



**RESEARCH OF FEEDING MACKEREL
IN THE NORWEGIAN SEA AND HER
ENVIRONMENTAL CONDITIONS WITH
USING OF AIRBORNE REMOTE
SENSING METHODS**

Authors: V. Zabavnikov, S. Egorov,

**6, KNIPOVICH STREET, MURMANSK, 183038,
RUSSIA**

PHONE: (+7)-815-2-47-25-72,

FAX: (+7)-815-2-47-33-31,

E-MAIL: LTEI@PINRO.RU





Research objects – fisheries-significant subsurface pelagic fishes aggregations, in the first feeding mackerel in the Norwegian Sea, marine mammals distribution and numbers (as predators for them), and marine environment conditions



The main research aim – development and improvement of methodical and technological approach for pelagic fishes distribution and biomass definitions (in the first feeding mackerel in the Norwegian Sea), including influence of environmental conditions and marine mammals distribution and numbers (as predators)



SOME COMMENTS:



- PINRO carried out annual feeding mackerel aerial surveys in the Norwegian Sea in July during 1997-2005. From 1997 to 2000 were used the same airborne remote sensing equipments, which was added by new in 2001. It was polarization aviation lidar (PAL-1), which was later modified in PAL-1M;



- all these aerial surveys carried out in the frame of ecosystem surveys when collected oceanographic data which described current conditions and phenomenon on the sea surface and subsurface layers (sea surface temperature-SST, transparency, pycnocline depth, chlorophyll "A" concentration, hydrodynamics special structure and distribution); marine mammals and sea birds distribution and numbers on species, that is need for assessment their influence to fishes, and in the first to mackerel as predators.





Appearance of An-26 «Arktika» and its main technical specification

Maximum range of flight, km	3200
Maximum duration of flight, hr	8-9
Number of board measuring complex	max. 14 (for harp seal-8)
Number of places for board operators	8
Height of flight, m	100-6000
Speed range, km/hr	250-400



Working fragments inside research aircraft An-26 "Arktika"

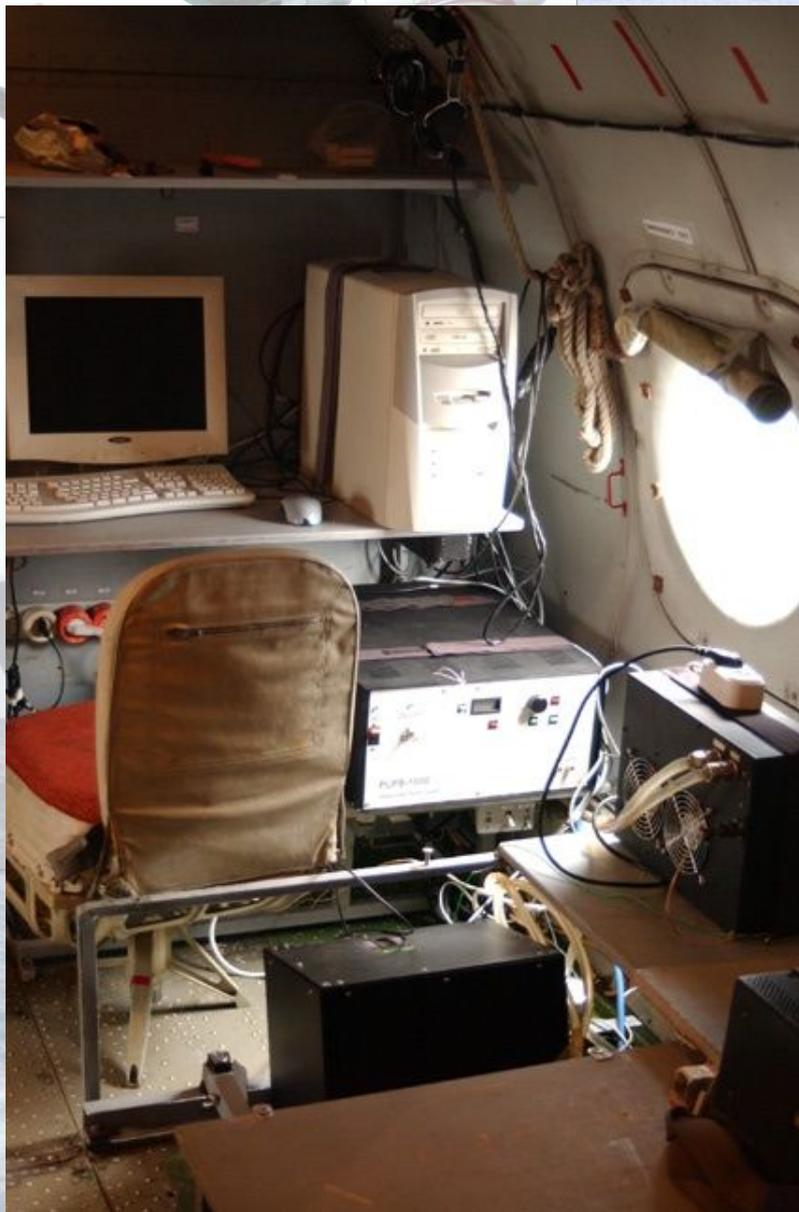
AIRBORNE EQUIPMENTS, MATERIALS AND METHODS FOR ECOSYSTEM AERIAL SURVEYS IN THE NORWEGIAN SEA

1. IR-RADIOMETER AND SCANNER. MEASURING OF SST (ALONG FLIGHT TRACK) - DATA HAVE ALMOST CONTINUOUS REALIZATION AND THERMAL CONDITION DEFINITION ON SEA SURFACE AS THERMAL IMAGES (IN SWATH ABOUT 90 M) - DATA HAVE CONTINUOUS REALIZATION.
2. LIDAR. MEASURING AND DEFINITION OF WATER TRANSPARENCY; PICNOCLINE DEPTH; CHLOROPHYLL "A" CONCENTRATION ON SEA SURFACE (IN RELATIVE UNITS); ZOOPLANKTON CONCENTRATION IN THE SUBSURFACE LAYERS (IN RELATIVE UNITS); SEARCH, RECORDING AND IDENTIFICATION OF PELAGIC FISH SCHOOLS (IN THE FIRST MACKEREL) - DATA HAVE ALMOST CONTINUOUS REALIZATION.
3. SYNTHETIC APERTURE RADAR (SAR). DEFINITION POSITION AND STRUCTURE OF HYDRODYNAMICS EFFECTS ON SEA SURFACE (EDDIES, MEANDERS, SLICKS AND SO-ON) AS SAR IMAGE (IN THE SWATH NO LESS THAN 1,5 N. MILES, IN DEPENDENT ON ALTITUDE) - DATA HAVE CONTINUOUS REALIZATION. IT IS ALL WHETHER REMOTE SENSING EQUIPMENT.
4. DIGITAL AND ANALOG FOTO-AND VIDEO EQUIPMENTS. FOR DOCUMENTATION OF DIFFERENT INTEREST OCEANOGRAPHIC EFFECTS AND BIOLOGICAL OBJECTS ON SEA SURFACE - CARRY OUT SOME TIMES, WHEN IT IS NECESSARY.
5. STANDARD VISUAL OBSERVATION. FOR DETECTION AND REGISTRATION OF BIOLOGICAL OBJECTS ON SEA SURFACE AND SUBSURFACE LAYERS. CARRY OUT CONTINUOUSLY.
6. OCS. ALL MEASURED AND OBSERVED DATA, EFFECTS AND PARAMETERS PUT ON COMPUTER SYSTEM IN THE REAL TIME AND POSITION WITH USING GPS AND THEN AFTER SPECIAL COMPUTER PROCESSING PRESENT IN THE MAPPING FORM IN GIS

AMONG ABOVE AIRBORNE REMOTE SENSING EQUIPMENTS LIDAR IS THE MAIN FOR MACKEREL AND OTHER PELAGIC FISHES SPECIES IDENTIFICATION

