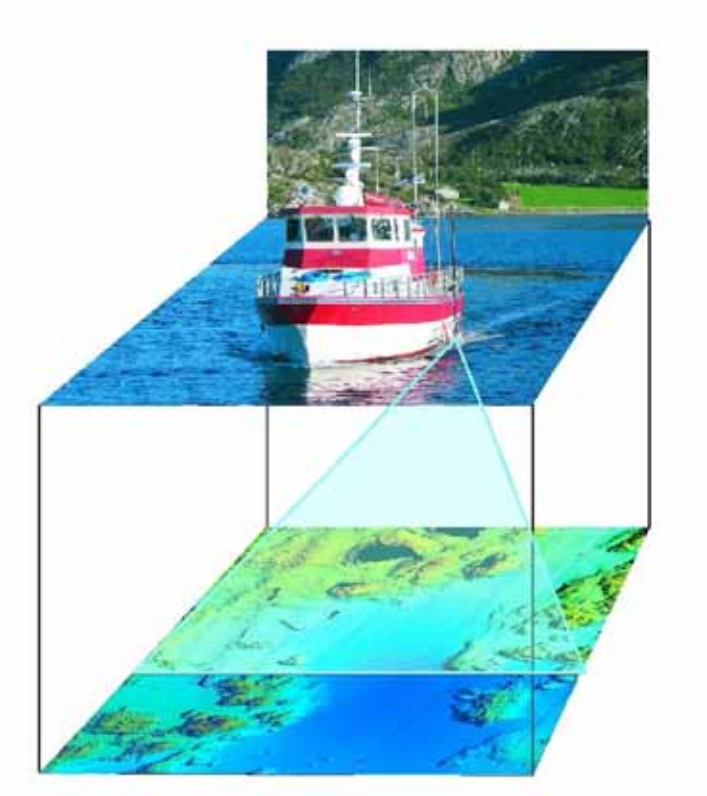


Figure 2. NGU's research vessel FF Seisma illustrating the principles of swath bathymetry mapping.

Sediments on the seafloor were formed during and after the last ice age, which ended approximately 10 000 years ago. Stone and gravel were left behind as till beds or moraine ridges when the ice melted. Since then, currents, waves and rivers have transported sediments from land into fjords and redistributed the sediments across the floor.

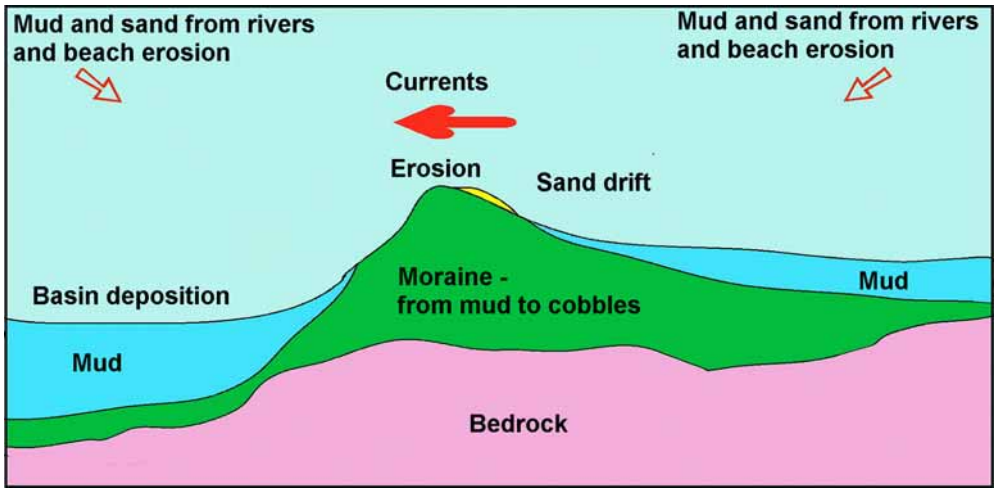


Figure 3. Processes forming the seafloor.

It is the current strength (Table 4), morphology of the sea floor and sediment grain size that determine what kind of sediment that will be deposited. If the current is strong, the sea bed is eroded and only smooth bedrock or large, heavy stones will be left behind. With decreasing

currents, finer grain sizes such as clay and silt will be deposited. By combining maps which show depth and substrate with other themes, such as fishing areas, information can be acquired on the preferred habitats of the various species.

Table 4. Current strength required to move various sediments on the seafloor (Li & Amos 2001).

Sediment type	Current strength required to move sediments on the seafloor
Clay	10 cm/sec
Silt	17.8 cm/sec
Shell sand	23.2 cm/sec
Fine sand	24.3 cm/sec
Medium sand	34 cm/sec
Coarse sand	52 cm/sec
Gravel	243 cm/sec

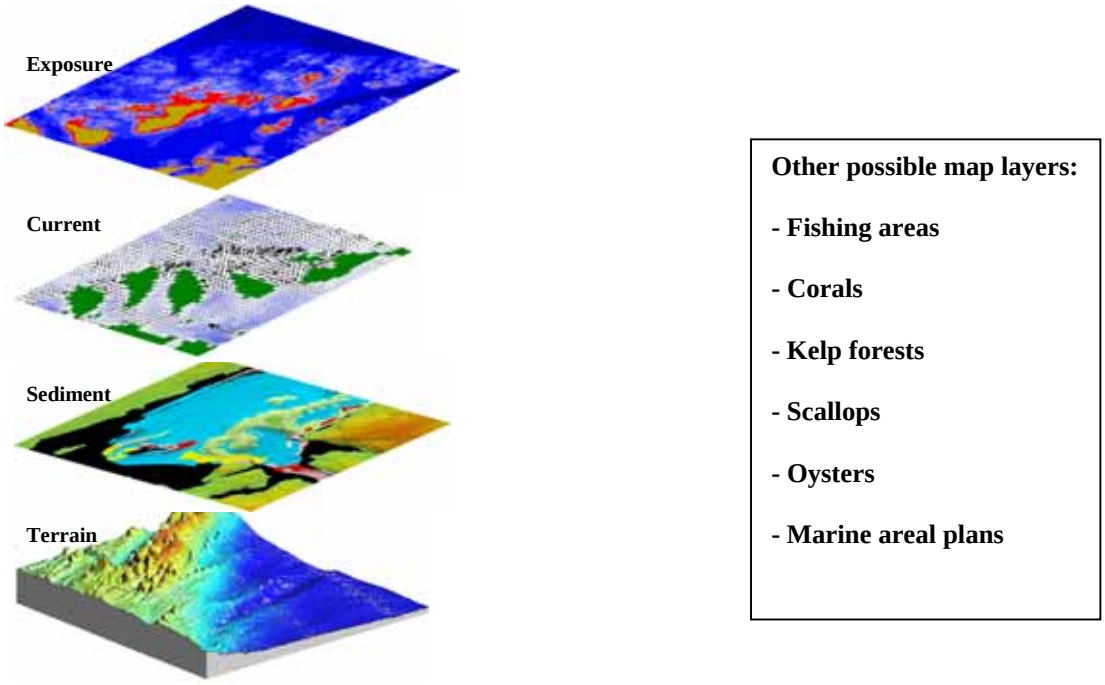


Figure 4. Principle for placing thematic maps layer on layer.

4 DATASETS AND PRESENTATION METHODS

4.1 Data

Data used in this project have been collected, processed and systematised in previous projects over the past years by several partners including NGU, the Defence Research Institute of Norway (FFI), the County Governor of Nord-Trøndelag (FMNT), Fosnes Municipality, the Directory of Fisheries (FiD), the Norwegian Mapping Authority (SK), local fishermen, Aqua Kompetanse A/S, Fish farming consultant Per Andersen and Marine Harvest A/S. Both vector and raster data formats were used in the project to represent features on the maps.

4.2 New products

Most of the data were collected during the HASUT-project in which NGU was heavily involved, or were sent to NGU/the AquaReg team as standardized and ready to use shape files. In the process of interpretation, the need for new datasets became obvious in order to present all the results on the thematic maps. For this purpose, Spatial Analyst and several other ArcGIS math and modelling tools were used, in addition to digitalization. To simplify the administration of data, small files with the same type of information were merged. Raster data sets with the original 3 m grid were re-sampled to 5 and 10 m grids to shorten the response time when sending requests to web-map servers.

Some maps/data sets are draped with data on sediment type/shaded relief multibeam bathymetry (geo-referenced tiff-images). This makes the relationship between various sediment types and morphological features obvious, and gives a more complete impression of the subaquous environment.

4.3 Map design

All maps were compiled using the ESRI software ArcGIS/ArcInfo. This software package provided a seamless work flow from creating and collecting the datasets to maps ready for print. Digital maps designed in ArcInfo are also well suitable for the web-map service established for presenting the maps on the Internet.

4.4 Preparing the maps for the web map service

One of the main goals of the Aquareg pilot study was to make basic marine data available and easily accessible for users, and a dedicated web map service "Marine base maps – coast" was created. This service consists of 10 thematic maps, for example "Sea floor sediments and natural habitats", which consists of several map layers, e.g. "Natural habitats", "Depths", "Sea floor sediments" etc. One layer can obtain data from one or many data sets containing the same thematic information. For example, layers with bathymetry raster data use three datasets with different grid sizes (3, 5 and 10 m), which dynamically change while zooming in or out. Similarly, the layer that shows depth contours becomes more detailed in close-up views. Background information such as coastlines, rivers, roads, elevations and geographical names shown on the maps are obtained from the SK and NGU map services.

The map service is built on an ArcIMS platform (ESRI), but its design and functionality has been adjusted to the NGU and MAREANO standards for presenting geographic information on Internet. The map service is made WMS compliant, which makes it possible for users of various GIS-software to use these maps in their own map services and applications.

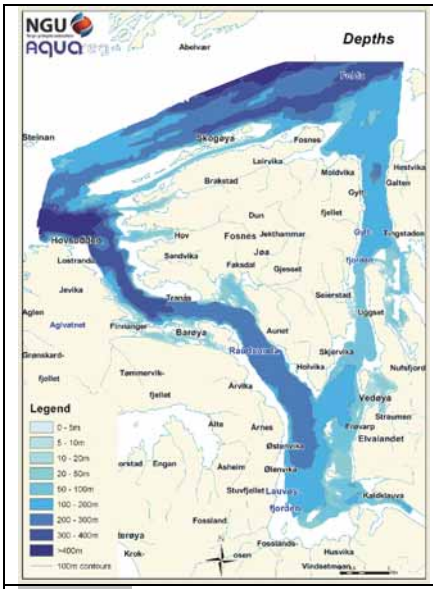
5 CONTENTS OF THE NEW MAPS

This chapter presents the maps with a short text explaining their themes. Examples are given how to use the maps, e.g. for fish farming, fishing, mapping biological diversity and planning- and management purposes.

