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Hydroakustisk undersökning vintertid av djuplekande sik i Vättern

Vätternvårdsförbundet

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Using mobile hydro-acoustics to monitor deep-spawning aggregations of whitefish in Lake Vättern.

Vättern-FAKTA från Vätternvårdsförbundet

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Innehåll

Abstract

Two important aspects in the long-term development of fisheries are to minimize unwanted by-catches and to enhance the catch of focal fish species in optimal size ranges. For certain species this can be achieved by targeting the species in question during periods when mature individuals aggregate in association to spawning. We studied winter aggregation of deep-spawning whitefish in Swedish Lake Vättern using mobile hydro-acoustics mounted to a traditional fishing boat and with benthic gillnets as ground-truth as a means to enhance the fishery on this species. Whitefish spawning in very deep areas (over 70 m) in the wintertime (Jan-Feb) is a rare phenomenon in Scandinavian lakes. Our acoustical assessment showed that the biomass of fish in areas deeper than 65 m was markedly higher than in the summertime/autumn when acoustical monitoring normally takes place indicating that certain fish species actively migrate to deeper areas in the winter. Our results also verify that relatively large biomasses of fish in the same size-spectrum as mature whitefish aggregate in certain areas of the deep North-Southerly rift of L. Vättern in the wintertime. The gill-net catches indicate that these targets primarily are made up of whitefish and secondarily by burbot. The biomass of fish in the same size group as spawning whitefish in the investigated area was estimated to be maximum 238 tonnes. If the rest of the deep rift should have the same biomass the total spawning stock biomass of deep-spawning whitefish would be 1763 tonnes. These figures should be viewed as absolute maxima given the uncertainties related to species- and size apportionment of acoustic targets. The study showed that scientific mobile acoustic gear easily can be arranged on a traditional fishing boat. This approach could be used in collaboration with local fishermen as a relatively cost-efficient method to identify spawning aggregations of whitefish and to further the understanding on fish distributions in a time of the season that is very seldom studied in the current monitoring programs.

Sammanfattning

Två viktiga faktorer för att utveckla ett fiske på lång sikt är att minimera bifångsten av undermåliga storlekar och oönskade arter samt att maximera fångsten av den önskade målarten inom önskade storleksintervall. För vissa arter kan detta uppnås genom att fiske koncentreras till vissa områden och tidpunkter där målarterna aggregeras. Vi studerade hur djuplekande sik aggregeras vintertid i de djupa delarna av östra Vättern, mellan Visingsö och Omberg. Målsättningen var att undersöka om man kan använda ekolod för att identifiera sik i anslutningen till leken, platser där det skulle kunna vara möjligt att ha ett lönsamt och selektivt fiske. Sik som leker sent på vintern (januari-februari) på stora djup (över 70 m) är ett ovanligt fenomen i Skandinaviska sjöar och sannolikt unikt för svenska förhållanden. För att kunna identifiera ansamlingar av fisk så använde vi ett mobilt vetenskapligt ekolod som monterades på en traditionell fiskebåt. Våra resultat visade att det var markant högre biomassa av fisk på djup över 65 m jämfört med på sommaren/hösten då det normalt genomförs akustiska fiskundersökningar i Vättern. Detta indikerar att vissa fiskarter aktivt migrerar till djupare områden vintertid. En avsevärd andel av de fiskekon som detekterades bedömdes vara i samma storleksklass/ekostyrka som vuxen, könsmogen sik. Fångster i bottensatta nät under och strax före den aktuella tidsperioden visar att de arter som dominerar det aktuella intervallet i ekostyrka är sik i första hand och lake i andra hand. Biomassan sik bedömdes vara som högst 238 ton i det undersökningsområdet. Förutsatt att biomassan av sik är likartad i resten av djupränna i Vättern skulle lekbiomassan hos det djuplevande sikbeståndet vara 1763 ton. Dessa bedömningar ska dock ses som absoluta maxima på grund av osäkerheter i art- och storlekssammanssättningen hos de detekterade fiskekona. Att använda mobil hydro-akustisk utrustning i samarbete med lokala fiskare bedöms vara en kostnadseffektiv och intressant metod för att identifiera ansamlingar av lekande djupsik samt för att öka kunskapen om fiskens rumsliga fördelning vintertid, en tid på året då undersökningar normalt aldrig genomförs.