LIDAR place inside and outside of aircraft

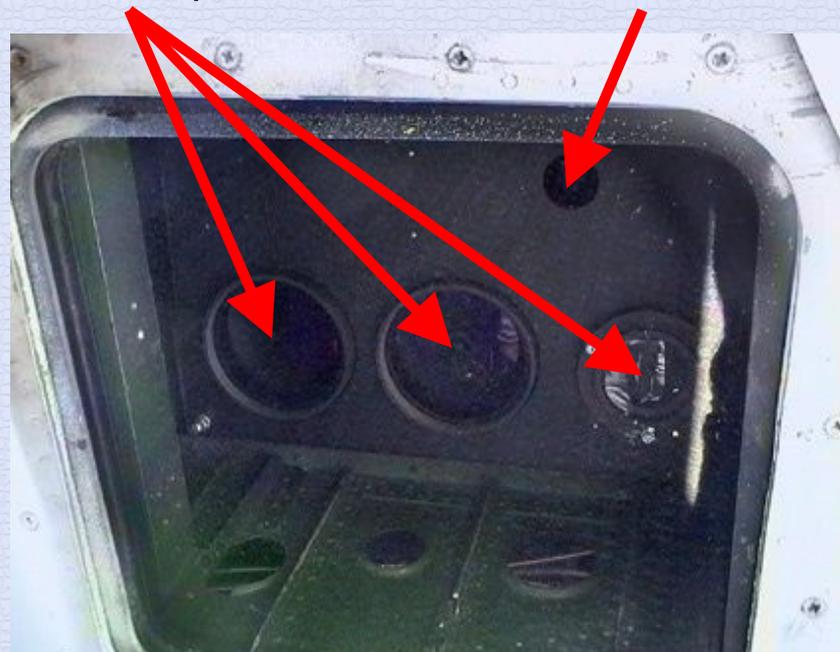
Working place for LIDAR operator



LIDAR in the hatch

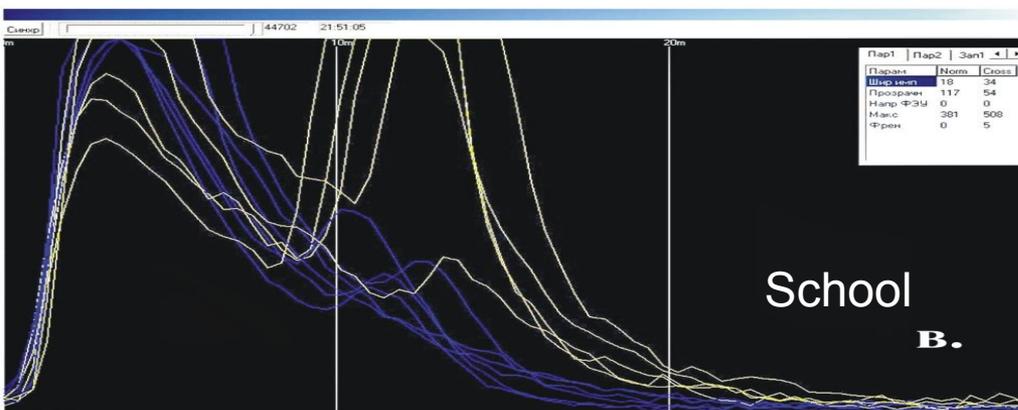
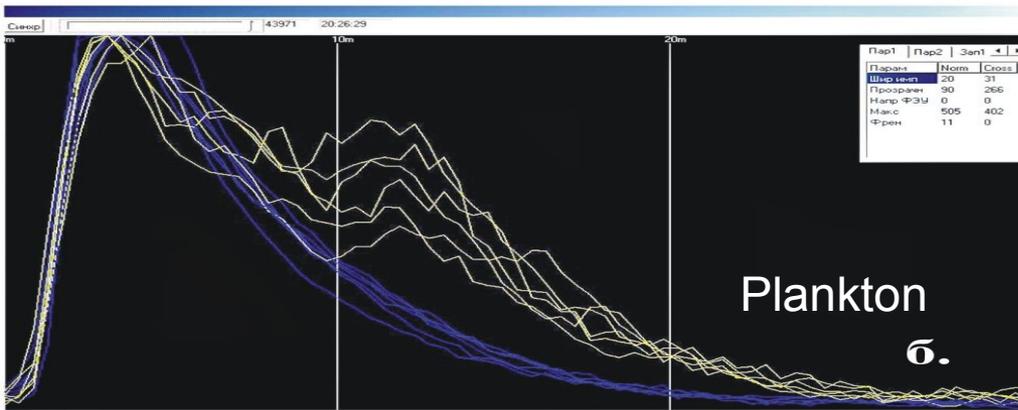
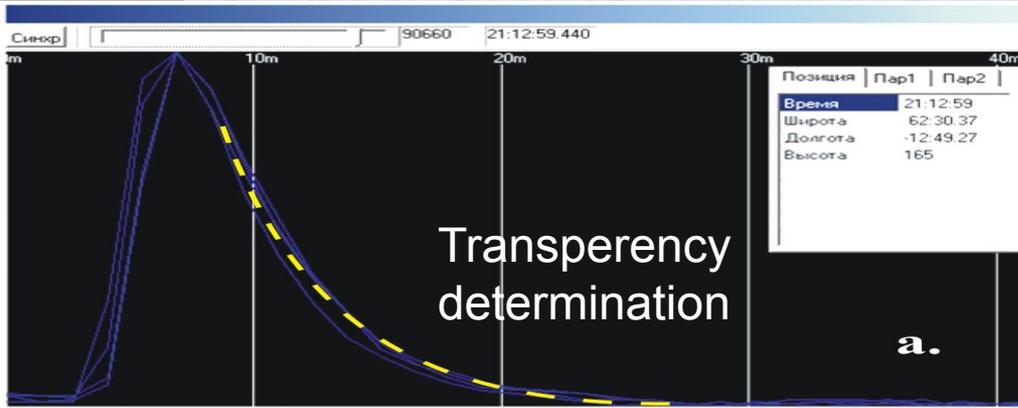
Received Apertures

