

Site surveys at Norwegian aquaculture sites

Methodologies for wave estimations

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PROBLEM / QUESTION

Advances in aquaculture has led to a need for renewing legislation and technical standards comprising aquaculture installations. Statutory site surveys in Norwegian waters include wave estimations at aquaculture sites based on NS9415:2009, where met-ocean conditions are reported to the authorities in the NYTEK scheme. Wave estimation methods and possible causes of deviation between methodologies have been analyzed.

Site surveys are today done in one single point, although installations (incl. moorings) can extend 2-3 km². As new cage designs are planned, the demand for precise wave estimation methods are rising. A feasibility study concerning spatial variations of wave conditions within an aquaculture site has been carried out. This included commencement of wave data collection and assumptions required for further studies of spatial variations of met-ocean conditions at aquaculture sites.

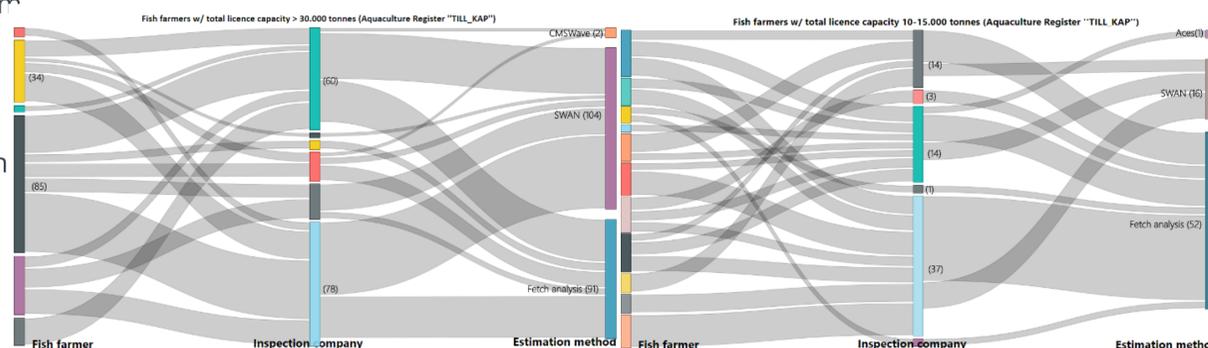
RESOURCES / COLLABORATORS

- Directorate of Fisheries: met-ocean data from site surveys for all Norwegian aquaculture sites
- SINTEF Ocean: full-scale measurements of linear acceleration from April 11th-May 8th at Hosenøyen
- Results from fetch length analysis ("simple" methodology based on wind) for all Norwegian aquaculture sites by Lader et al. 2017

PROCEDURE

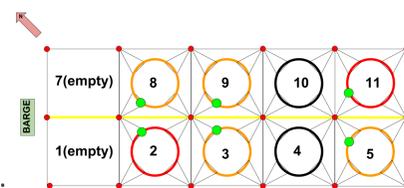
Data sets for qualitative analysis have been build up by (occasionally insufficient) met-ocean information from site surveys in Norway, and combined with publicly available information about aquaculture sites.

Assumptions for reviewing wave conditions based on acceleration measurements of multiple floating ring collars are determined. Procedures for processing data from full scale measurements are established.