Introduction

During the period 1 April 2011 and 31 March 2014, a case-study connected to the EU FP-7 project GAP2 has been conducted in Lake Vättern, Sweden. The case-study was planned, administrated and channelled via Lake Vättern Fisheries Co-management group. The main topic of the case-study has been to develop the previously important fisheries on whitefish. One of the main research themes has been to find solutions for minimising by-catches of undersized Arctic charr (*Salvelinus salvelinus*) and trout (*Salmo trutta*).

Already at an early stage of the project fishermen highlighted the potential of targeting whitefish when they aggregate adjacent to spawning areas. A particularly interesting area was the North-Southerly deep rift where a unique variety of deep-spawning whitefish was said to aggregate in the winter to spawn. Preliminary results from a joint selectivity trial involving fishermen and scientists have shown that it is possible to get high catches of whitefish in December-February in this area. Many of the whitefish in the catch has been ripe and running indicating that this indeed is whitefish aggregating for spawning. An in-depth analysis of this and other stocks identified by fishermen using genetic, meristic, morphological and diet data (Sandström et al. unpublished) denoted that the deep-spawning stock appears to be mostly related to the lesser sparsely rakered whitefish ("sandsik" in Swedish) described by Svärdson (1979). The phenomenon of deep-spawning whitefish is very rare in Swedish lakes. There are, however, some observations from deep oligotrophic Norwegian lakes that indicate the presence of deep-spawning populations in these systems (Præbel et al. 2013, Enge, 1959). In alpine lakes, deep spawning populations appears to be more common (Hirsch et al. 2013), although certain of these populations have gone extinct, mainly due to extreme eutrophication (Vonlanthen et al. 2010).

According to the current fisheries regulations in Lake Vättern it is prohibited to use smaller mesh sizes than 60 mm (bar) at depths exceeding 30 m. Thus, it is currently not possible for fishermen to target deep-spawning whitefish since that would require the use of smaller mesh sizes than 60 mm (bar). The short term solution is for fishermen to apply for temporal permits from regional county administration boards. These permits are limited to small and specific areas. To be able to find the most suitable places to allocate such areas there is a need to find the most optimal localities where whitefish are aggregating and by-catches are minimal.

Using hydroacoustics could be a potential method to identify the most suitable areas for temporal whitefish permits. It could also be an interesting method to assess the status of this stock. As a comparison, hydroacoustic surveys of coregonids aggregating at their spawning sites are used successfully in Lake Superior to follow the stocks of cisco (Yule et al. 2012) and in Lake Constance to follow the pelagic whitefish stocks (Eckmann, 2011).

This study aimed to test the potential of assessing the spatial distribution of aggregations of deep-spawning whitefish when equipping a traditional fishing boat in L. Vättern with a mobile scientific hydro-acoustics system.

Anders Asp and Johnny Ståhl are preparing the tow body (left). Thomas Axenrot and Daniel Ståhl are pulling gillnets (right).

Anders Asp och Johnny Ståhl förbereder to-bodyn (vänster). Thomas Axenrot och Daniel Ståhl drar nät (höger).