Radiated Outlet

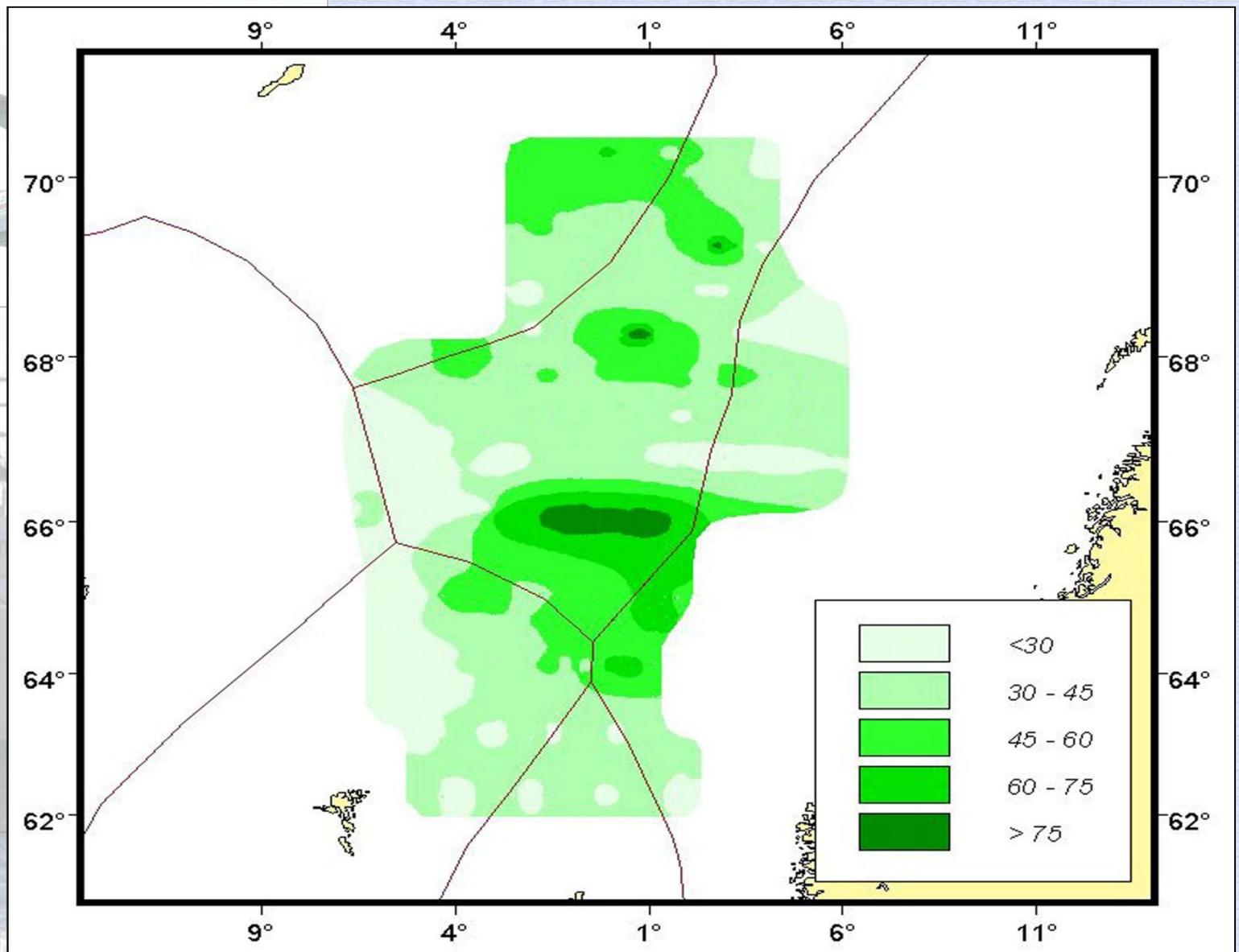


PAL-1M MAIN SPECIFICATION

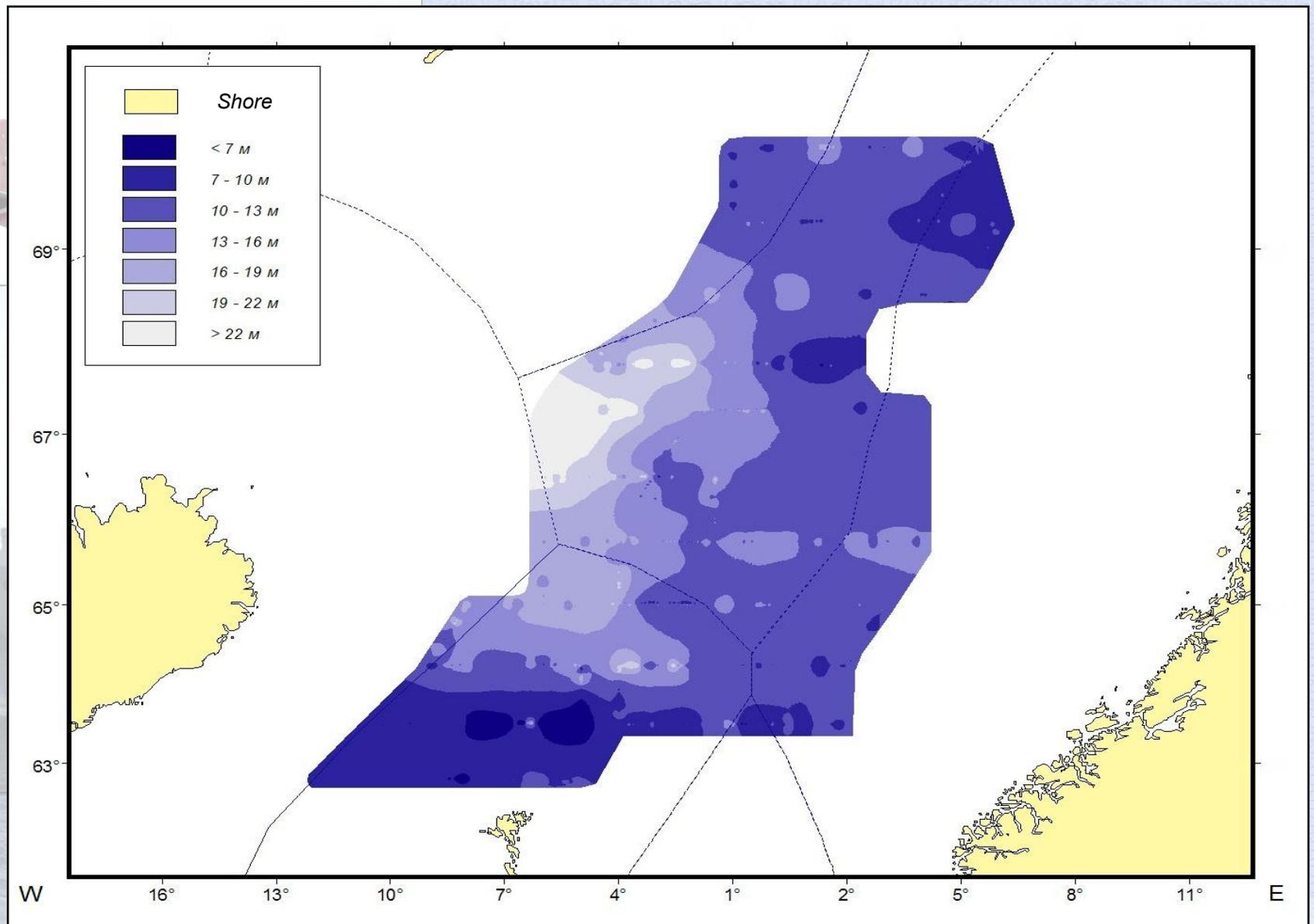
Radiation Wavelength, nm	1064,532
Pulse Energy (532 nm), mJ	120
Pulse Length on Level 0.5 ns	no more 10
Repetition Rates, Hz	1...40
Radiate, °	1.5 - 3
Radiation	polarizable
Sample Rate, Mhz	80
Number of Receiver Channel	3 (co-linear,cross, fluorescence)
Weight, kg	70



Examples of single raw lidar signals (white line – cross-polarization channel, blue line – co-polarization channel)



Example of sea surface chlorophyll "A" spatial distribution in relative units on data of aerial surveys in the Norwegian Sea



Example of sea transparency spatial distribution on data of aerial surveys in the Norwegian Sea

