Inventory of marine species and habitats for development of NATURA 2000 network in the offshore waters of Lithuania (DENOFLIT)

# Evaluation of diversity and distribution of habitats, fishes and birds in the Lithuanian exclusive economic zone for development of NATURA 2000 network

# Technical report


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# CONTENT

# 1. INTRODUCTION

During last decades marine nature conservation measures in the Lithuanian Baltic Sea waters were exclusively focused on territorial sea, which includes all the coastal waters. So far 3 sites have been established for conservation of marine values, the two largest being aimed at protection of significant concentrations of marine birds species, one site being delineated for protection of underwater coastal reefs and integrity of marine and terrestrial landscape; additional site has been established for protection of important area along the migration route of Twait shad *Alosa fallax* from the coastal sea to the freshwater in the Curonian lagoon. In total, all protected sites in the territorial waters account for 477.6 $km^2$ area, i.e. 25.6% of the total territorial sea.

Lithuanian offshore areas have neither national nor EU protection status. Common measures are applied for fishery limitations, but there were little considered in respect to other marine species and habitats. On the other hand, intensive economic growth after 1990's resulted in fast developments of various economic activities including exploration of potential sites for wind mill parks, exploration and exploitation of sand extraction and dumping sites, implementation of coast protection measures. Intensive progress in development of economic activities has been particularly observed during the last decade, its vision is currently bound with the development of a marine spatial plan, which coincided with the last site evaluation stages of the current DENOFLIT (Inventory of marine species and habitats for development of NATURA 2000 network in the offshore waters of Lithuania) project.

DENOFLIT project is aimed to conduct inventories of marine species and habitats in the offshore waters of Lithuanian EEZ and designate NATURA 2000 areas selected during site evaluation. The project objectives include evaluation of the offshore Lithuanian EEZ areas based on all available data including those collected during the project field inventories with respect to habitat types and species listed in the Habitat and Bird Directives. Additionally, project defines spatial boundaries for potential NATURA 2000 sites in the assessed offshore areas, develops recommendations for adequate and efficient conservation of habitats and species as well as designates NATURA 2000 sites, which are selected during evaluation phase.

This report is contains data and results from all three filed inventories and site evaluation. It serves main information source on how project data have been collected and analysed in order to carry out a complex assessment of offshore areas. It also provides information on site evaluation procedure and justifies proposed boundaries for NATURA 2000 sites to be designated during the forthcoming project period.

## 2. CRITERIA FOR PROTECTION OF NATURA 2000 SITES

**Benthic habitats.** Habitat inventory is targeted on reefs, defined as a hard compact substrata on solid and soft bottoms, which arise from the sea floor and are topographically distinct from the surrounding seafloor in the sublittoral or littoral zone (European Commission, 2007). Reefs may support a zonation of benthic communities of plants and animals, however this is more pronounced in the littoral or upper sublittoral zones. Hard compact substrata is defined as rocks (including soft rock, e.g. chalk), boulders and cobbles, generally >64 mm in diameter. Above mentioned criteria are used for general guidance in defining potential reef areas, while local expertise and knowledge in setting up quantitative criteria for justification of boundaries should be used. These criteria are usually related to the minimum coverage or abundance of the main reef building features: pebbles, gravel, boulders, cliffs or biogenic concretions (Dahl et al., 2003, Dahl et al., 2004), cobble, slope and type of biota (Irving, 2009), density of reef building species, biodiversity score according to Margalef's index and species richness, longevity score for biogenic reefs (Hendrick, Foster-Smith 2006).

Lithuanian national description of reefs was legally updated by the order of Minister of Environment in May 2014 (2014-05-22, Order Nr. 2014-05612) after consultations with the DENOFLIT project. Following national definition of reefs is currently valid:

In the coastal waters reefs comprise fields of large boulders, which are underwater extensions of terrestrial moraine ridges stretching from the coastline to the depth of 20-25 m. In the upper part of underwater slope single boulders can be exposed to the water surface, while with increasing depth vegetation and sessile faunal communities are characterized by distinct ecological zonation. In the offshore waters and deeper coastal areas reefs are geomorphologically distinct from the surrounding seafloor moraine shallows or ridges. Reefs in aphotic zones are dominated by fauna attached to the hard substrate.

Characteristic species. Plants (in coastal waters to the depth of 20 m.): green algae *Cladophora glomerata, C. rupestris, Ulva intestinalis, U. prolifera*; red algae *Furcellaria lumbricalis, Ceramium tenuicorne, Polysiphonia fucoides, Coccotylus truncatus*; brown algae *Ectocarpus siliculosus, Sphacelaria arctica*. Macrofauna: colonies of mussles *Mytilus edulis*; barnacles *Balanus improvisus*; bryozoan *Electra crustulenta*, polychaete *Fabricia sabella*, amphipods *Gammarus sp*.