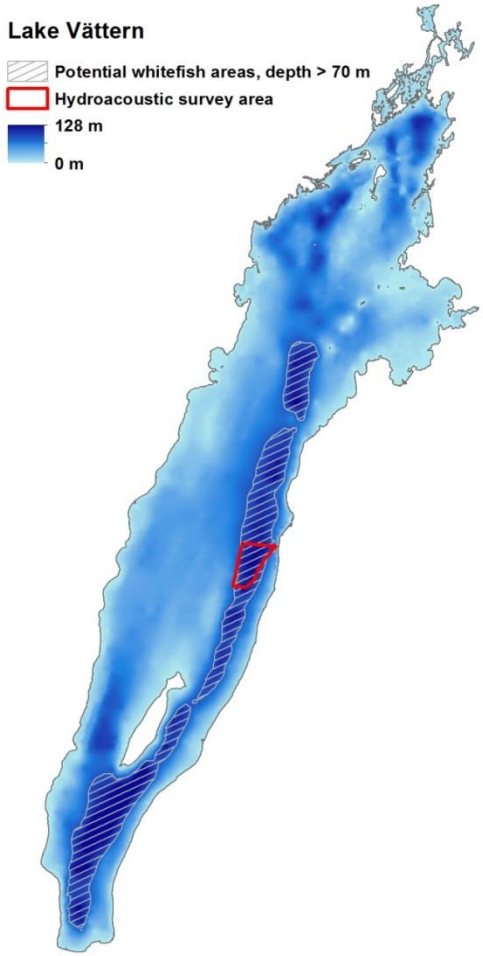

Figure 1.Hydroacoustic study area and areas with depth over 70 m possibly holding deep-spawning whitefish (shadowed).

Figur 1. Karta över undersökningsområdet utmärkt med en röd linje och de delar av djuprännan (skuggade) där det sannolikt kan finnas djuplekande sik vintertid.

Material and methods

Mobile acoustics

To investigate if it would be possible to identify spawning aggregations and to estimate their density and biomass a pilot study was conducted in early February 2013. The study was performed in a limited area situated in the middle part of L. Vättern where spawning aggregations had been reported and fishing was regularly occurring. We used hydroacoustics (Simrad echo sounder EK60 with a 120 kHz transducer) in cooperation with a local fisherman. The hydroacoustic equipment could be arranged on the fishing boat with some minor adjustments. The transducer was fixed on a tow-body and running at 1.5 m depth and 1 m distance to the port side. The echosounder was calibrated according to Foote (1987) and recommendations from the manufacturer (Simrad A/S). The pulse width was set to 0.512 ms and power to 100 W. The ping rate (i.e. the frequency of emitted sound pulses) was 2 per second.

Ground truth:

To attain ground truth data to enable species and size apportionment of acoustic single targets we used data from the benthic gillnets used by commercial fishermen in the investigated area. These benthic gillnets varied from 40 to 43 mm in mesh size (bar). The net height varied from 10 to 15 feet. In total, data was used from eleven fishing occasions made during the period from 6 January to 13 February. Mean soak time was 76 hours (min 72 hours, max 96 hours). Mean fishing depth was 102 meters (min: 71 m and max: 112 m). A subsample of the captured species, at least 30 individuals per mesh was measured for total length. This ground truth data set was corrected for gillnet selectivity using a modification of the SELECT approach (described earlier and in Jonsson et al. 2013). Hydroacoustic fish size – target strength (TS) - is measured in decibels (dB). The corresponding TS to whitefish size interval of 320 to 480 mm length is from -36 to -32 dB (TL to TS equation according to Love 1977).

Results

The catches of whitefish declined markedly starting from early January and onward. The latest date (13 February) the catches of whitefish were relatively low. Thus, we had to use catch data from the period slightly before the acoustic investigation to get a large enough ground truth dataset. Many of the whitefish were ripe and running indicating that they were captured close to or directly associated to the time of spawning. The catches were dominated by whitefish (54% of the catch) and burbot (37% of the catch). Other occurring species was Arctic charr (3% of the catch), trout (one individual), ruffe, smelt and four-horned sculpin. The gillnet data reported whitefish lengths from 320 mm to 480 mm (total length, TL), the dominating size classes was in the range of 35-41 cm (Fig. 2). The main size overlap with burbot was from a size of 40 cm and larger (Fig. 2).