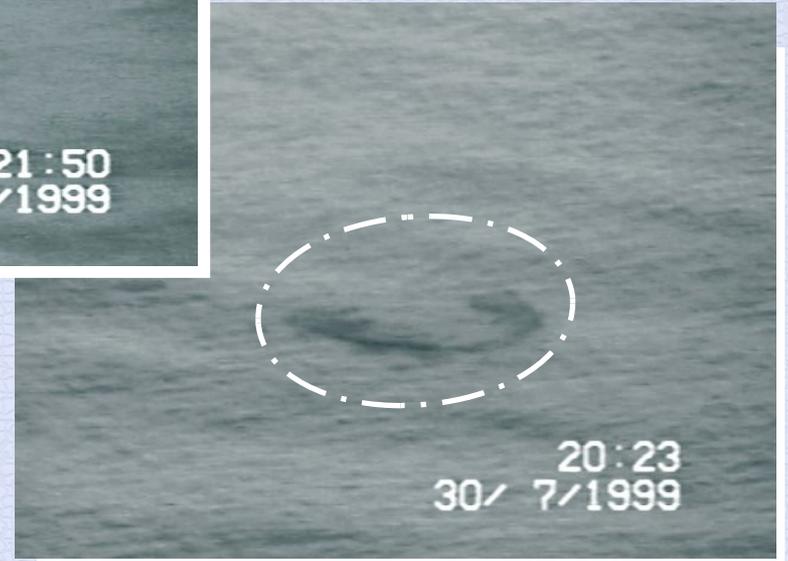
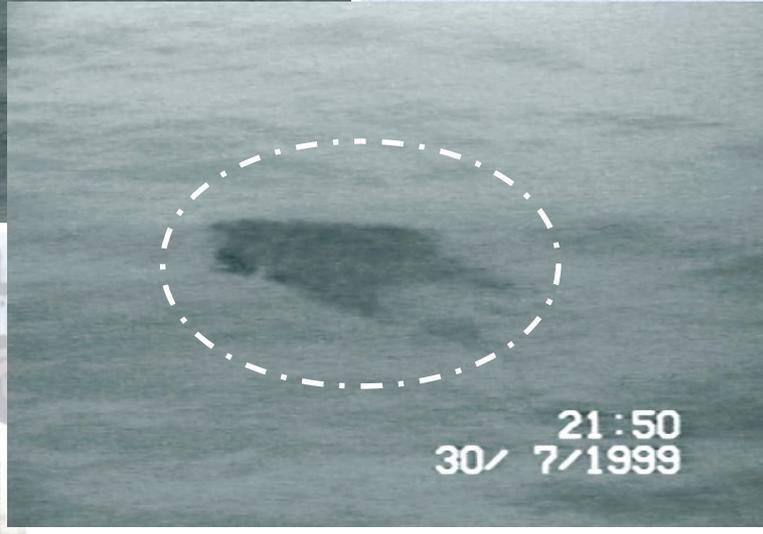
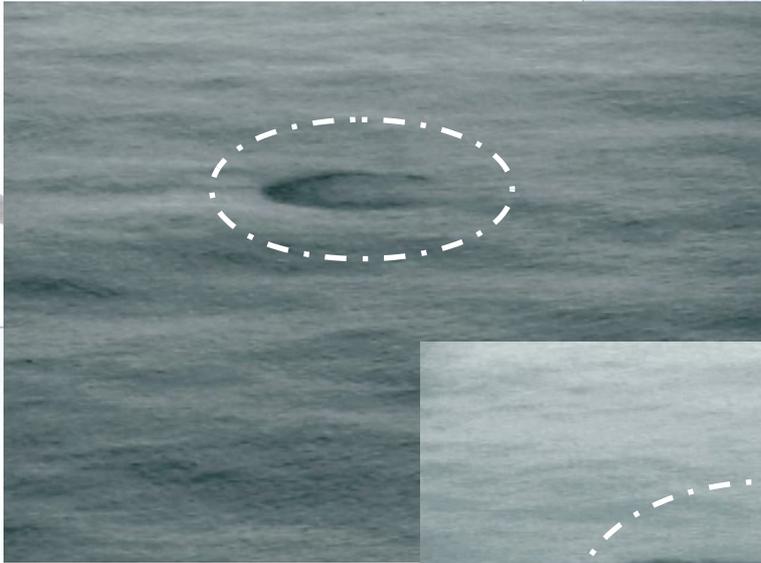
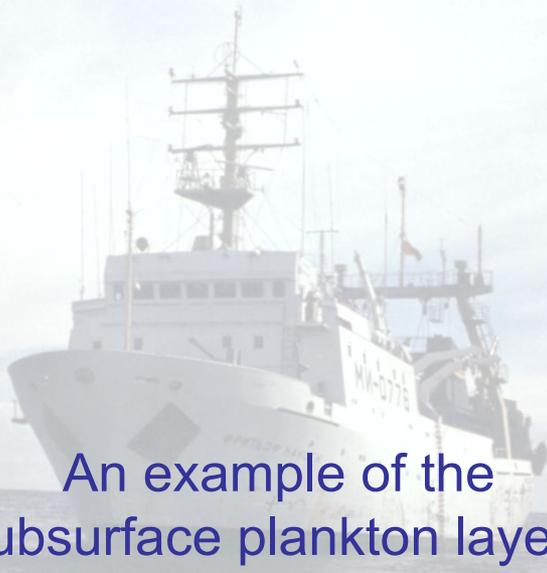
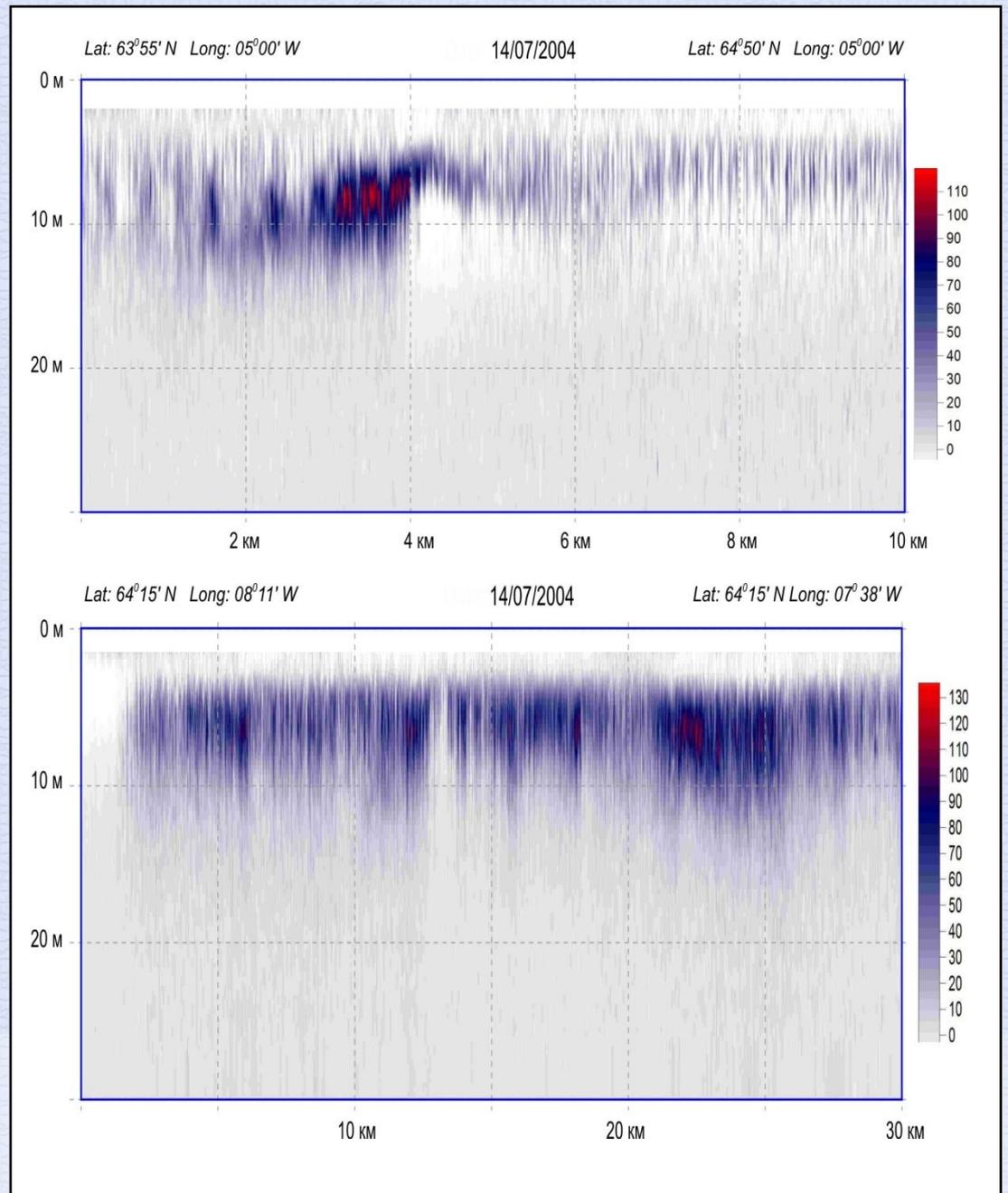
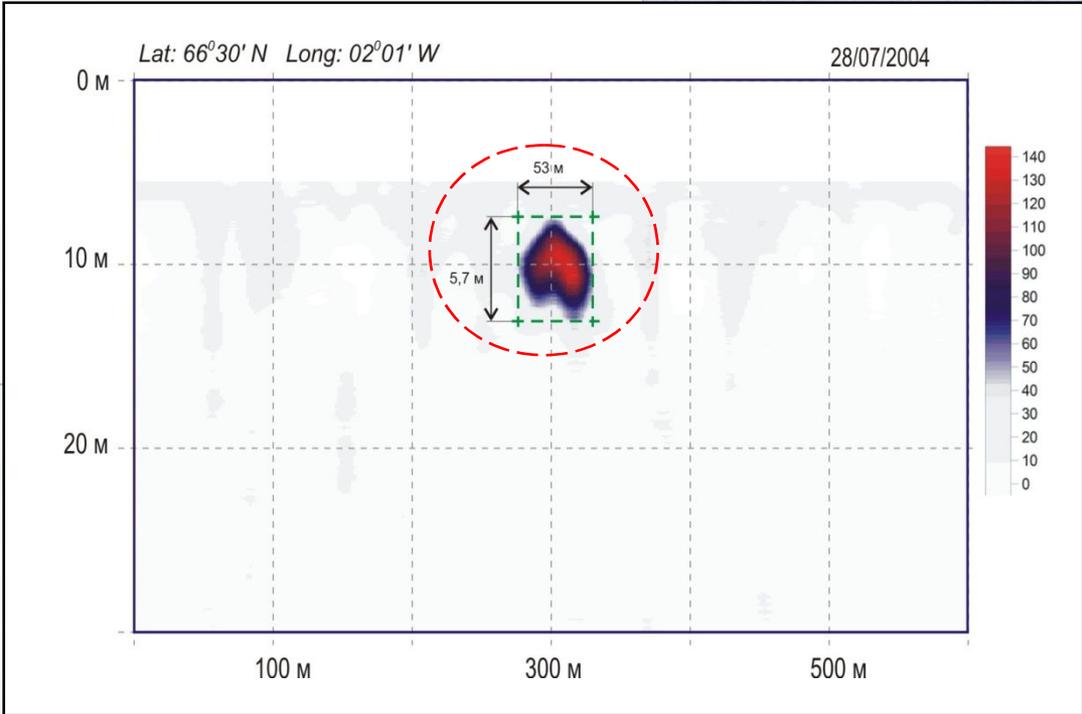