Table 5. Maps made for the AquaReg pilot study www.mareano.no.

1	**Depths.**
2	**Slopes.**
3	**Seafloor sediments and natural habitats.**
4	**Strength of bottom currents interpreted from bottom morphology and sediment types.**
5	**Accumulation basins and areas with risk of oxygen deficiency.**
6	**Anchoring conditions – interpreted from bottom type and depth.**
7	**Seafloor sediments and biological diversity.**
8	**Fish habitats and spawning areas.**
9	**Fishing activity and aquaculture sites.**
10	**Fosnes Municipality area plan - sea.**

5.1 Depth



The map shows water depths in the coastal area of Fosnes. Zooming into a smaller area will reveal more details.

Useful for:

Fish farming: The map provides detailed bathymetric information for planning purposes. Sills, open passages, narrow passages, deep-water areas and shallow waters can easily be identified. By zooming in, more details will be available.

Fishery: Detailed bathymetry is of fundamental help for optimal use of fishing gear like gill nets and trawls and to avoid rough sea bottom. This information will reduce damage on gear and environment and lower the cost of fuel and time per catched kilo.

Marine biological diversity: Many species (e.g. fish, corals and kelp) and environmental qualities are dependent of certain depths and geotopes.

Coastal Zone planning and management: The map will be useful for a first identification of areas for fish farming, lobster cultivation, shell farming etc.

General information

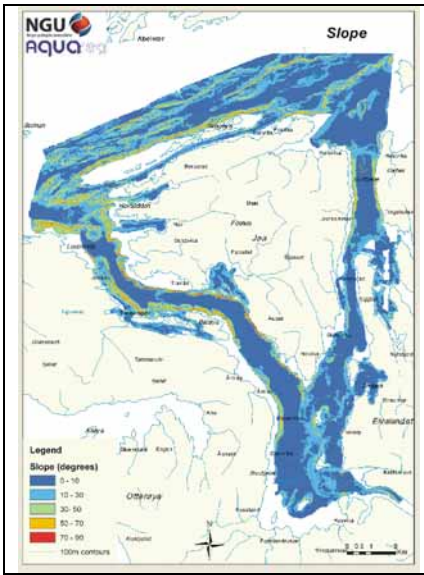
Sources: Areas if water depths >20 meters were mapped by the Norwegian Defence Research Establishment, while the Geological Survey of Norway surveyed the shallow areas (Longva et al. 2003)

Comments: There is generally one depth measurements for every 1-10 m^2 of the seafloor (except for a few shallow areas). Changes in depth of a few centimetres can be observed, however, in this first presentation, a very rough bathymetry, in different shades of blue, is shown.

Depth soundings were done with EM 1002 below 20 m water depth, and with GeoSwath interferometric sonar in shallower water. Areas without colour show no data. The grid size for most of the area is 10 m, but a few areas close to the shore are gridded at 1 m. A 50 m grid exists for the entire area, but is not shown here.

Technically, it is possible to show details with a depth accuracy of ca. 10 cm. The Norwegian Department of Defence provide rules for the use of detailed bathymetry for civil purposes in coastal areas. Some shallow areas in Fosnes were not mapped. In those areas, maps from the Norwegian Mapping Authority can be used.

5.2 Slopes



The map shows the slopes of the marine landscape varying from flat bottom areas to slopes up to 90 degrees.

Useful for:

Fish farming: Immediate impression of slopes for positioning of fish farms. Slope is important for the distribution of organic waste, anchoring etc.

Fishery: For some species, slopes are preferred habitats.

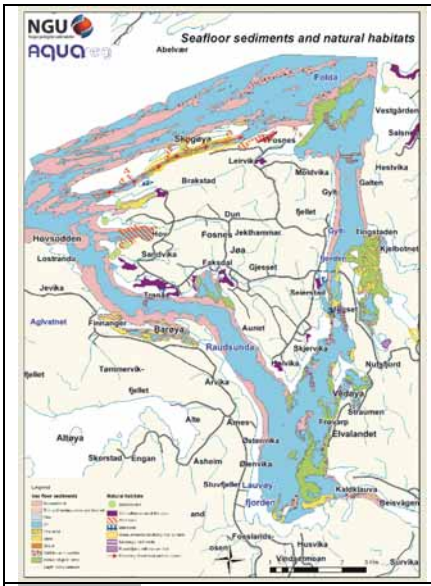
Marine biological diversity: For some species, slopes are preferred habitats. Corals are often found on edges connected with slopes, where they can feed on nourishing water. Kelp forests frequently occur on the upper parts of exposed slopes.

Coastal zone planning and management: Might use knowledge from fish farming, fishery and marine biological diversity in their plans.

General information

Sources: Areas if water depths >20 meters were mapped by the Norwegian Defence Research Establishment, while the Geological Survey of Norway surveyed the shallow areas (Longva et al. 2003).

5.3 Seafloor sediments and natural habitats



The map shows sediment and bottom types and physical qualities of the environment.

Useful for:

Fish farming: Combined with depth, sediment and bottom types tell where currents are strong and oxygen rich water abundant. This is important information for the identification of suitable sites for fish farms.

Fishery: Various species prefer specific habitats which relate closely to sediment and bottom types. When the relation between geology and fish is established locally, the sediment maps can be used directly for fishing purposes.

Marine biological diversity: This information is useful for precise and objective descriptions of areas, providing a good fundament for negotiations between different interests, e.g. marine activities versus protection.

Coastal Zone planning and management: The map provides information that can be used for management.

General information

Sources: Fosnes Municipality has been responsible for the collection and documentation of data. The County Governor in Nord-Trøndelag has standardized the data to SOSI-format (national standard) and made them available in GIS.

Comments: NGU has mapped the distribution of carbonate sand for large parts of the Norwegian coast. Examples of the data can be found at www.hordaland.no and a complete dataset will be presented at www.mareano.no by the end of 2005.

5.4 Strength of bottom currents interpreted from bottom morphology and sediment types

The map shows the strength of bottom current interpreted from bottom morphology and sediment types.

Useful for:

Fish farming: Planning of fish farm localities and design.

Fishery: Choice and design of fishing gear.

Marine biological diversity: Indication of species and their preference regarding current.

Coastal Zone planning and management: Gives an idea how organic matter is spread and deposited on a more regional basis e.g. related to fish farm waste or sewage outfalls.

General information

Sources: NGU

Comments: The map shows currents immediately above the bottom and not in the watercolumn as a whole. It is not made a quantitative classification of the strength of the current in this description, but it is referred to table 4 (Li, M.Z. and Amos, C.L.2001).

5.5 Accumulation basins and areas with a risk of oxygen deficiency

The map shows accumulation basins and areas with a risk of oxygen deficiency.

Accumulation basins are dominated by clayey and silty sediments and experience weak bottom currents. If they represent natural depressions on the sea floor, the renewal of bottom water may be so low that input of extra organic matter may result in reducing conditions.

Useful for:

Fish farming: In areas with a risk of oxygen deficiency, awareness must be taken when establishing large fish farms. Food waste and excrements from fish might accumulate so that anaerobic processes lead to production of H_2S. This gas might be poisonous if the concentration is high.

Fishery: In some of the areas showing risk of oxygen deficiency, also local spices of herring are localized.

Marine biological diversity: In some of the areas showing risk of oxygen deficiency, also local spices of herring are localized. (Information of fishing areas is also part of marine biological diversity).

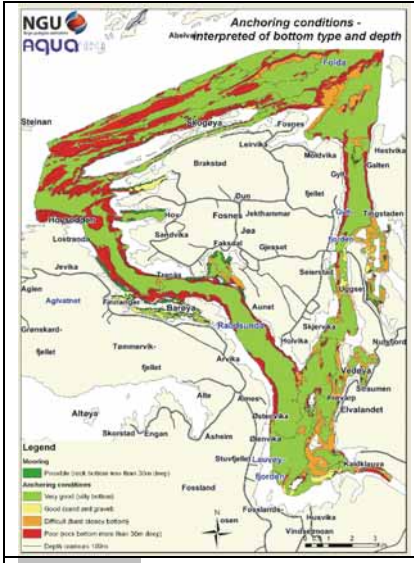
Coastal Zone planning and management: Surplus of organic matter, like wastes and sewage from households, industry and fish farms will accumulate, in areas with risk of oxygen deficiency. Therefore this information should be taken into account in planning processes, not to add extra activity extending organic pressure in sensitive areas. It is also important to valuate the currents in the areas, where outlets are located, to help predict if wastes will influence near by areas with risk for oxygen deficiency.

General information

Sources: Longva et al. (2003).

Comments: Per Andersen, the fish farmer consultant, confirms that areas with sediment traps experiencing fish farming activity in the past, were not suitable for fish farming.

5.6 Anchoring conditions – interpreted from bottom type and depth



The map shows anchoring conditions interpreted from bottom type and depth.

Marine installations, for instance fish farms (cages and fleets), depend on good mooring.

The text distinguishes between mooring and anchoring conditions. In this context, mooring means the possibility for divers to mount bolts directly into exposed bedrock, usually at depths less than 30 m. Anchoring conditions means the anticipated relative hold of anchors in the substrate.

Useful for:

Fish farming: Planning purposes for the localization of fish farms.

Fishery: Useful for port authorities.

Coastal Zone planning and management: Planning purposes and documentation.

General information

Source: NGU

5.7 Seafloor sediments and biological diversity

The map shows sediments and bottom types, physical environmental qualities and species that will be mapped by the municipalities in Norway within the next few years.

Useful for:

Fish farming: Plans for localization of aquaculture industrial facilities in relation to to valuable natural environment.

Fishery: Corals make good habitats for many species of fish, and knowledge of where they occur help to protect habitats and to make fishing more effective.

Marine biological diversity: The relationship between species and their habitats is important for management and science.

Coastal Zone planning and management: Knowledge about species, environmental qualities and habitats is important for the management of the coastal zone. Objective information makes it easier to verify verbal information, for instance about fishing areas, and to justify geographical boundaries in coastal zone management plans.

Science: Basal marine maps confirm a close relation between the substrate and the habitats of different species. This opens new possibilities to do research on stock behaviour and management and harvesting of marine resources**.** Related information can be found at www.niva.no under the project MarModell.