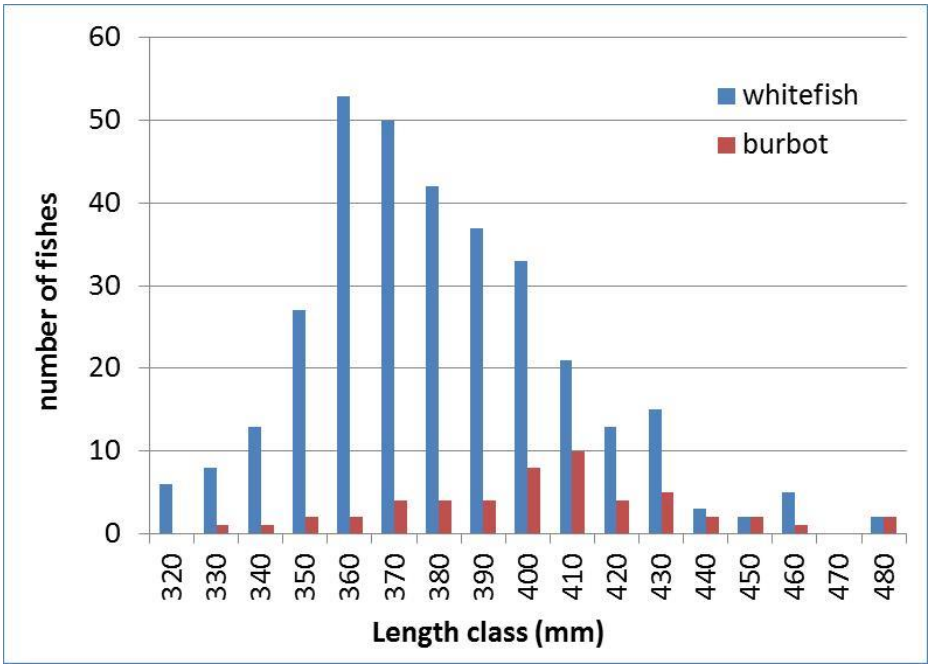

Figure. 2. Size distribution of the two main fish species, whitefish and burbot, caught in ground truth fishing with benthic gillnets.

Figur 2. Storleksfördelning hos de två arter som dominerade fångsten med bottensatta nät, sik och lake. Y-axeln visar antal fiskar och x-axeln längdklass i mm.

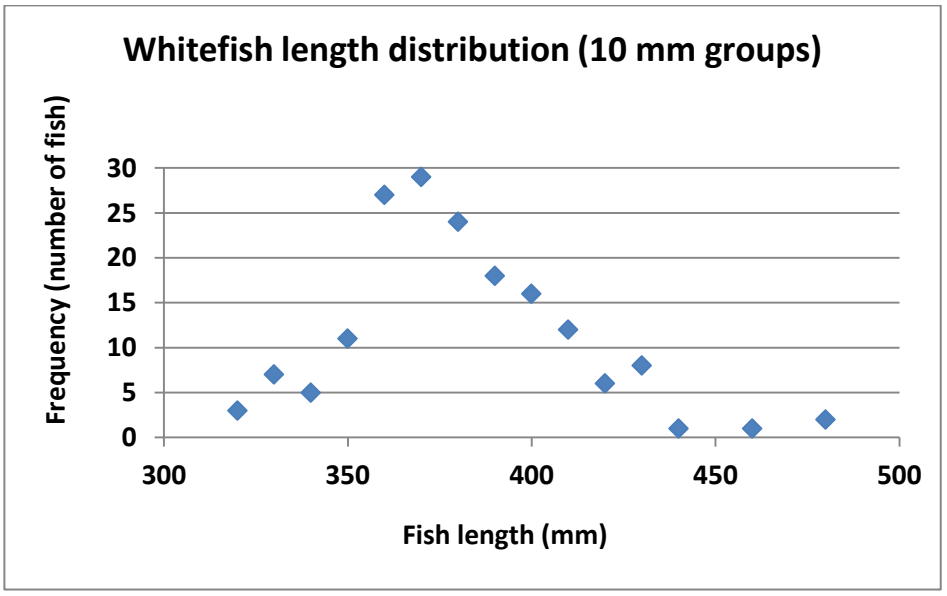

Figure 3. Gillnet selectivity corrected size distribution of whitefish from gill net catches at large depths in L. Vättern 6 January to 13 February 2013.

Figur 3. Nätselektivitetskorrigerad storleksfördelning hos sikar fångade på stora djup vintertid I Vättern från perioden 6:e Januari – 13:e Februari.


Many of the whitefish were ripe and eggs and yolk were running (left). The investigation was conducted during the few hours with light (right).

Många sikar i fångsten hade rinnande rom och mjölke (vänster). Undersökningen gjordes under dagtid – de få timmar under säsongen då det är dagsljus (höger).