Photo-images of mackerel schools as their sighting aircraft observers

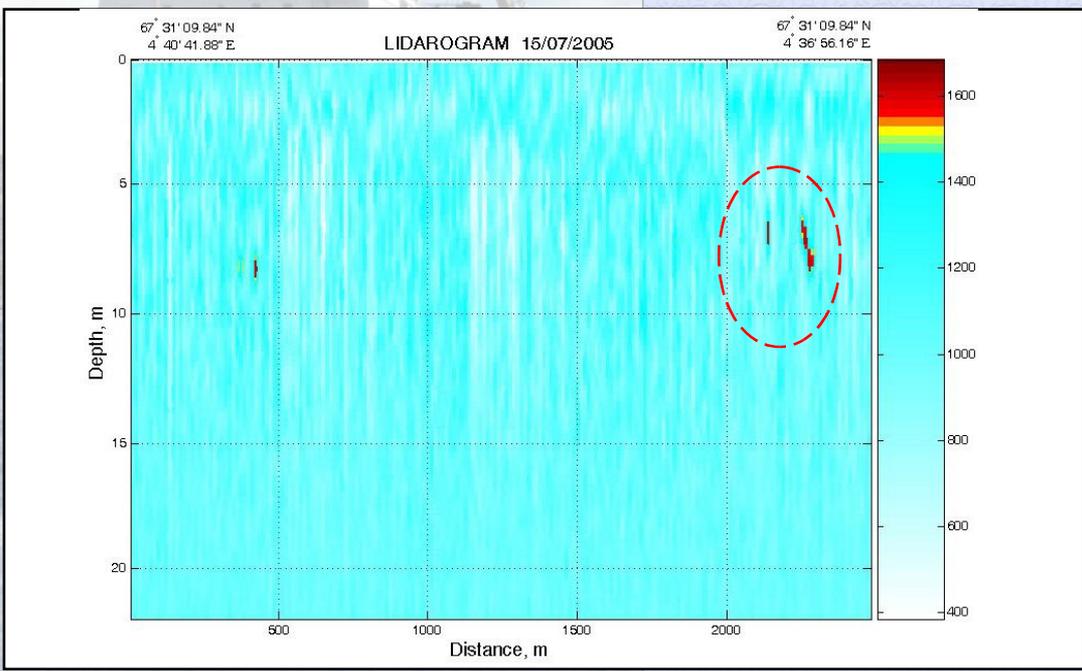


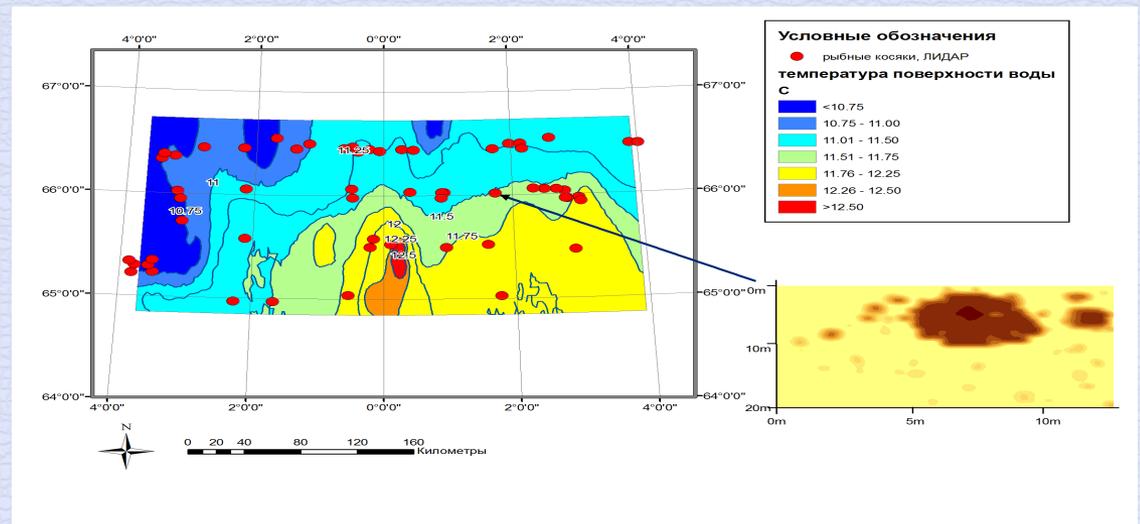
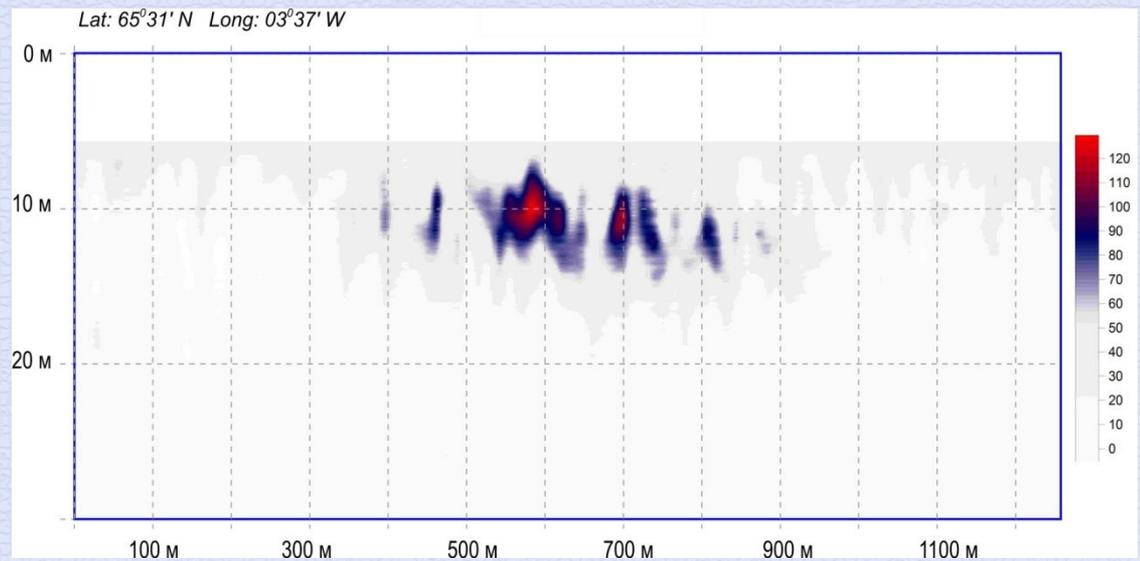
An example of the subsurface plankton layers (blue structure) and mackerel schools (red patches) on so-named “Lidarogramm”, which prepare on base special mathematics and software providing