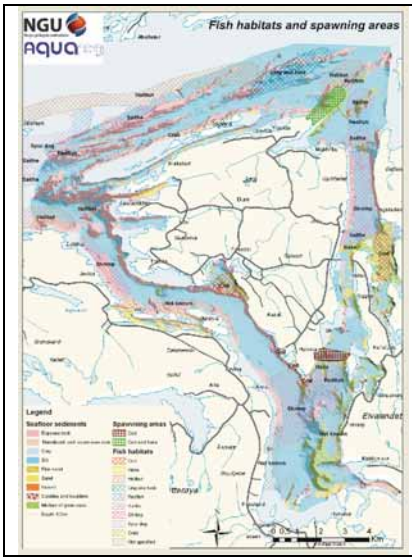
General information

Sources: Fosnes Municipality has been responsible for the collection and documentation of data. The County Governor in Nord-Trøndelag has standardized the data to SOSI-format (national standard) and made them available in GIS. Data on fishing areas, corals and kelp forests are supplied by the local fishermen. Local divers have provided information about scallops and merl-beds. Information on currents was provided by the aquaculture industry (documentation in applications for licences).

Comments

Fishing and spawning areas are mapped by the Directory of Fisheries. This information will also be used in connection with marine biological diversity registrations. Corals are not specified to species.

5.8 Fish habitats and spawning areas



The map shows fish-habitats and spawning areas combined with the sediment types.

Useful for:

Fish farming: Discussions on use of areas between fishermen, fish farmers and authorities.

Fishery: Understanding the relation between the distribution of species, their biology and their habitats. Makes fishing more effective for deployment of fishing gear.

Marine biological diversity: Fishery is part of the ongoing marine biological diversity registrations.

Coastal zone planning and management: Knowledge from fishermen, accumulated over generations, will be documented for the future in a database at the Directorate of Fisheries. By combining this information with sediment type information, it will be easier to manage areas for different purposes.

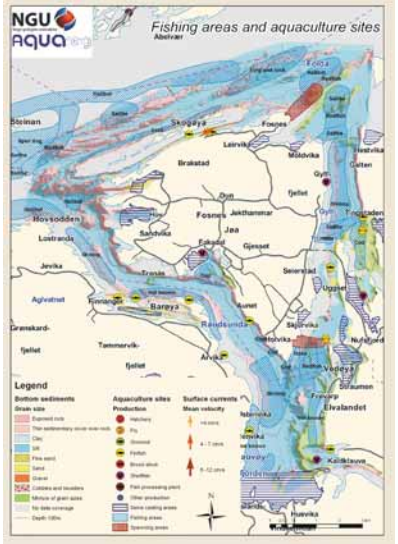
Science: By comparing fishing and spawning areas with bottom types, information on bottom preference by various species during different periods of their life cycle will be obtained. This can be modelled to identify new habitats for various species.

General information:

Sources: The Directory of Fishery in the region of Trøndelag collected the information on fishing and spawning areas**.** They interviewed local fishermen to obtain information on fishing areas in use until 15 years ago.

Comments:
Usually a map showing "fishing area" does not tell which species are found. In this study we were allowed to use more detailed information to demonstrate the value, both for management, science and commercial purposes. Even more detailed information on volumes, types of fisheries and fishing gear being used is held at the Directory of Fisheries. This information is not publicly available.

5.9 Fishing activity and aquaculture sites



The map shows fish habitats and spawning areas in the Fosnes area combined with allowances given for fish farming and other aquaculture activities.

Ocean current data from two fish-farming sites are shown on the map.

Useful for:

Fish farming: Identification of suitable areas for fish farming.

Fishery: Overview of the fishing activity in the area.

Coastal zone planning and management: The overview of fish farming sites and fishing and spawning areas is useful for planning and management purposes and preparedness (accidents, oil pollution etc.). By combining this information with sediment data, discussions between fishermen, fish farmers and others will have a higher level of precision. It will become easier to plan for the use/protection of areas. Geographical distance between activities is important for estimation of risk, pollution and danger of infections.

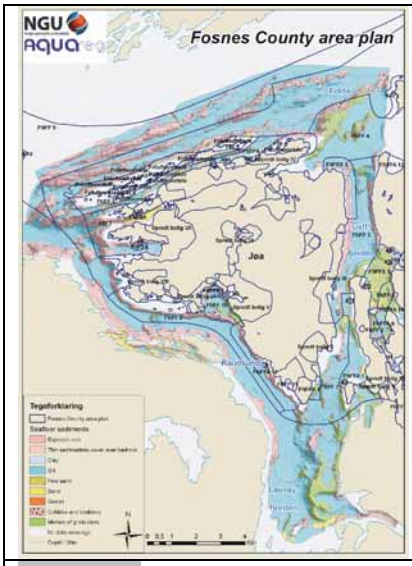
Other: The maps will be suitable for making models to judge risk for pollution and infections in an area.

General information

Sources: the Directory of Fishery in the region of Trøndelag has collected the information on fishing and spawning areas. Data on fish farming and other aquaculture activities comes from the Directory of Fishery in Bergen, available on www.fiskeridir.no Geographical positions refer to the centre of the fish farms.

Comments: Usually a map showing "fishing area" does not tell which species are found. In this study we were allowed to use more detailed information to demonstrate the value, both for management, science and commercial purposes. Even more detailed information on volumes, types of fisheries and fishing gear being used is held at the Directory of Fisheries. This information is not publicly available.

5.10 Fosnes Municipality area plan



The map shows the Fosnes Municipality area plan - sea, combined with sediment information.

The plan is under revision, and will be finished in April 2006.

Useful for:

Fish farming: By combining existing area plans with suitable areas for fish farming, it is possible to secure the best areas for the fish farming industry.

Fishery: It is important to maintain and develop fisheries and protect sensitive areas from other activities that may influence fishery- and spawning areas in a negative way.

Marine biological diversity: The new maps make it possible to be aware of the values identified.

Coastal zone planning and management: The area plan is the municipality's frame for prioritizing the use of areas over the next years.

General information

Source: Fosnes municipality.

Comments: The maps developed in this project will be used during the revision of the area plan for Fosnes.

6 EVALUATION OF FUNCTIONALITY AND CONTENT

The HASUT-project demonstrated the need for translating map information into simple thematic maps that can be used by the industry and for planning purposes. To ensure that this goal was reached in the AquaReg pilot project, a workshop was arranged in Fosnes 14 th of April 2005, in cooperation with Fosnes Municipality and the Innovation office of Midtre-Namdal. Most of the 27 participants involved in the HASUT- project attended the workshop. The participants represented fishery, fish farming, municipalities, the County Council of Nord-Trøndelag, the County Governor of Nord-Trøndelag, the AquaReg project, the Norwegian Food Safety Authority, the Norwegian Mapping Authority, the Norweigian Institute for Water Research, Aqua Kompetanse A/S and a fish farming consultant.

The workshop was arranged to present the maps and to get feedback on contents and functionalities. Ten thematic maps were presented to demonstrate how spatial seabed information (depths, sediment and bottom types, seabed structures) together with other GIS information can be used for planning and management purposes. It was also demonstrated and explained how the flexible web-system, were the maps will be released, might be used for special design of maps.

Fosnes municipality and the Innovation office of Midtre-Namdal added a session to the workshop discussing the possibilities for regional development in Namdalen, using all the information they have received through the HASUT- project and the AquaReg pilot study.

Figure 5. Workshop in Fosnes. From the left: Kjell Tranås (Innovation Office of Midtre Namdal), Kristian Julien (County Governor of Nord-Trøndelag), Geir Risvik (Flatanger Municipality) and Kjellrun Moan (Fosnes Municipality).

At the workshop the project got useful feed back on the contents and design of the maps. The web system for presentations and the ease that the maps can be used or combined with other data was highly approved. The feedback is now as far as possible included into the maps and they are distributed on the web at www.mareano.no.

The participants agreed on the selection of themes chosen for the maps. The most important feedback from the workshop was:

- The new thematic maps (depths, sediments and bottom types, seabed structures and processes) were important for all end users, and useful for different purposes.
    - Fish farming: Identifying optimal locations for fish farms.
    - Fishery: Identifying habitats of different fish species.
    - Marine biological diversity: Identifying habitats of different marine organisms, e.g. corals, kelp forests and scallops.
    - Planning and management purposes: Identifying marine areas and qualities necessary for Integrated Coastal Zone Management.

The workshop also concluded that beyond the themes that was dealt with there is a need for thematic maps showing:

- Current through the water column for all the fish farming sites.
- Environmental conditions from fish farms (MOM).

- Areas used by fish farms (not only a point showing the centre position of the fish farms)
- Fish farm bottom anchoring positions.

7 SUMMARY AND CONCLUSIONS

- The information needed for Integrated Coastal Zone Planning and Management (ICZPM) comes from several sources (e.g. municipalities, regional authorities, Directory of Fisheries, the Geological Survey) and cover different disciplines. Integrated GIS and knowledge systems, like www.mareano.no, are crucial.
- Thematic maps (depths, sediment and bottom types, bottom structures and processes, current conditions, slopes, accumulation basins) are useful for planning purposes, aquaculture and fishery activities, and for environmental care in the coastal zone.
- Geological maps need to be interpreted and refined as thematic maps.
- Maps need to be carefully designed to allow non-professionals to understand them.
- Integrated maps available on user-friendly web/GIS systems open new opportunities to develop specially designed maps.
- The information must be used actively and developed further by fish farmers, authorities and scientists.
- There is a need for active participation from the management to build competence and systems to utilize the new data.
- Documenting experience from use of the new data will help others in need for detailed information on their marine areas.
- Exchange of experience with others (e.g. partner in AquaReg) will help to further develop maps and systems.

8 REFERENCES

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Andresen, K.H.B. 2004a: Arealdataprosjektet, Sluttrapport HASUT, 25 p. www.hasut.no.

Andresen, K.H.B. 2004b: Nye Marine Grunnkart, Sluttrapport HASUT, 42 p. www.hasut.no.