**Marine birds.** For identification and delineation of important waterbird aggregations, Marine Conservation Criterion (Skov *et al*., 2007) was used. It uses thresholds of both bird density and bird numbers for the assessment of the importance of area to birds. According to this site selection methodology, in order to be designated, sites should meet two main criteria: i) the density of birds should be at least four times higher than the average density of the species in question in the entire Baltic Sea and ii) the site should contain at least 1% of the species' biogeographic population. However, the threshold numbers for the designation of SPAs in Lithuania, including the marine areas for migrating birds, are stated in Annex 3 of the order of the Minister of Environment No D1-358 of 2 July 2008 "On the approval of criteria for the selection of Special Protection Areas for birds". While these numbers originally were based on the 1% biogeographic population estimates, in case of marine waterbirds, they have not been updated with the update of biogeographic estimates for the Baltic Sea region (Wetlands International, 2014). Therefore, the official threshold numbers were used for the site selection in this project, while the updated population estimates were used for the calculation of threshold bird densities (Table 2.1).

Table 2.1. Threshold bird densities and threshold bird numbers used for identification of SPAs in the Lithuanian EEZ. Threshold bird numbers according to the updated population estimates are provided for comparison (WPE 5 – Waterbird Population Estimates 5).

| Species | Bird density threshold | Bird number threshold | |
|---|---|---|---|
| | | MoE order | WPE 5 |
| Red-throated Diver | 0.8 | 3000 | 2600 |
| Black-throated Diver | 0.8 | 3750 | 3500 |
| Long-tailed Duck | 19.73 | 20000 | 16000 |
| Velvet Scoter | 5.53 | 10000 | 4500 |
| Razorbill | 2.1 | 100 | 12000 |
| Guillemot | 0.3 | 450 | 450 |

# 3. LITHUANIAN MARINE AREA AND PROJECT SITES

***Lithuanian offshore areas.*** Lithuanian Exclusive Economic zone is extended over 6,104 km$^2$ along the 90 km coastline. Although the depths can reach 120 m, the territory exclusively belongs to the shelf area. Salinity of surface waters vary between 7-8‰, halocline is observed from 60 to 80 m depth, with increasing salinity up to 10‰.