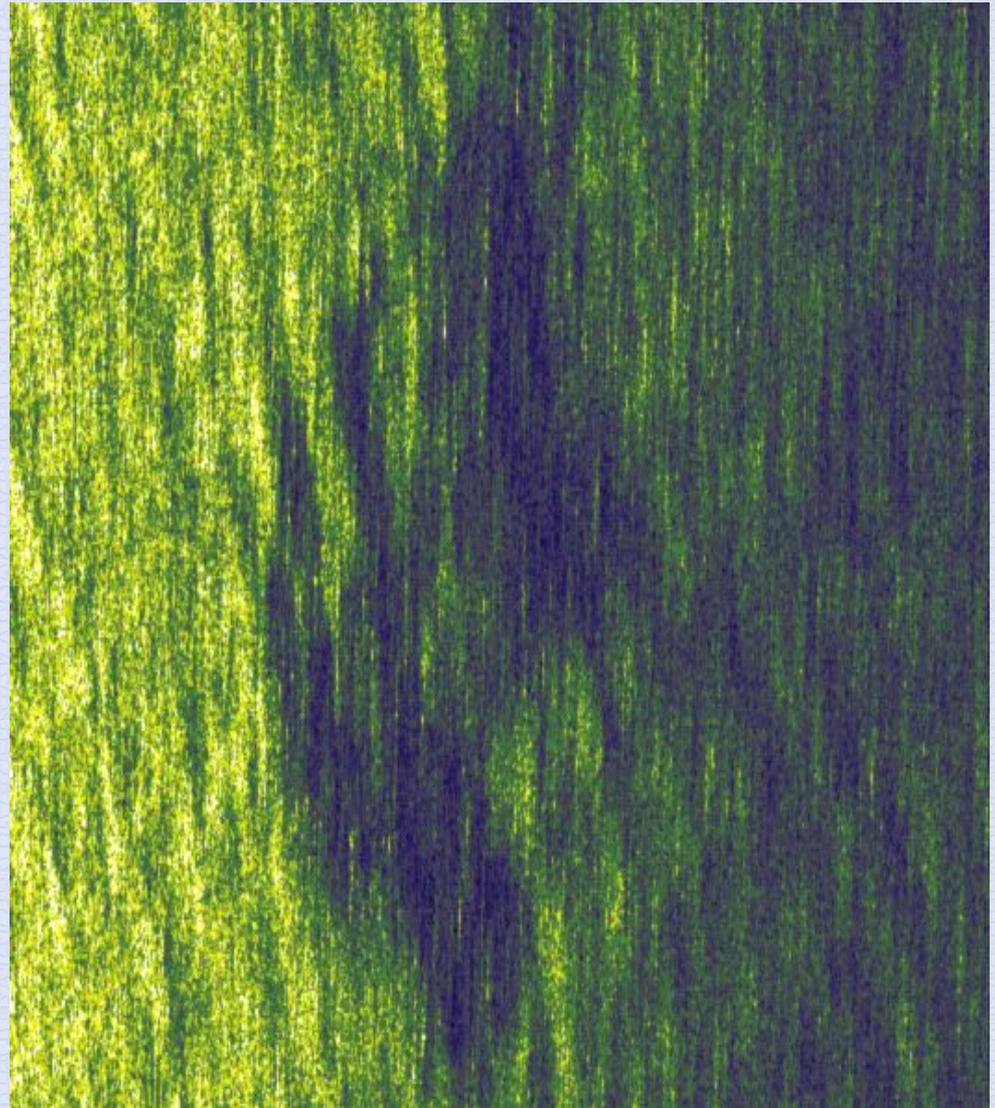
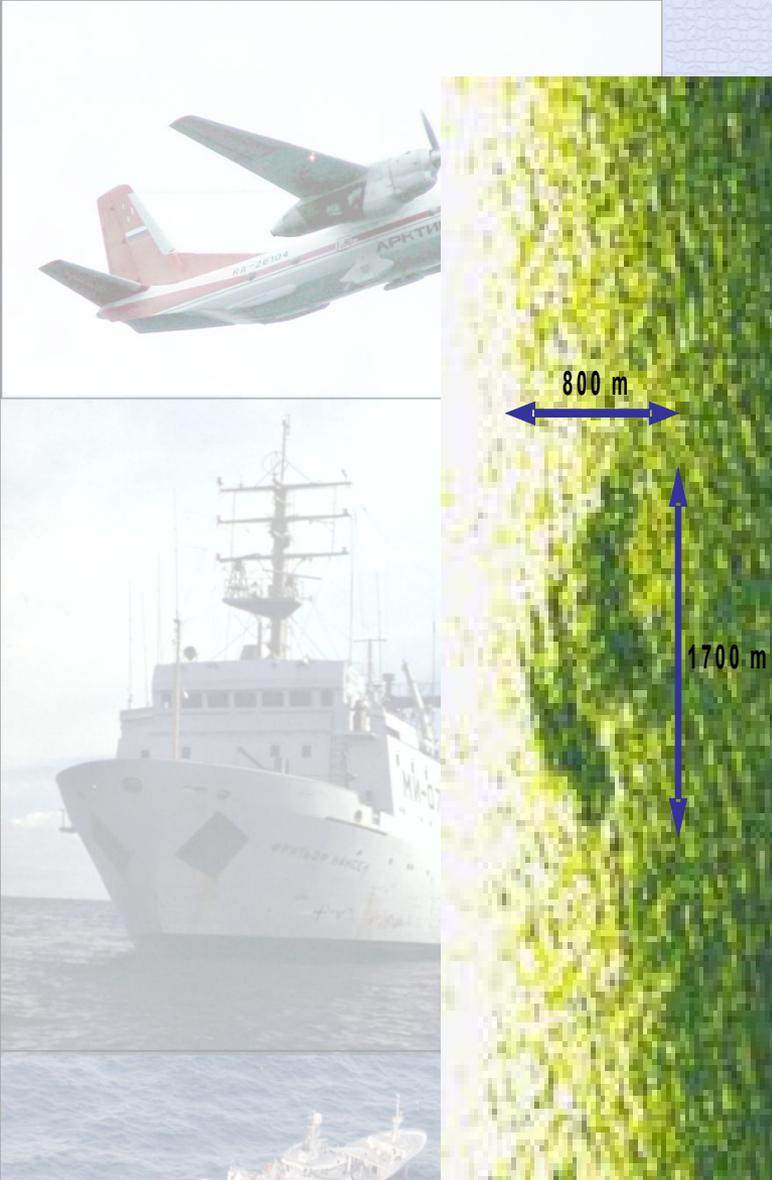


Some examples of the mackerel schools aggregation on visual observations and the same schools on "Lidarogramm" after exclusion of plankton layers with use new special mathematics and software providing