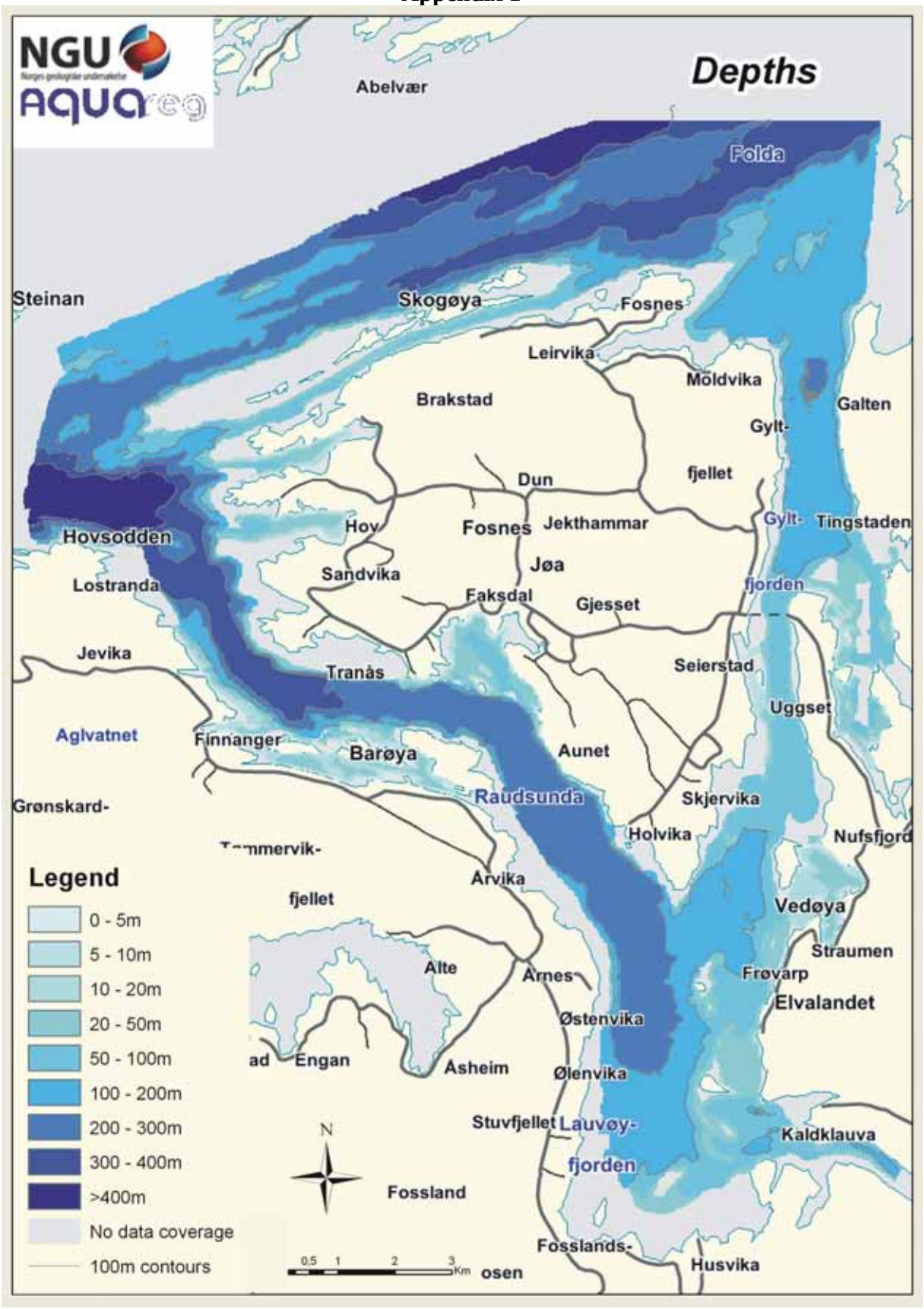
Li, M.Z. & Amos, C.L. 2001: SEDTRANS96: the upgraded and better calibrated sediment-transport model for continental shelves. *Computers & Geosciences 27*, 619-645.

Longva, O., Christensen, O., Dahl, J.A. & O. Totland, O. 2003. HASUT-prosjektet i Fosnes og Flatanger; djupner, seismikk, prøvetaking og video-opptak, toktrapport og tolkning av botntyper. *NGU rapport 2003.095*, 26 p.

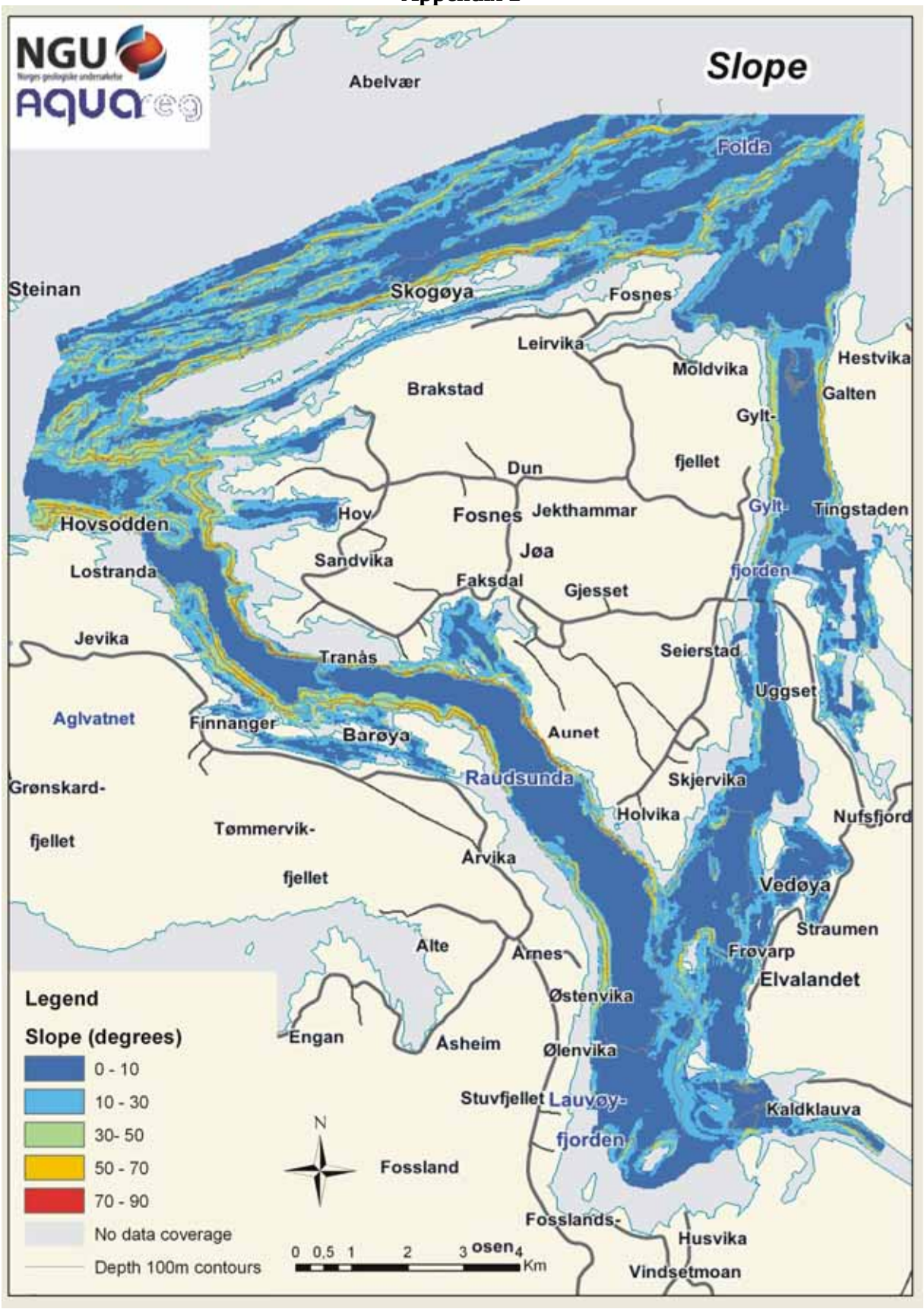
Sandberg, J.H. 2004: Hovedrapport for HASUT-prosjektet 2001-2004, 58 p. www.hasut.no.

Sandnes, O.K. 2004: Samlokaliseringsprosjektet. Hvordan påvirker samlokaliserte lakse- og skjellanlegg hverandre med hensyn til vannkvalitet og vanntransport? Sluttrapport HASUT, 17 p. www.hasut.no.

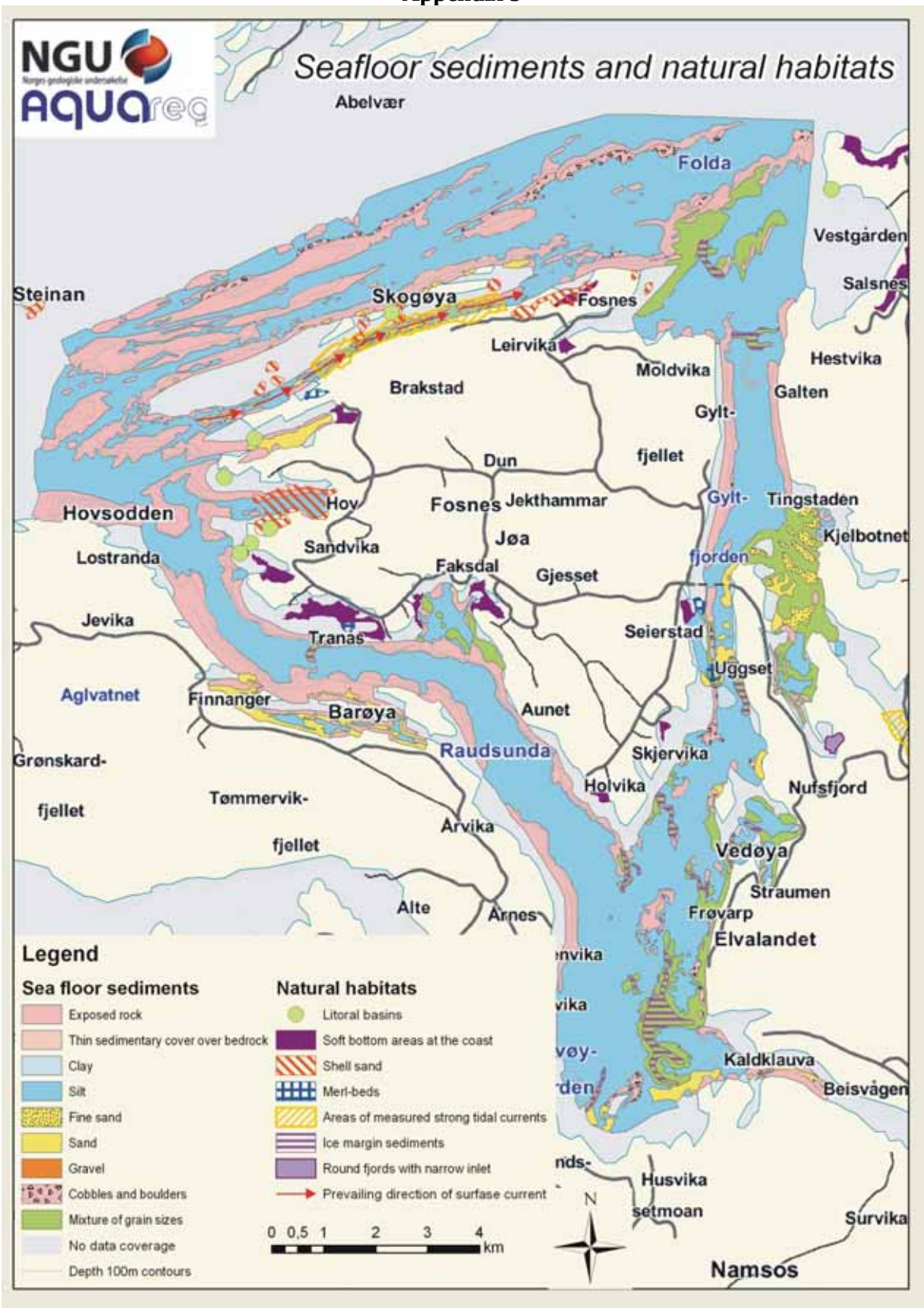
Appendix 1


NGU
Aquareg
Depths
Abelvær
Folda
Steinan
Skogøya
Fosnes
Leirvika
Moldvika
Brakstad
Galten
Gylt-
fjellet
Dun
Hov
Fosnes
Jekthammar
Gylt-
Tingstaden
Hovsodden
Jøa
Sandvika
Lostranda
fjorden
Faksdal
Gjesset
Jevika
Tranås
Seierstad
Uggset
Aglvatnet
Finnanger
Barøya
Aunet
Raudsunda
Skjervika
Grønskard-
Holvika
Nufsfjord
Arvika
Legend
fjellet
Vedøya
0 - 5m
5 - 10m
Straumen
Alte
Arnes
Frøvarp
10 - 20m
Elvalandet
20 - 50m
Østenvika
50 - 100m
Engan
Asheim
Ølenvika
100 - 200m
Stuvfjellet
Lauvøy-
Kaldklauva
200 - 300m
fjorden
300 - 400m
N
Fossland
>400m
No data coverage
Fosslands-
100m contours
Husvika
0.5 1 2 3 Km
osen