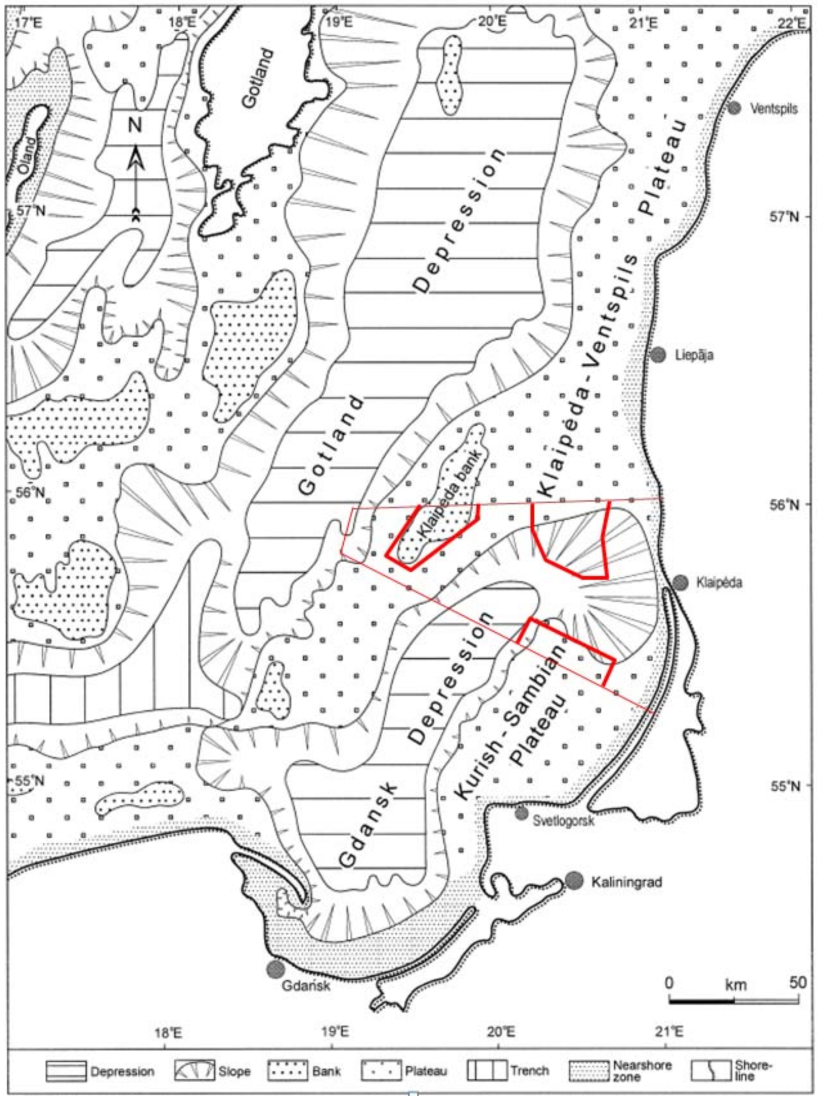



**Figure 3.1.** Map of the south-eastern and central Baltic seabed morphology and location of three project areas: 1. Sambian plateau; 2. Klaipeda – Ventspils plateau; 3. Klaipeda Bank From: Gelumbauskaite et al. 1991.

Major part of the territory belongs to several geomorphologically distinct areas. In the north it borders Klaipėda-Ventspilis plateau, while in the south-west - northern slopes of the Gdansk basin (Fig. 3.1). The Sambian plateau stretches in the very south of the Lithuanian marine waters, whereas western part of the EEZ morphologically belongs to the western part of the Gotland depression and Klaipėda Bank. The project inventories focused on three major shallows in the areas outside territorial sea: northern part of the Sambian plateau in the south (further referred as to Sambian plateau), southern part of the Klaipeda – Ventspils plateau in the north (further referred as to Klaipeda-Ventspils plateau) and Klaipeda Bank next to the slopes of the Gotland Depression in the west (Fig. 3). All three project areas account for 1607 km$^2$ territory, i.e. 26% of the Lithuanian marine waters.

***Sambian Plateau.*** The project area is located in the southern part of the Lithuanian EEZ, at a distance of approximately 22 km from the coastline, bordered by Russian EEZ in the south-west and Lithuanian territorial sea at the south-eastern edge (Fig. 3.2). The area covers part of the Sambian plateau and extends to the north towards the slopes of the Gdansk depression. It occupies 436 $km^2$, i.e. 7% of the total Lithuanian marine waters. The area has neither national nor EU protection status. Common measures are applied for fishery limitations. The area is intensively exploited by commercial and recreational fishing of the Baltic cod. It is crossed by major navigation route, underwater cable, partly overlaps with former minefields and burial places of chemical weapon. The area is in close vicinity to potential oil sources of the Lithuanian EEZ and operating D6 Oil Platform in the EEZ of the Russian Federation.

***Klaipeda-Ventspils Plateau.*** This project area is located on the northeastern part of the Lithuanian EEZ, in a distance of approx. 22 km from the coastline, bordered by Latvian EEZ in the north and Lithuanian territorial waters in the east (Fig. 3.2). It is the largest project area which occupies 663 $km^2$, i.e. 10% of the total Lithuanian marine waters. The northern part of the area is situated in the Klaipėda-Ventspils plateau, while the southern part extends towards south-east along the slope of the Gdansk depression. The area has neither national nor EU protection status. Common measures are applied for fishery limitations. Main use of the marine area is commercial fishing by trawling and netting. The area is intersected by major navigation route and lane of underwater cable, as well as occupied by dangerous area (former minefields and burial places of chemical weapon). Klaipeda-Ventspils Plateau is in close vicinity to the Butinge Oil Terminal and tanker anchoring zone. Recently the area has been included into the list of potential marine windfarm areas and is the largest foreseen zone in the Lithuanian EEZ for such development.

***Klaipeda Bank.*** The project area is located at the westernmost part of the Lithuanian EEZ, in a distance of approximately 72 km from the coastline, bordered by Latvian EEZ in the north (Fig. 3.2). The area constitutes a part of the Klaipeda Bank in close vicinity to the Gotland Deep (noted as Gotland depression in Fig. 3.2); it extends over 508 $km^2$, i.e. 8% of the total Lithuanian marine waters. The Klaipeda Bank is mainly exploited by commercial fishing and has neither national nor EU protection status. Common measures are applied for fishery limitations. The target area is crossed by underwater cables, it partly overlaps the former minefields and burial places of chemical weapon. Central part of the study area has been classified as suitable for establishment of marine windfarms.