An estimate of whitefish density (size 320-480 mm) in the study area, based on the hydroacoustic data combined with corrected gillnet data as ground truth, resulted in 148 fish per hectare. The corresponding biomass was 76 kg per hectare. The TL to weight (W) relationship was calculated from whitefish catches in L. Vättern (Eq. 1).

$$W = 12{,}935 \times e^{(0{,}009 \times TL)} \qquad \text{(Eq. 1)}$$

We compared the spatial distribution of fish targets from similar acoustic assessments conducted in the vicinity of the investigated area in the summertime (mid-August) by examining the echograms. It was evident that fishes change their spatial distribution in the winter, migrating to deeper areas (depths over 60 m) compared to summertime when the majority of the fishes are distributed above or slightly below the thermocline at approximately 20 m depth.

Four-horned sculpin were collected alive for the Lake Vättern Aquaria in Motala (right). A newly caught deep-spawning whitefish (left).

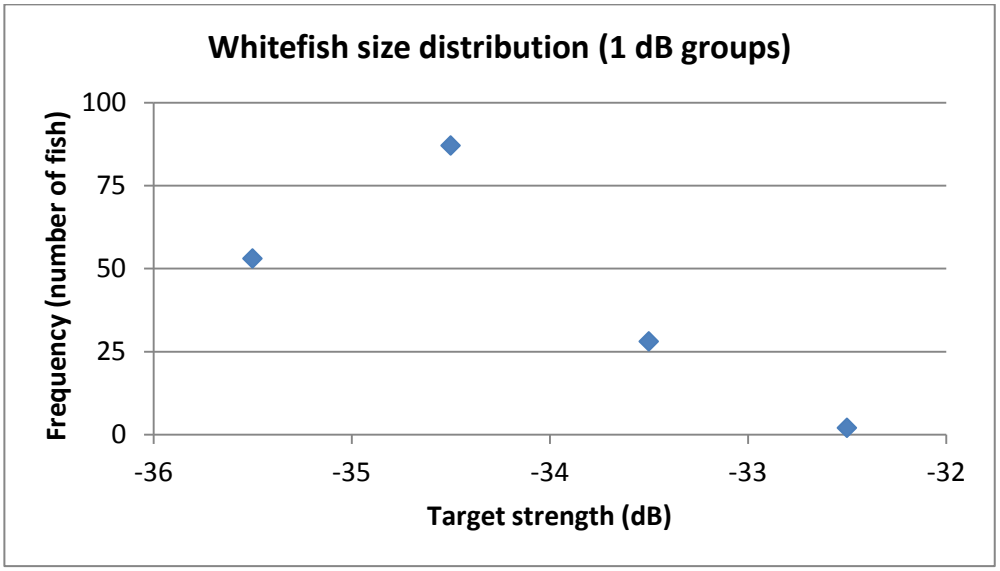

Figure 4. Size distribution of hydroacoustic single echo detections (from -36 to -32 dB) from 70 m depth in L. Vättern in early February 2013.

Figur 4. Storleksfördelning på djup över 70 m hos enskilda bottennära ekon med ekostyrka från -36 dB till -32 dB tidigt i februari 2013.