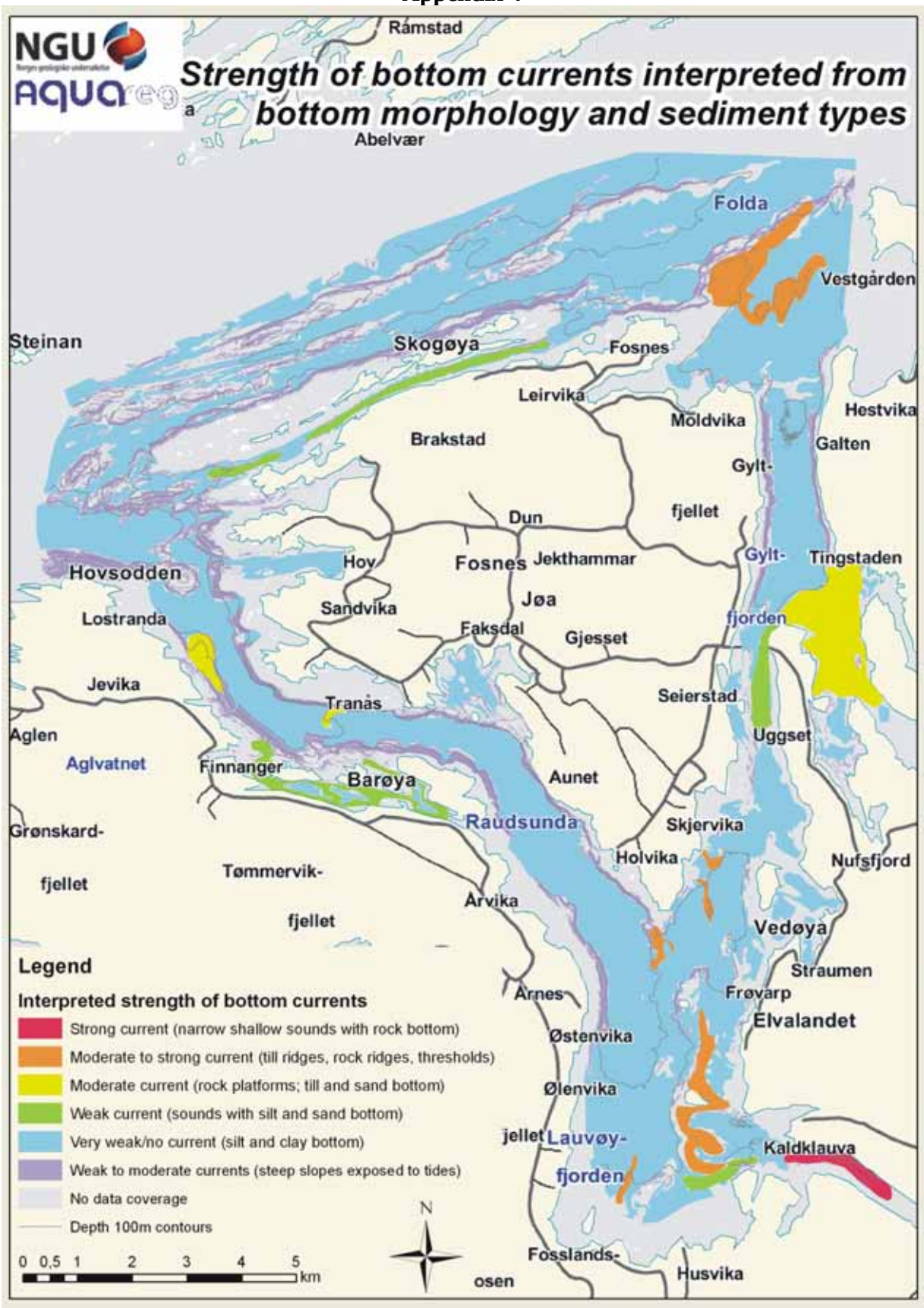
Appendix 2


NGU
Aquareg
Slope
Abelvær
Folda
Steinan
Skogøya
Fosnes
Leirvika
Hestvika
Møldvika
Brakstad
Galten
Gylt-
fjellet
Dun
Hov
Fosnes
Jekthammar
Gylt-
Tingstaden
Hovsodden
Jøa
Sandvika
Lostranda
fjorden
Faksdal
Gjesset
Jevika
Seierstad
Tranås
Uggset
Aglvatnet
Finnanger
Barøya
Aunet
Raudsunda
Skjervika
Grønskard-
Holvika
Nufsfjord
Tømmervik-
fjellet
Arvika
fjellet
Vedøya
Straumen
Alte
Arnes
Frøvarp
Elvalandet
Østenvika
Engan
Asheim
Ølenvika
Stuvfjellet
Lauvøy-
Kaldklauva
fjorden
N
Fossland
Fosslands-
Husvika
0 0,5 1 2 3 4 Km
osen
Vindsetmoan
Legend
Slope (degrees)
0 - 10
10 - 30
30- 50
50 - 70
70 - 90
No data coverage
Depth 100m contours

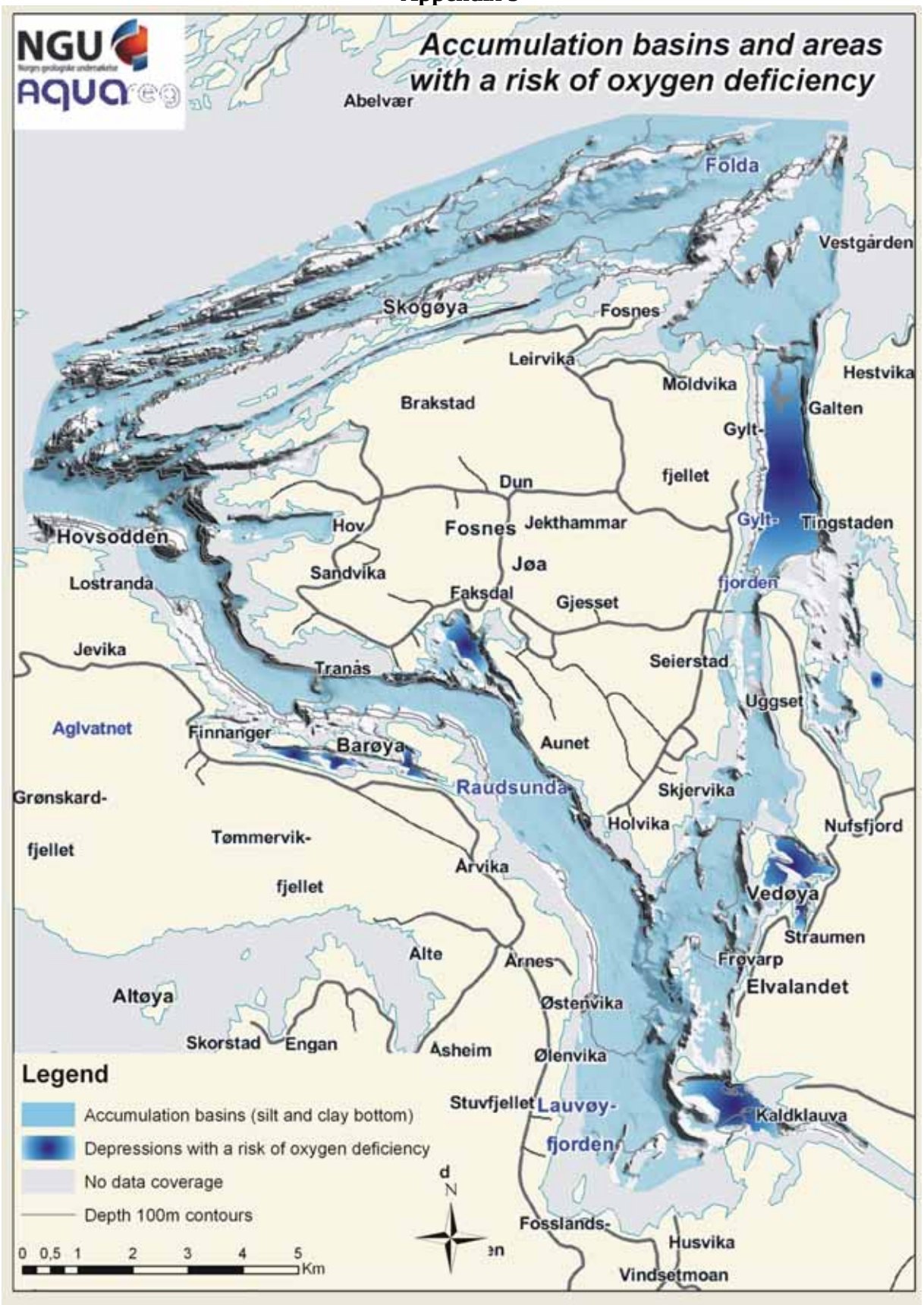
Appendix 3


NGU
Aquareg
Seafloor sediments and natural habitats
Abelvær
Folda
Vestgården
Steinan
Skogøya
Fosnes
Salsnes
Leirvika
Hestvika
Moldvika
Brakstad
Galten
Gylt-
fjellet
Dun
Hov
Fosnes
Jekthammar
Gylt-
Tingstaden
Hovsodden
Kjelbotnet
Sandvika
Jøa
Lostranda
fjorden
Faksdal
Gjesset
Jevika
Seierstad
Tranas
Uggset
Aglvatnet
Finnanger
Barøya
Aunet
Raudsunda
Skjervika
Grønskard-
Holvika
Nufsfjord
Tømmervik-
fjellet
Arvika
fjellet
Vedøya
Straumen
Alte
Arnes
Frøvarp
Elvalandet
Legend
Sea floor sediments
Exposed rock
Thin sedimentary cover over bedrock
Clay
Silt
Fine sand
Sand
Gravel
Cobbles and boulders
Mixture of grain sizes
No data coverage
Depth 100m contours
Natural habitats
Litoral basins
Soft bottom areas at the coast
Shell sand
Merl-beds
Areas of measured strong tidal currents
Ice margin sediments
Round fjords with narrow inlet
Prevailing direction of surfase current
0 0,5 1 2 3 4 km
N
Kaldklauva
Beisvågen
Husvika
setmoan
Survika
Namsos