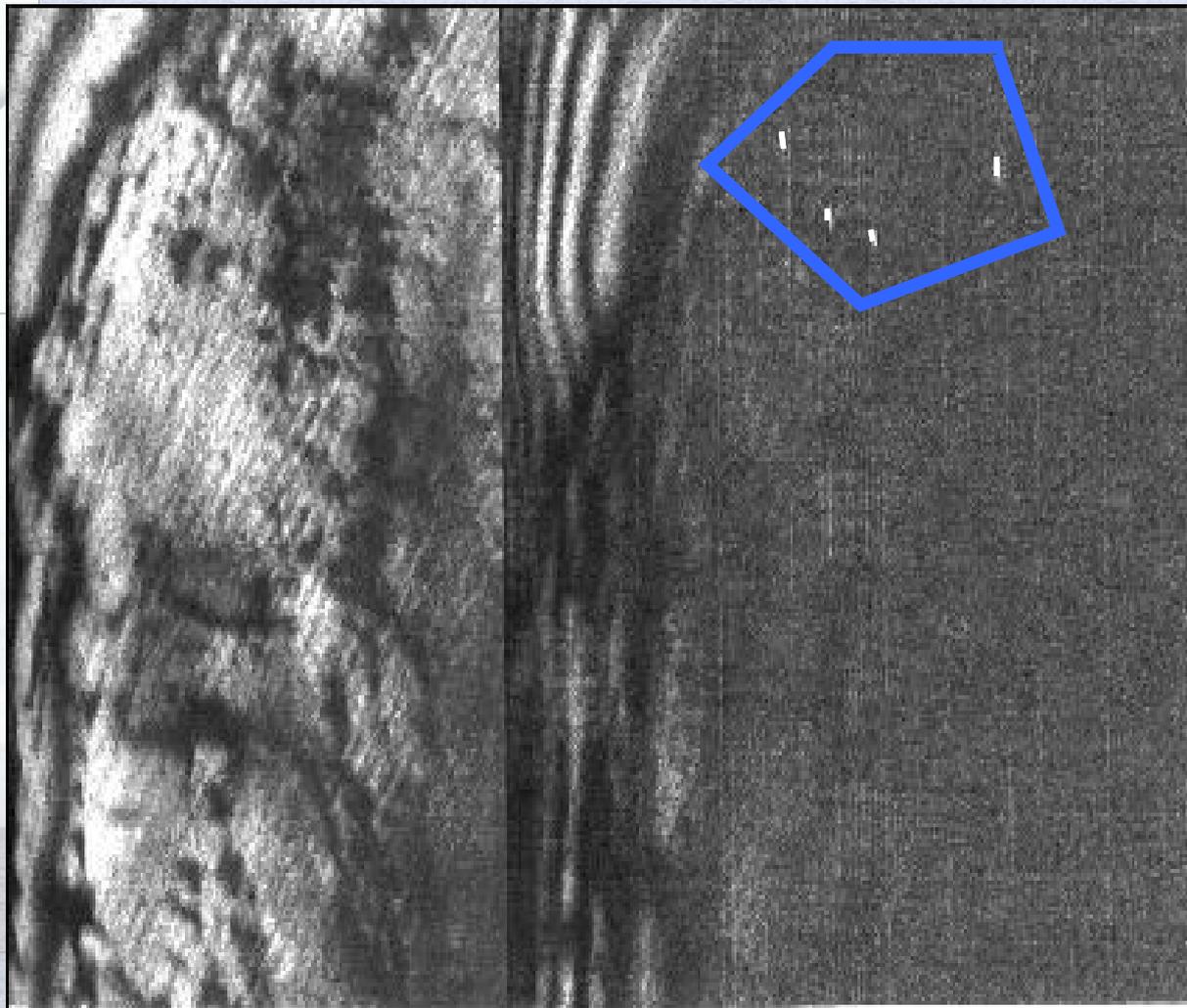




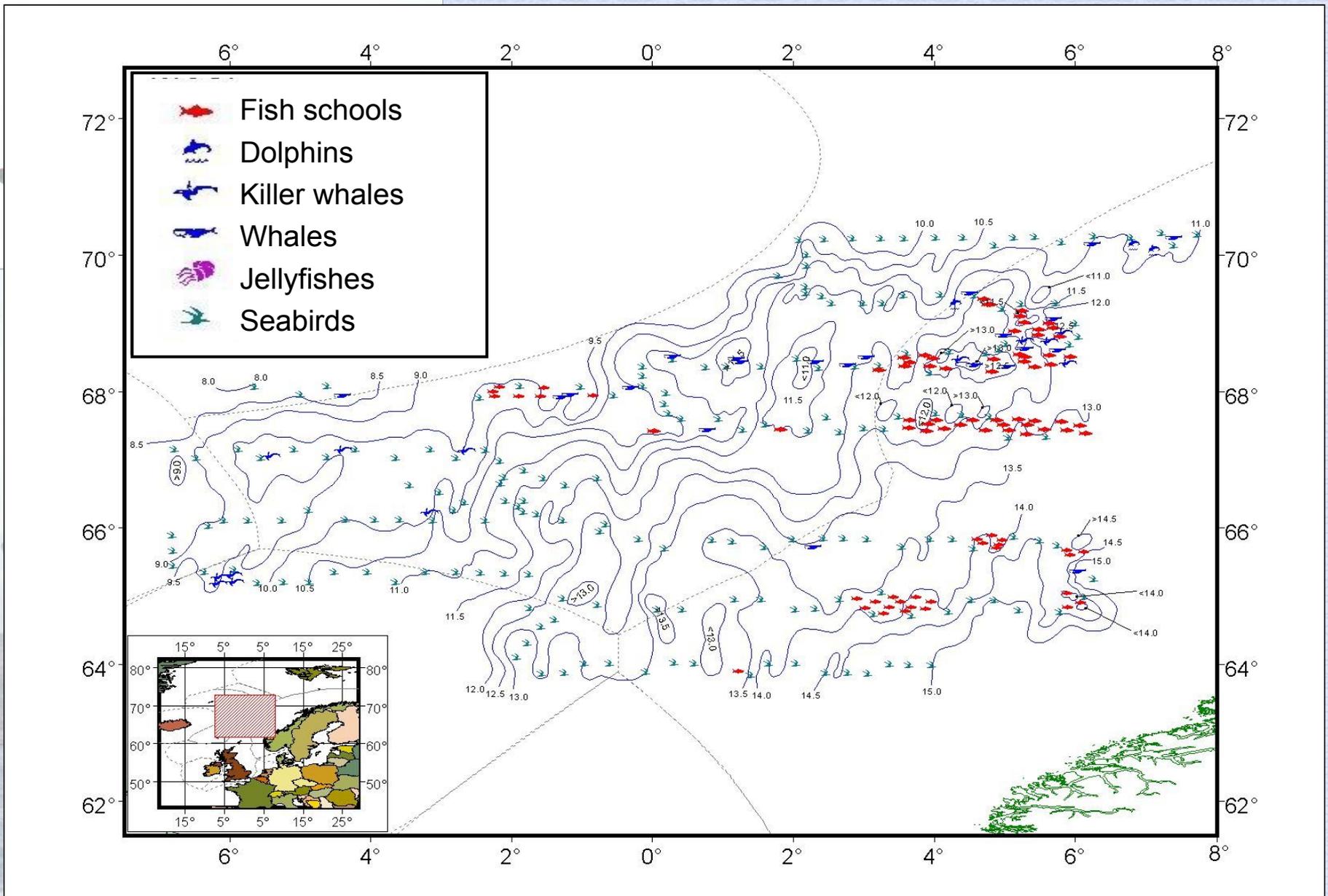
Example of "Lidarogram" with mackerel schools only, plankton is excluded, on the top is the first version of software and mathematical approach, lower is it developed and improved version



Example of SAR-image reflected local divergence area on sea surface, size of raw image (left side) – 2x6 km, in right side increased part of local divergence area