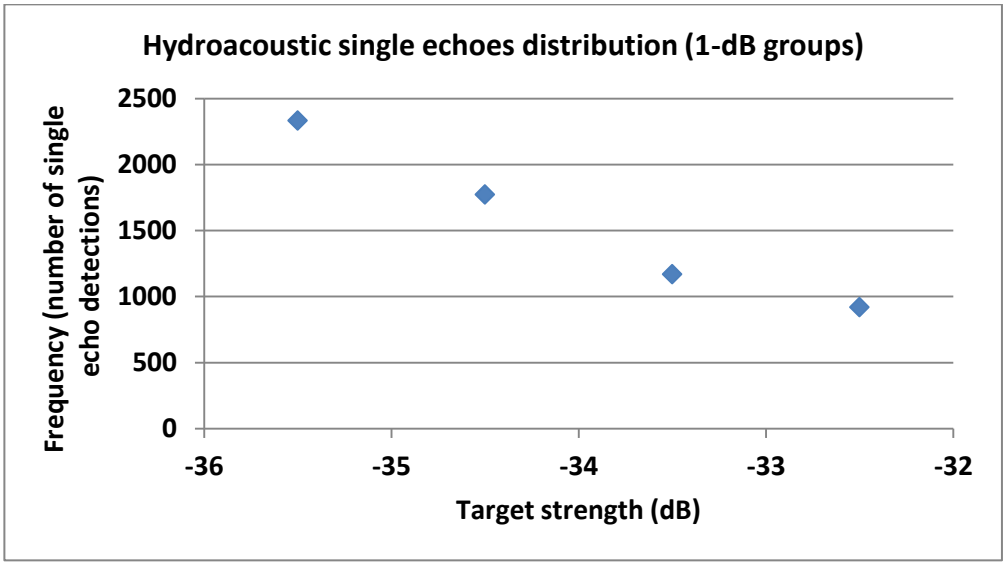

Figure 5. Summary of the number of single echo detections in the target size range of -32 dB to -36 dB in deep areas (over 70 m) of Lake Vättern in early February 2013.

Figur 5. Summering av antal fiskdetektioner i olika storleksklasser, från -36 dB till -32 dB.

Discussion

This assessment showed that using hydroacoustics in collaboration with fishermen could provide information that can enable managers to identify specific areas where fishermen can get permits for targeting deep-spawning whitefish in the winter when by-catches of other species normally are lower (see earlier paragraph on gill-net trials). The biomass of whitefish in the investigated area was estimated to be 238 tonnes. This figure should be seen as an absolute maximum given

that some fish targets could have been confused with other species, mainly burbot. If the biomass of deep-spawning whitefish would be homogenously distributed all over the deep rift (constituting 13% of the whole lake surface area), the estimated maximum biomass of the spawning stock would be 1 763 tonnes. Even though these estimates are relatively insecure, they confirm the strong status of the whitefish stock and the currently low exploitation rate. Winter catches of whitefish were under 1 tonnes before the GAP2 project started, thereafter they have increased to 3-6 tonnes annually.

The mean by-catch of under-sized Arctic charr in the investigated area was 1.6 individuals per 1000 m net and day. This is a little bit under the target threshold for the fishery of 2.15 individuals per 1000 m net and day. The main by-catch in the area was instead burbot with a mean catch of 14.7 individuals per 1000 m net and day. The species collapsed in the early 70s, most probably due to overexploitation when caught as a bycatch in the whitefish and Arctic charr fisheries. There is no current size limit for burbot in L. Vättern. But bycatches of burbot under the size of sexual maturation should, if possible, be avoided. This could be achieved by concentrating fishing activities where burbot are less abundant and by avoiding gill-nets with a mesh size lower than 43 mm.

To summarize, this study showed that the deep-spawning whitefish stock in L. Vättern aggregates and spawns in the deep rifts of Lake Vättern. Using hydroacoustics in collaboration with fishermen could be a promising method to further assess this unique phenomenon and to assess the status of the stocks which could be important if fishing pressure increases in the future.