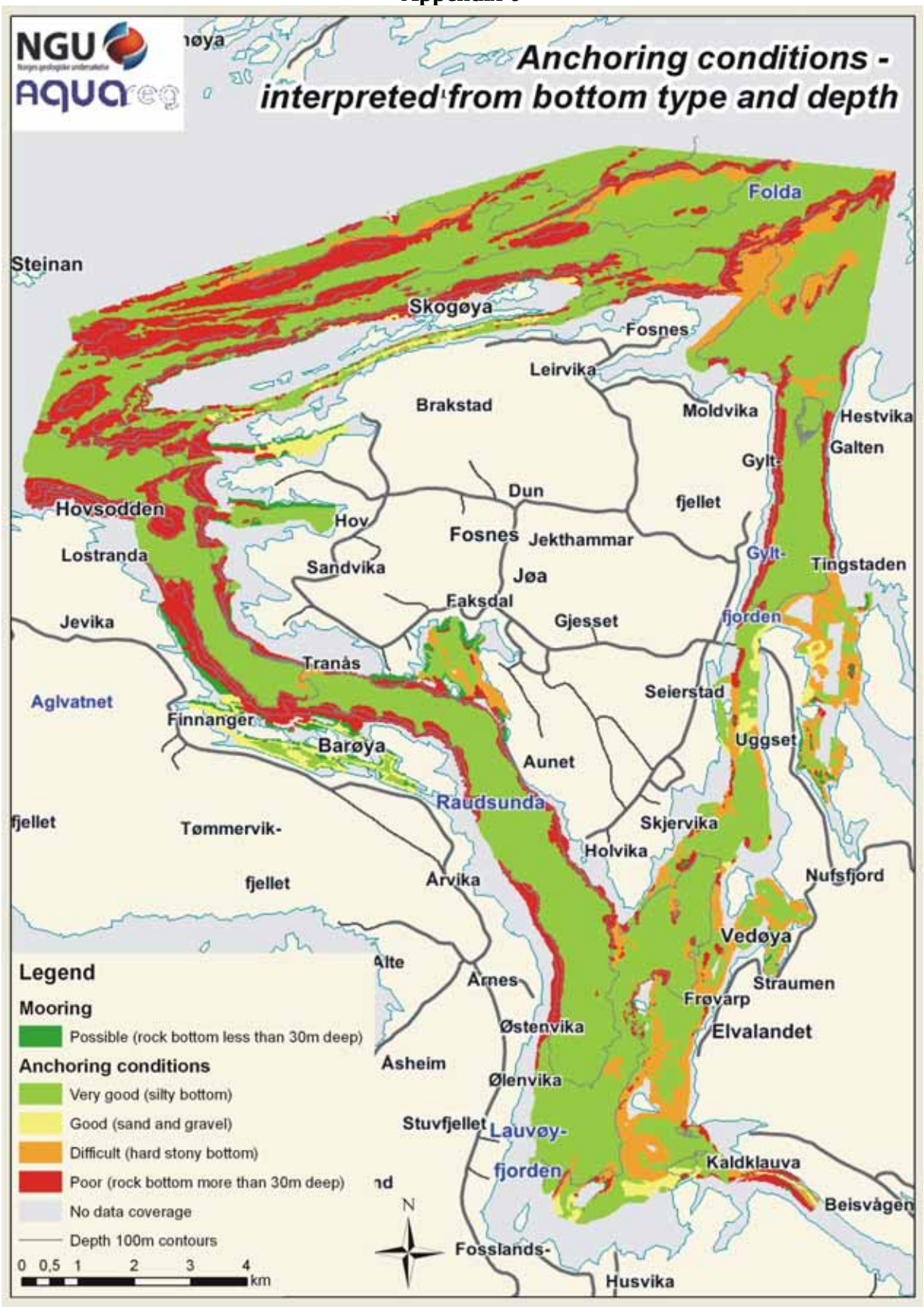
Appendix 4


NGU
AquaReg
Strength of bottom currents interpreted from bottom morphology and sediment types
Ramstad
Abelvær
Folda
Vestgården
Steinan
Skogøya
Fosnes
Leirvika
Møldvika
Hestvika
Brakstad
Galten
Gylt-
fjellet
Dun
Hov
Fosnes
Jekthammar
Gylt-
Tingstaden
Hovsodden
Sandvika
Jøa
Lostranda
Faksdal
Gjesset
fjorden
Jevika
Tranås
Seierstad
Aglen
Uggset
Aglvatnet
Finnanger
Barøya
Aunet
Raudsunda
Skjervika
Grønskard-
Holvika
Nufsfjord
Tømmervik-
fjellet
Arvika
fjellet
Vedøya
Straumen
Legend
Arnes
Frøvarp
Interpreted strength of bottom currents
Elvalandet
Strong current (narrow shallow sounds with rock bottom)
Østenvika
Moderate to strong current (till ridges, rock ridges, thresholds)
Ølenvika
Moderate current (rock platforms; till and sand bottom)
jellet
Lauvøy-
Kaldklauva
Weak current (sounds with silt and sand bottom)
fjorden
Very weak/no current (silt and clay bottom)
Weak to moderate currents (steep slopes exposed to tides)
No data coverage
N
Depth 100m contours
Fosslands-
0 0,5 1 2 3 4 5
km
osen
Husvika

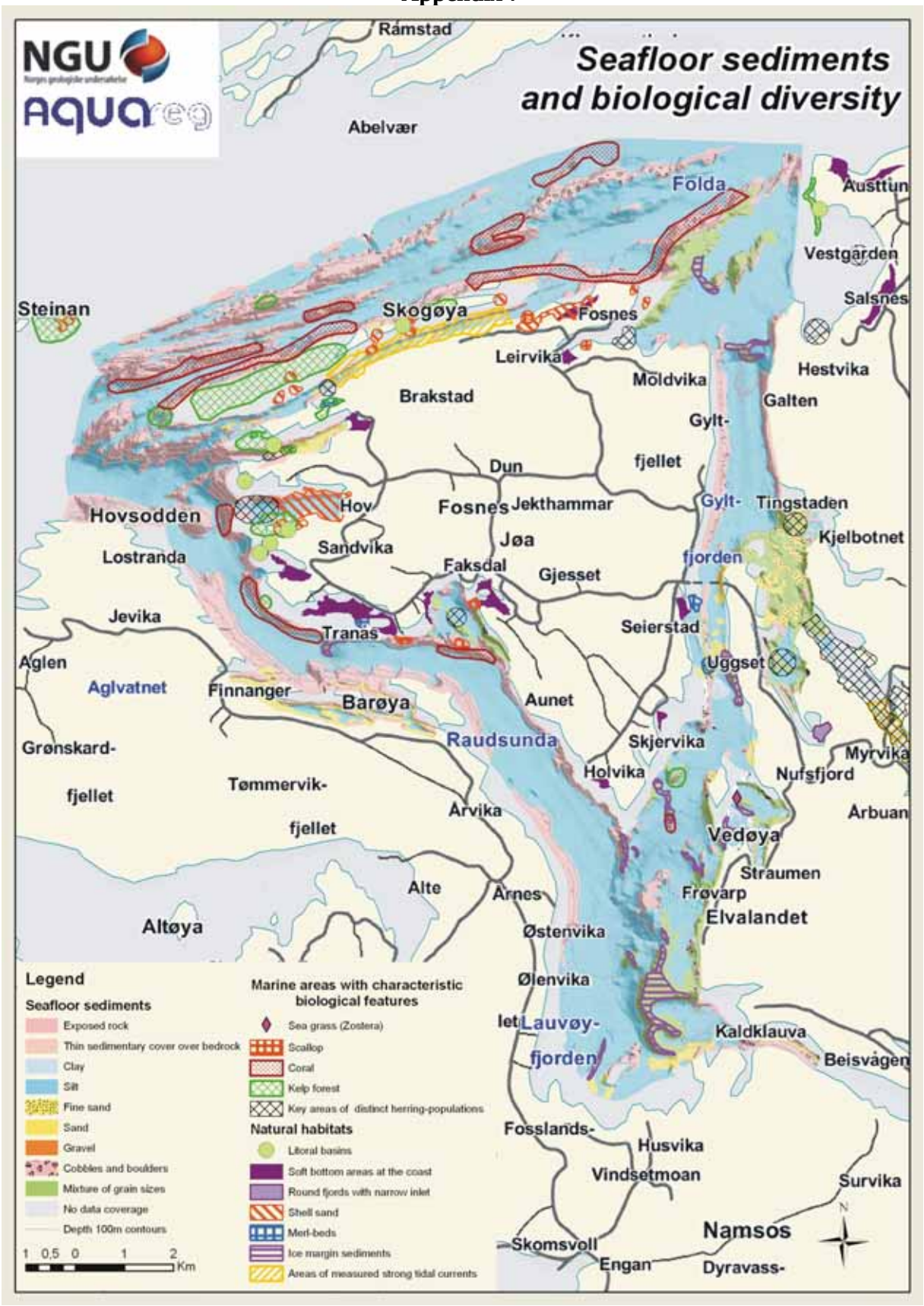
Appendix 5


NGU
aquareg
Accumulation basins and areas with a risk of oxygen deficiency
Abelvær
Folda
Vestgården
Skogøya
Fosnes
Leirvika
Hestvika
Moldvika
Brakstad
Galten
Gylt-
fjellet
Dun
Hov
Fosnes
Jekthammar
Gylt-
Tingstaden
Hovsodden
Sandvika
Jøa
Lostranda
fjorden
Faksdal
Gjesset
Jevika
Seierstad
Tranås
Uggset
Aglvatnet
Finnanger
Barøya
Aunet
Raudsunda
Skjervika
Grønskard-
Holvika
Nufsfjord
Tømmervik-
fjellet
Arvika
fjellet
Vedøya
Straumen
Alte
Arnes
Frøvarp
Elvalandet
Altøya
Østenvika
Skorstad
Engan
Asheim
Ølenvika
Legend
Stuvfjellet
Lauvøy-
Kaldklauva
Accumulation basins (silt and clay bottom)
fjorden
Depressions with a risk of oxygen deficiency
No data coverage
Depth 100m contours
Fosslands-
Husvika
0 0,5 1 2 3 4 5 Km
Vindsetmoan