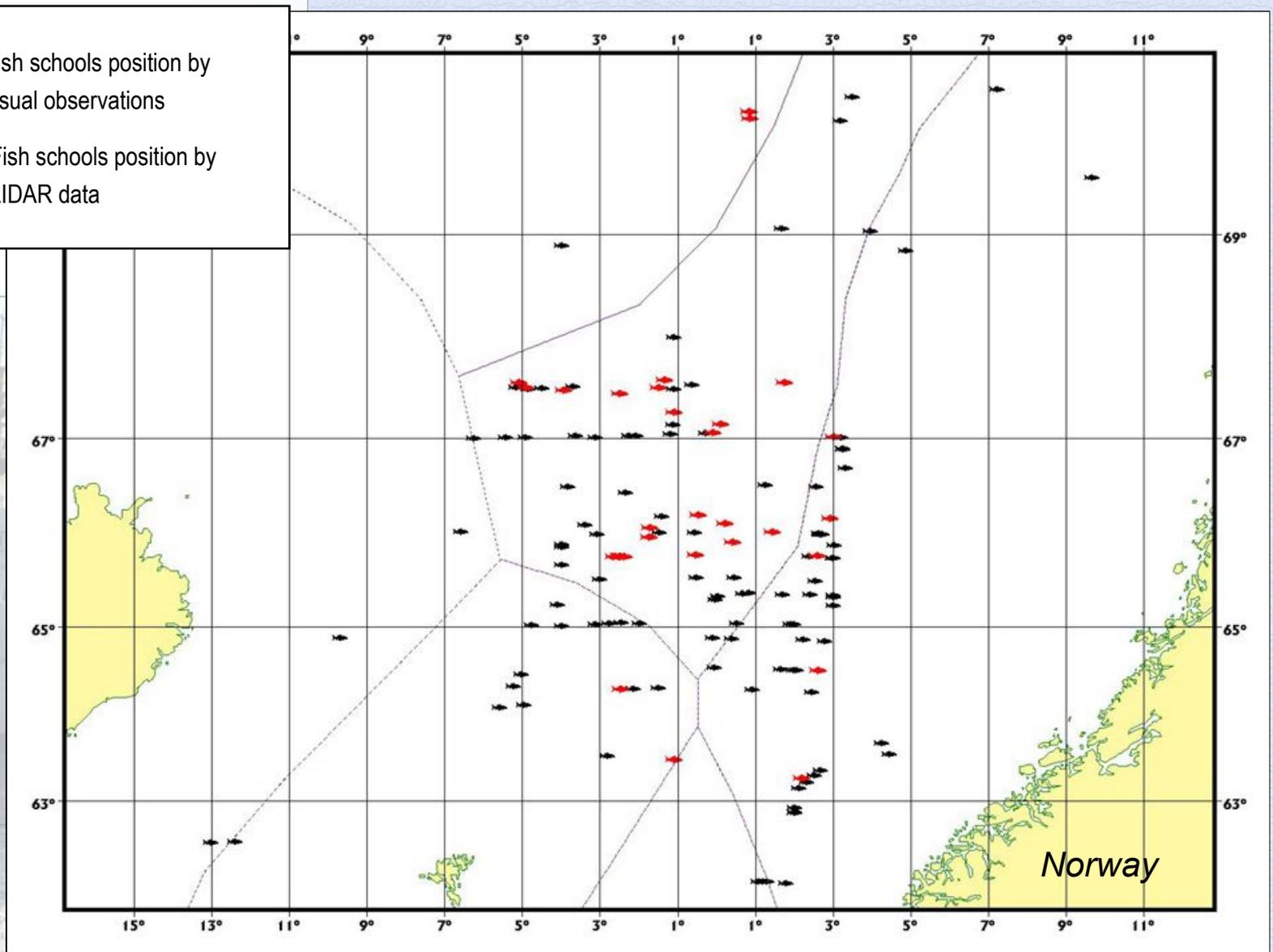


One more SAR-image example of hydrodynamics inhomogeneous local area (left part of SAR-image) and SAR-image of subsurface mackerel schools



Example of resulting GIS-map of the aerial surveys in 15-19.07.2005

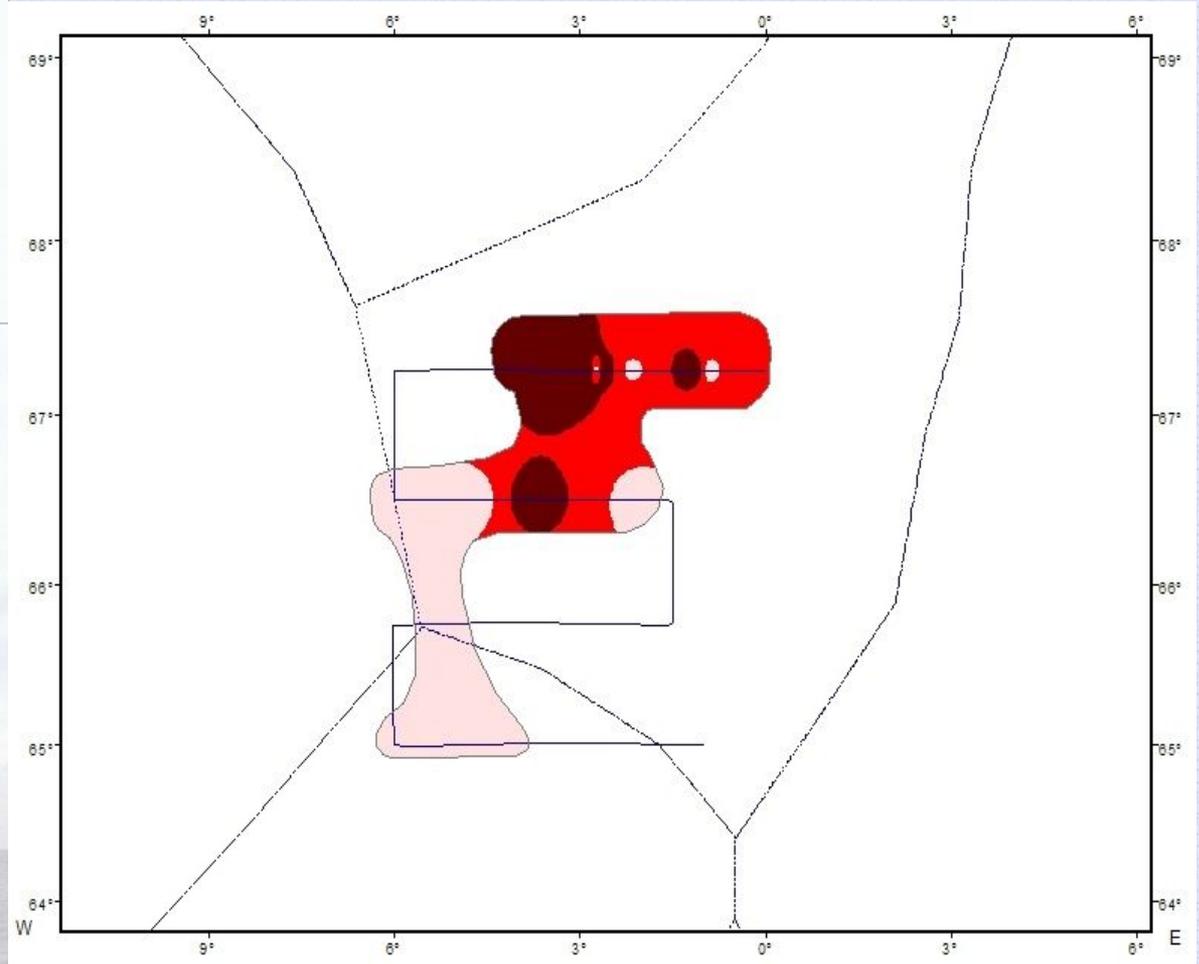
-  Fish schools position by visual observations
-  Fish schools position by LIDAR data



An example of feeding mackerel schools GIS-map spatial distribution by visual observations and lidar data

The main stages of pelagic fishes schools biomass probabilistically estimated calculation (for example of feeding mackerel)

1. Estimate shape of fish school horizontal section in subsurface layer (visual data) and define its size (visual observation and/or SAR-data);
2. Define fish school vertical size (lidar-data);
3. Make assumption that fish school horizontal section shape and size are constant along all their vertical (it has a very small probability);
4. Make calculation of fish school volume with using of standard mathematical methods (V);
5. Get information about mackerel average length (L) and weight (M) from research or fisheries vessels which work closely detected mackerel schools or right here;
6. Using research materials and results of Leonid Serebrov, Mikhail Zaferman, G.M. Gulen E. Shaw, and H.A. Baldwin about distance between separate fishes inside elementary fish school ($2,4L$), on base data about V и L , calculate fishes numbers in the school (N);
7. Make biomass probabilistically estimated calculation of school biomass ($N \times M$) – M_s ;
8. Calculate total biomass of all separate schools in aerial survey area (MS);
9. Carry out MS extrapolation to all research area where mackerel schools were detected.



Example of aerial research route and squared feeding mackerel spatial distribution on density for her biomass probabilistically estimated calculation



**COMPARISON OF FEEDING MACKEREL BIOMASS
PROBABILISTICALLY ESTIMATED CALCULATION (ON BASE OF
AERIAL RESEARCH DATA) AND SPAWNING MACKEREL
(RV "G.O. SARS" AND "SCOTIA") FOR THE SAME SEA AREA**



RESEARCH-AIRCRAFT (RA) – 372 000 T

"G.O. SARS" (GOS) – 375 000 T

"SCOTIA" (S) – 432 000 T



DIFFERENCE : RA-GOS – 0,8%, RA-S – 14%, AVERAGE – 7,4%
S-GOS – 14%



COUPLE MAIN CONCLUSIONS (IN OUR OPINION)

- *Here was showed possibility to use aerial research data for feeding mackerel biomass probabilistically estimated calculation which was use not only for local area but for all aerial research area. We can tell it after comparison with data of TAS spawning standard survey for the same sea area;*
 - *Using of aerial research for feeding mackerel biomass calculation and their environmental allow to decrease of financial expenditure in comparison of standard TAS in 5-6 times as show our estimation and information from other sources.*
- 
- 



***THANKS A LOT FOR
YOUR ATTENTION!***