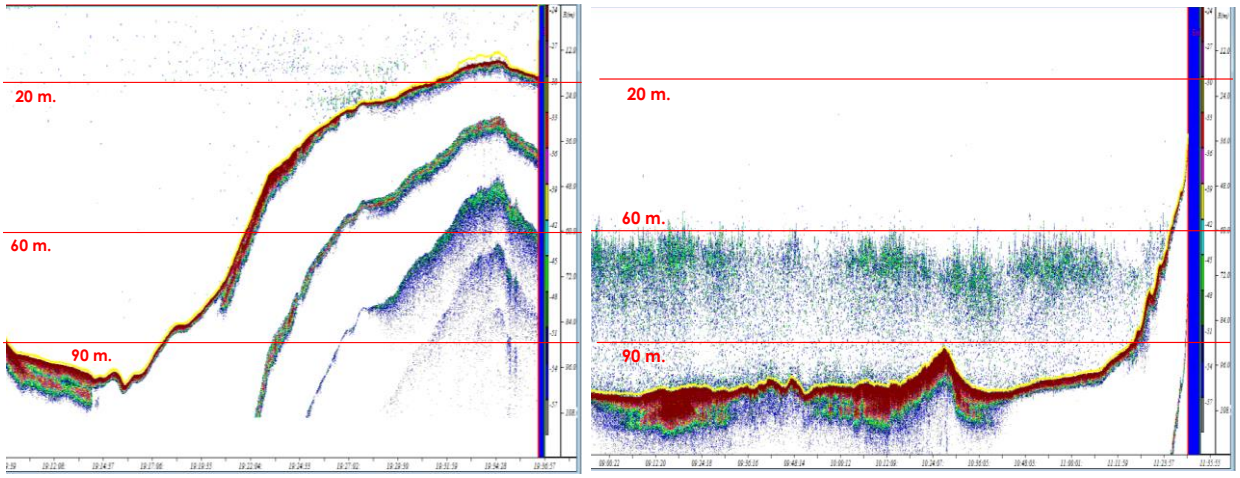

Figure 6. Echograms showing the spatial distribution of targets in summer monitoring (left) and in this survey in the winter-time (right). The summer monitoring data is collected from the eastern part of acoustic transect nr 7, close to the investigated area in this study.

Figur 7. Ekogram från akustiska undersökningar sommartid (vänster) och vintertid (höger) i det undersökta området. Data från sommaren är hämtat från den östligaste delen av transekt nummer 7 i de årliga akustiska undersökningar som genomförs i Vättern.

The transducer was fixed to a tow body mounted on the fishing boat (left), GAP2 scientist Thomas Axenrot is temporarily working as a "captain" since the computer had to be protected inside the cabin from the harsh weather conditions in February (right).

Ekolodets svängare monterades på en så kallad "tow body" som drogs fram på sidan av båten (tv), Thomas Axenrot fungerar som tillfällig kapten då datorn till ekolodet placerats inne i hytten för att få skydd från det bitvis bistra vädret i februari (th).

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References/litteratur

Foote, K. G., Knudsen, H. P., Vestnes, G., Mac Lennan, D. N. and E. J. Simmonds. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. Const. Int. Explor. Mer. 144, ICES Cooperative Research Report, Copenhagen.

Enge, K. 1959. Om siken i Randsfjorden. Fauna 3: 123-135. . (In Norwegian. "On the whitefish in L. Randsfjorden").

Eckmann, R. 2011. A hydroacoustic study of the pelagic spawning behavior of whitefish (Coregonus lavaretus) in Lake Constance. Canadian Journal of Fisheries and Aquatic Sciences, 1991, 48:995-1002, 10.1139/f91-116.

Hirsch, P. E., Eckmann, R., Oppelt. C. and J. Behrmann-Godel (2013). Phenotypic and genetic divergence within a single whitefish form – detecting the potential for future divergence. Evolutionary applications 6: 1119-1132. Doi:10.1111/eva12087.

Jonsson, T., M. Setzer, J. G. Pope and A. Sandström. 2013. Addressing catch mechanisms in gillnets improves modelling of selectivity and estimates of mortality rates: a case study using survey data on an endangered stock of Arctic charr. Canadian Journal of Fishery and Aquatic Sciences, 70(10): 1477-1487, doi: 10.1139/cjfas-2012-0472.

Love, R.H., 1971. Dorsal aspect target strength of an individual fish. J. Acoust. Soc.Am. 49, 816–823.

Præbel, K., Knudsen, R., Siwertsson, A., Karhunen M., Kahilainen K., Ovaskainen O., Østbye K., Peruzzi, S., Fevolden S.-E. and P.-E. Amundsen (2013). Ecological speciation in postglacial European whitefish; rapid adaptive radiations into the littoral, pelagic and profundal lake habitats. Ecology and evolution 3(15): 4970-4986. Doi: 10.1002/ece3.867

Svärdson, G. 1979. Speciation of Scandinavian Coregonus. Rep. Inst. Freshw. Res. Drottningholm 57: 1-95.

Vonlanthen, P., Bittner, D., Hudson, A. G., Young, K. A., Müller, R., Lundsgaard-Hansen, B., Roy, D., Di Piazza, S., Largadier, C. R. and O. Seehausen. 2012. Eutrophication causes speciation reversal in whitefish adaptive radiations. Nature 482: 357-362. doi:10.1038/nature10824

Yule, D. Schreiner, D. R. Addison, P. A., Seider, M. J., Evrard, L. M., Geving, S. A. & H. R. Quinlan 2012. Repeat surveys of spawning cisco (Coregonus artedi) in western Lake Superior: timing, distribution and composition of spawning stocks. Advanc. Limnol. 63, p. 65–87.