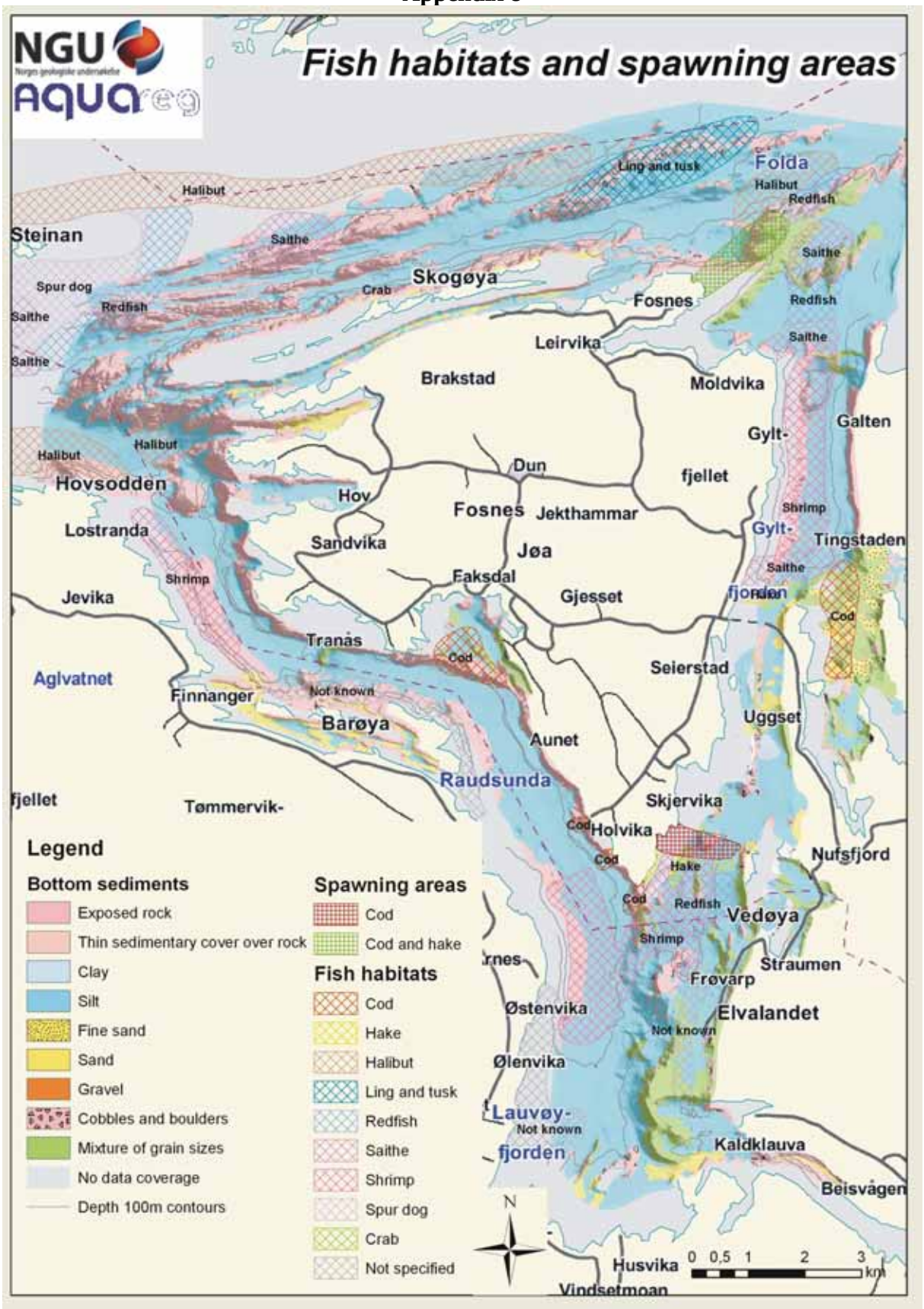
Appendix 6


NGU
AquaReg
Anchoring conditions -
interpreted from bottom type and depth
Folda
Steinan
Skogøya
Fosnes
Leirvika
Brakstad
Moldvika
Hestvika
Galten
Gylt-
fjellet
Dun
Hovsodden
Hov
Fosnes
Jekthammar
Lostranda
Sandvika
Jøa
Gylt-
Tingstaden
Faksdal
Jevika
Gjesset
fjorden
Tranås
Seierstad
Aglvatnet
Finnanger
Barøya
Uggset
Aunet
Raudsunda
fjellet
Tømmervik-
Skjervika
Holvika
fjellet
Arvika
Nufsfjord
Vedøya
Ålte
Straumen
Arnes
Frøvarp
Østenvika
Elvalandet
Åsheim
Ølenvika
Stuvfjellet
Lauvøy-
fjorden
Kaldklauva
Beisvågen
Fosslands-
Husvika
N
Legend
Mooring
Possible (rock bottom less than 30m deep)
Anchoring conditions
Very good (silty bottom)
Good (sand and gravel)
Difficult (hard stony bottom)
Poor (rock bottom more than 30m deep)
No data coverage
Depth 100m contours
0 0,5 1 2 3 4
km

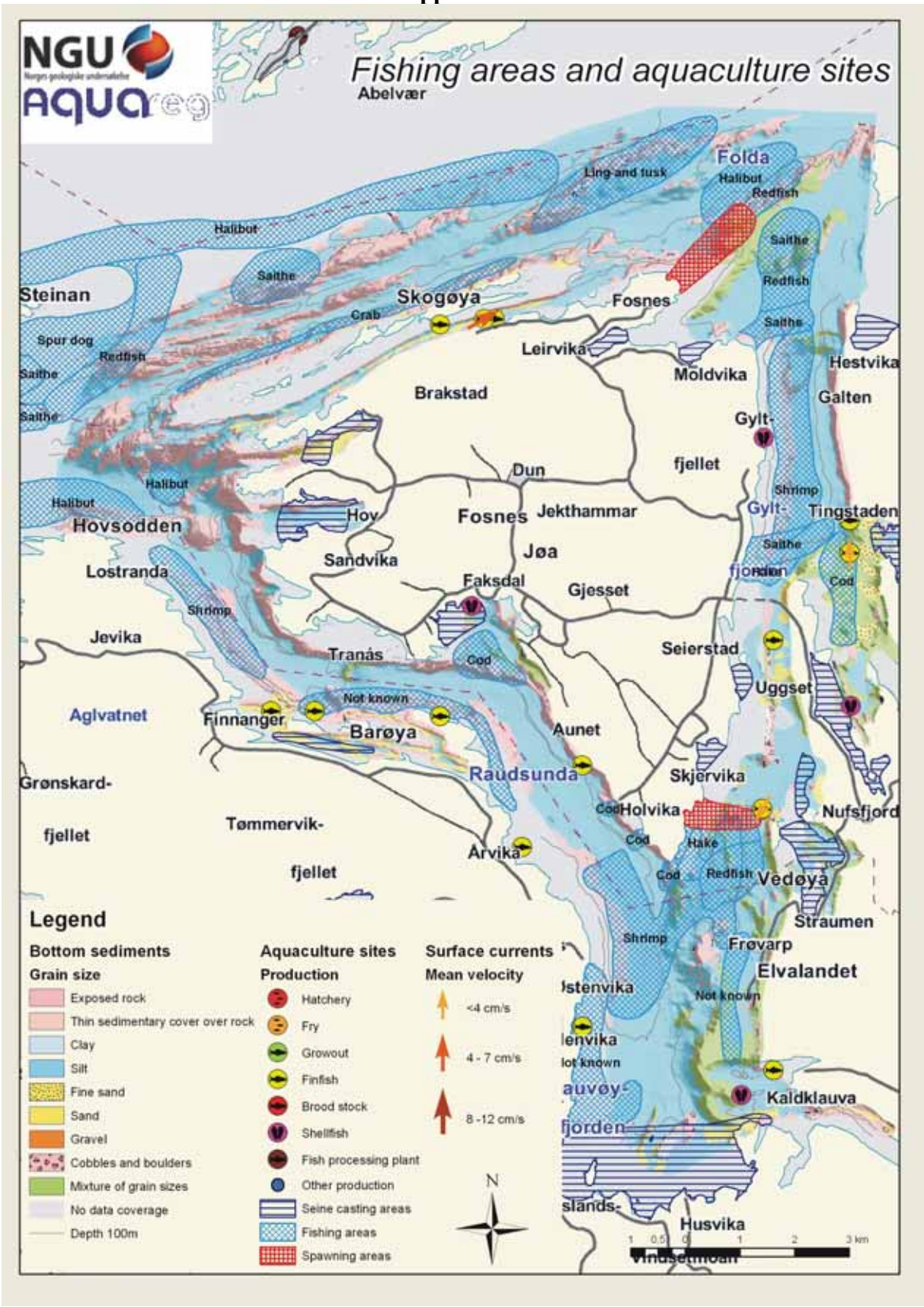
Appendix 7


NGU
Aquareg
Seafloor sediments and biological diversity
Rømstad
Abelvær
Folda
Austtun
Vestgarden
Salsnes
Steinan
Skogøya
Fosnes
Leirvika
Hestvika
Moldvika
Brakstad
Galten
Gylt-
fjellet
Dun
Hov
Fosnes
Jekthammar
Gylt-
Tingstaden
Hovsodden
Kjelbotnet
Sandvika
Jøa
Lostranda
Faksdal
Gjesset
fjorden
Jevika
Tranas
Seierstad
Aglen
Uggset
Aglvatnet
Finnanger
Barøya
Aunet
Raudsunda
Skjervika
Grønskard-
Myrvika
Holvika
Nufsfjord
Tømmervik-
fjellet
Arvika
Arbuan
fjellet
Vedøya
Straumen
Alte
Arnes
Frøvarp
Elvalandet
Altøya
Østenvika
Ølenvika
Lauvøy-
Kaldklauva
fjorden
Beisvågen
Fosslands-
Husvika
Vindsetmoan
Survika
Namsos
Skomsvoll
Engan
Dyravass-
Legend
Seafloor sediments
Exposed rock
Thin sedimentary cover over bedrock
Clay
Silt
Fine sand
Sand
Gravel
Cobbles and boulders
Mixture of grain sizes
No data coverage
Depth 100m contours
1 0.5 0 1 2 Km
Marine areas with characteristic biological features
Sea grass (Zostera)
Scallop
Coral
Kelp forest
Key areas of distinct herring-populations
Natural habitats
Litoral basins
Soft bottom areas at the coast
Round fjords with narrow inlet
Shell sand
Merl-beds
Ice margin sediments
Areas of measured strong tidal currents
N