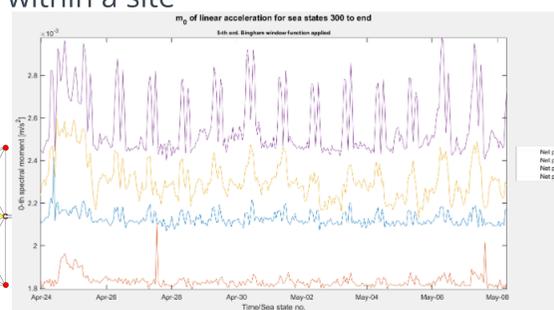


RESULTS - HOSENØYAN

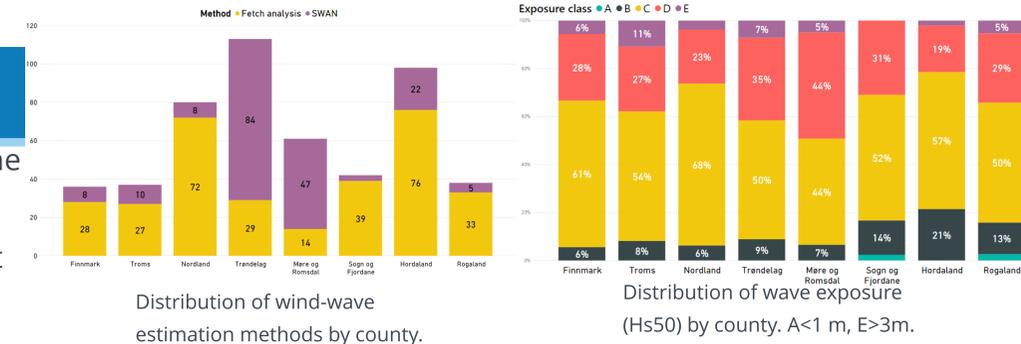
- Spatial variation in mean spectral energy content within the site
- Net pen 9 has a magnitude of fluctuation deviant from net pen 8, 5 and 3 and should be investigated further
- The measurements suggest possible spatial deviations of wave energy content within a site



Alignment of accelerometers at Hosenøyen site (green dots).

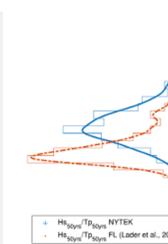


Wave energy content at net pen 3, 5, 8 and 9 at Hosenøyen. Measurements at net pen 2 and 11 was discontinued.

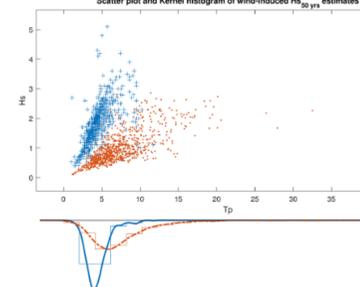


Distribution of wind-wave estimation methods by county.

Distribution of wave exposure (Hs50) by county. A<1 m, E>3m.



Met-ocean data from site surveys (blue) and fetch length analysis from Lader et al. 2017 (red).



Localization of reported swell existence at sites in southern Trøndelag - red: occurring, blue: not occurring. Size of bubbles indicates magnitude of combined Hs50 yrs.

RESULTS - NYTEK DATA

- Fetch analysis most applied wind-wave estimation method (36%), followed by SWAN (36%, numerical wave model)
- Swells (havdønninger) are reported at 27% of the sites
- Large geographical variations in wind-wave estimation methods applied
- Numerical wave models are mainly used at sites operated by large sized fish farming companies
- Fetch analysis is mainly used by small/ medium sized companies
- SWAN gives larger wave heights than fetch analysis

CONCLUSION / FURTHER WORK

Quality of site surveys are varying, and methods may not cover spatial variations in wave conditions within a site sufficiently. Input-data for wave estimations are not documented and effects of input-data quality should be investigated. Outcomes of wave estimations and site surveys highly rely on decision-making processes and thoroughness of estimation methodologies, where numerical methods are more extensive (2-4 days) than fetch analysis (hours-1 day). The dependency of fiscal strength of companies on wave estimation methods may in practice interrupt the principle of independent inspection bodies, stipulated in NYTEK §7.

WORKS CITED

- Lader P, Kristiansen D, Alver M, Bjelland HV, Myrhaug D. Classification of Aquaculture Locations in Norway With Respect to Wind Wave Exposure. ASME. International Conference on Offshore Mechanics and Arctic Engineering, Volume 6: Ocean Space Utilization
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- Norsk Standard. (2009). Marine fish farms - Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation (NS9415:2009).