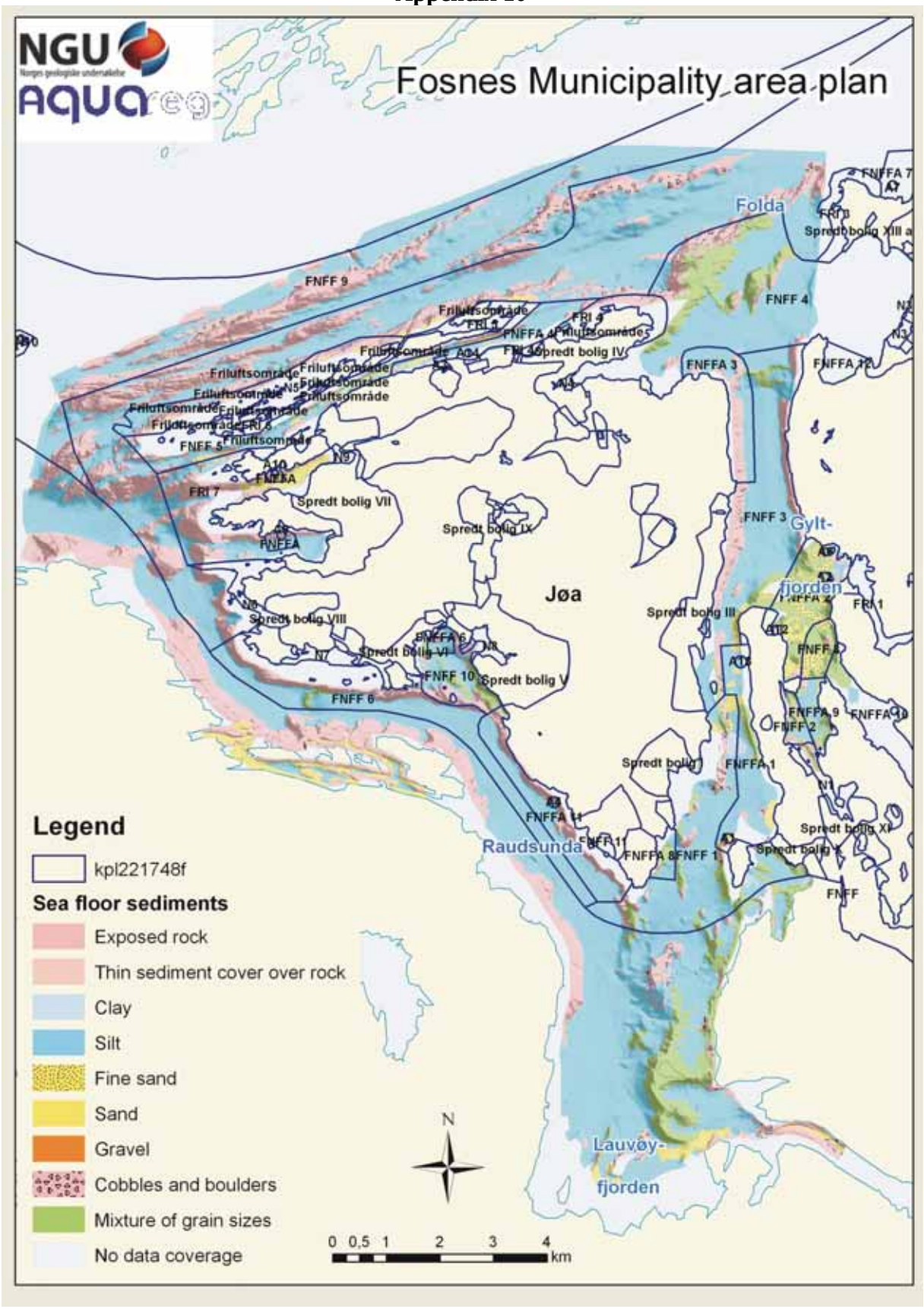
Appendix 8


NGU
Norges geologiske undersøkelse
AquaReg
Fish habitats and spawning areas
Halibut
Ling and tusk
Folda
Halibut
Redfish
Steinan
Saithe
Saithe
Spur dog
Redfish
Saithe
Crab
Skogøya
Fosnes
Redfish
Saithe
Saithe
Leirvika
Brakstad
Moldvika
Galten
Gylt-
Halibut
Halibut
Hovsodden
Dun
fjellet
Hov
Fosnes
Jekthammar
Shrimp
Lostranda
Sandvika
Gylt-
Tingstaden
Jøa
Saithe
Shrimp
Faksdal
Jevika
Gjesset
fjorden
Cod
Tranås
Cod
Seierstad
Aglvatnet
Finnanger
Not known
Barøya
Uggset
Aunet
Raudsunda
fjellet
Tømmervik-
Skjervika
Cod
Holvika
Nufsfjord
Cod
Hake
Cod
Redfish
Vedøya
Shrimp
Straumen
Frøvarp
Østenvika
Elvalandet
Not known
Ølenvika
Lauvøy-
Not known
fjorden
Kaldklauva
Beisvågen
Husvika
Vindsetmoan
N
0 0,5 1 2 3
km
Legend
Bottom sediments
Exposed rock
Thin sedimentary cover over rock
Clay
Silt
Fine sand
Sand
Gravel
Cobbles and boulders
Mixture of grain sizes
No data coverage
Depth 100m contours
Spawning areas
Cod
Cod and hake
Fish habitats
Cod
Hake
Halibut
Ling and tusk
Redfish
Saithe
Shrimp
Spur dog
Crab
Not specified

Appendix 9


NGU
Aquareg
Fishing areas and aquaculture sites
Abelvær
Folda
Halibut
Redfish
Ling and tusk
Saithe
Halibut
Steinan
Saithe
Skogøya
Crab
Fosnes
Redfish
Saithe
Spur dog
Redfish
Saithe
Leirvika
Moldvika
Hestvika
Galten
Brakstad
Saithe
Gylt-
fjellet
Dun
Halibut
Shrimp
Halibut
Hov
Fosnes
Jekthammar
Gylt-
Tingstaden
Hovsodden
Saithe
Sandvika
Jøa
Lostranda
Faksdal
Gjesset
Cod
Shrimp
Jevika
Tranås
Cod
Seierstad
Uggset
Not known
Aglvatnet
Finnanger
Barøya
Aunet
Grønskard-
Raudsunda
Skjervika
Cod
Holvika
Nufsfjord
fjellet
Tømmervik-
Hake
Arvika
Cod
Redfish
Vedøya
fjellet
Straumen
Shrimp
Frøvarp
Elvalandet
Not known
Husvika
Kaldklauva
Legend
Bottom sediments
Grain size
Exposed rock
Thin sedimentary cover over rock
Clay
Silt
Fine sand
Sand
Gravel
Cobbles and boulders
Mixture of grain sizes
No data coverage
Depth 100m
Aquaculture sites
Production
Hatchery
Fry
Growout
Finfish
Brood stock
Shellfish
Fish processing plant
Other production
Seine casting areas
Fishing areas
Spawning areas
Surface currents
Mean velocity
<4 cm/s
4 - 7 cm/s
8 -12 cm/s
N
1 0.5 0 1 2 3 km

Appendix 10


NGU
Norges geologiske undersøkelse
Aquareg
Fosnes Municipality area plan
Folda
Jøa
Gylt-
fjorden
Raudsunda
Lauvøy-
fjorden
Spredt bolig I
Spredt bolig II
Spredt bolig III
Spredt bolig IV
Spredt bolig V
Spredt bolig VI
Spredt bolig VII
Spredt bolig VIII
Spredt bolig IX
Spredt bolig X
Spredt bolig XI
Spredt bolig XIII a
FNFF 1
FNFF 2
FNFF 3
FNFF 4
FNFF 5
FNFF 6
FNFF 7
FNFF 8
FNFF 9
FNFF 10
FNFF 11
FNFFA 1
FNFFA 2
FNFFA 3
FNFFA 4
FNFFA 5
FNFFA 6
FNFFA 7
FNFFA 8
FNFFA 9
FRI 1
FRI 2
FRI 3
FRI 4
FRI 5
FRI 6
FRI 7
Friluftsområde
Legend
kpl221748f
Sea floor sediments
Exposed rock
Thin sediment cover over rock
Clay
Silt
Fine sand
Sand
Gravel
Cobbles and boulders
Mixture of grain sizes
No data coverage
N
0 0,5 1 2 3 4
km

Appendix 11

AGREEMENT

BETWEEN

SØR-TRØNDELAG FYLKESKOMMUNE (STFK)

AND

NORGES GEOLOGISKE UNDERSØKELSE (NGU)

1. This agreement covers the sub-contracting of services by NGU in the AquaReg sub-project CZM (Coastal Zone Management), ID 1-05 AP. AquaReg is an INTERREG IIIC RFO operation partly-financed by the European Commission

2. NGU's task is to manage and carry forward part of the PILOT STUDY for Trøndelag region as described in the original application. The work shall be carried out in close cooperation with STFK, the regional coordinator for Trøndelag (Fiskeridirektoratet Trøndelag region), Fosen Regional Council and in accordance with the objectives expressed in the original application and in the annexed PILOT STUDY description (WP3) dated January 6th 2005.

3. Detailed budget for the PILOT STUDY is described in the here above referred to document (AquaReg Pilot Study -(WP3- Description) annexed to this agreement. The total budget for the PILOT STUDY is 47 500 Euro. It is agreed that NGU's own financial contribution to the project's budget will amount to 23750 Euros.

4. STFK financial contribution will amount to 23 750 Euros, payable in two (2) instalments. The first instalment of 19 000 Euros (or 80 % of the contract amount) will be invoiced on 1st of June 2005 and the second instalment of 4 750 Euros (20%) will be invoiced on 1st July 2005. Invoices are payable within 30 days of receipt.

5. The Project's contact person for NGU will be Kari Helene Bachke Andresen (Postboks 7491 Trondheim, tel: 73904276; e-mail: Kari.helene.andresen@ngu.no) and Geir Tevasvold (Sør-Trøndelag fylkeskommune, Postuttak, 7004; tel: 97710719 ; e-mail: Geir.tevasvold@stfk.no) will be the contact person for STFK.

Trondheim, 13 January 2005

for Norges geologiske undersøkelse

Terje Thorsnes
Programme Manager

for Sør-Trøndelag fylkeskommune

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