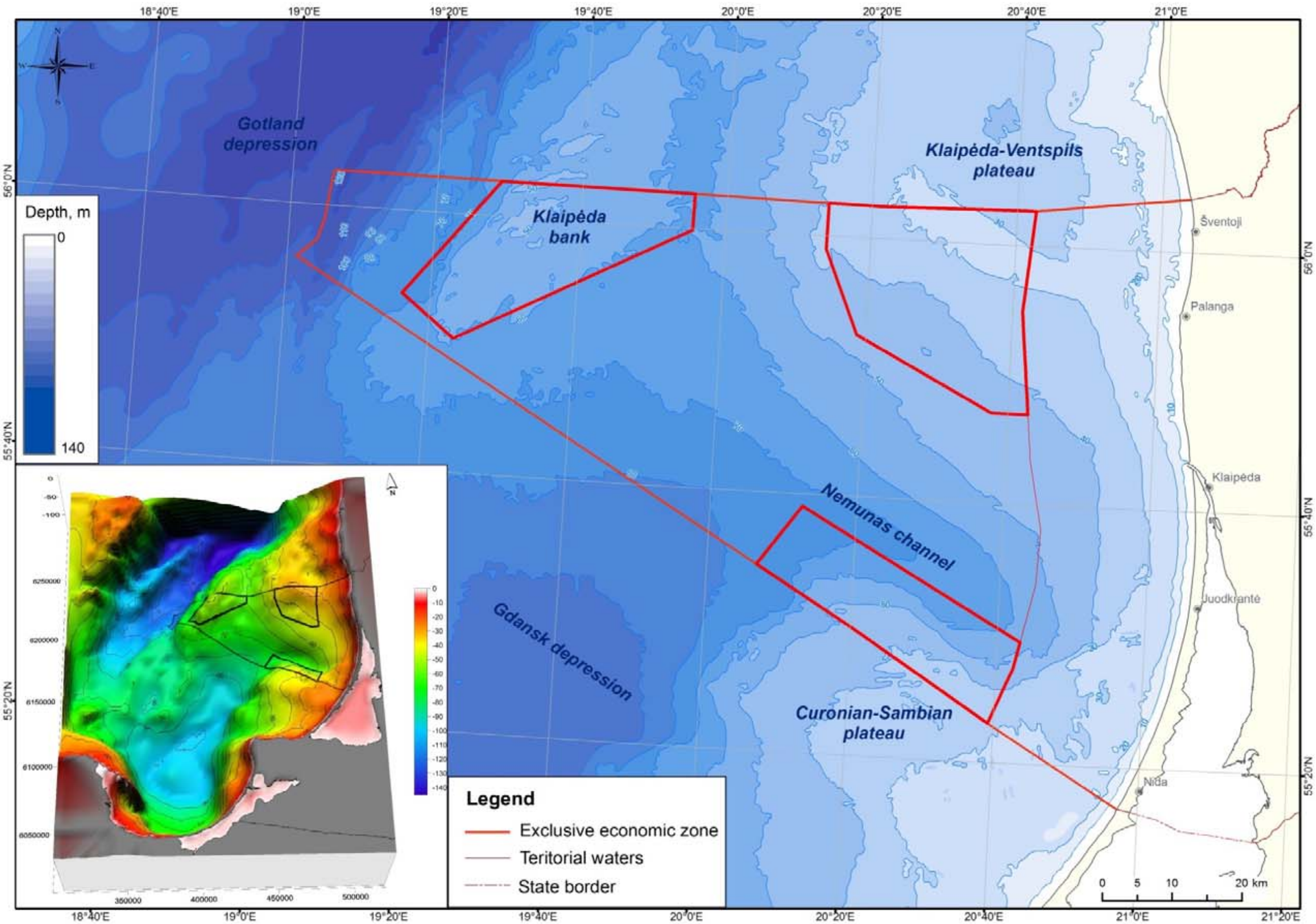



Figure 3.2. General positioning of the project areas in a context of large geomorphological structures of the south-eastern Baltic Sea.

# 4. HABITAT INVENTORY

## 4.1 Material and methods

Habitat inventory consisted of bathymetric, geological and biological mapping in all three project areas. Data sampling resulted in 1063 km of acoustic lines, 60 grain size samples (no replication in study sites), 110 grab and dredge samples for biological analysis (one to three samples per site) and 140 video transects of 30 sec. each (Table 4.1). Distribution of grab/dredge and ROV sampling sites was adjusted according to the historical data on seabed geology (Simenas et al. 1989, not published), which have been digitized and allowed to replace random or systematic sampling by stratified sampling with optimized effort per substrate type and depth zone. Sampling sites are shown in Figure 4.1.

Three different data layers have been generated after analysis: distribution of sediment types (based on results from side scan sonar and ground-truthing, adjusted using historical data from Simenas et al. 1989), bathymetric charts (multibeam acoustic data) and habitat distribution (integrated sediment, bathymetry and biology data).

Table 4.1. Amount of data collected during the habitat inventory in three project areas.

| Project area | Acoustic profiles, total length, km | Area covered by SSS, km² | Grain size samples | Grab and dredgde samples | Video transects (30 sec.) |
|---|---|---|---|---|---|
| Sambian Plateau | 258 | 78 | 20 | 50 | 45 |
| Klaipeda-Ventspils plateau | 485 | 67,5 | 22 | 35 | 45 |
| Klaipeda Bank | 320 | 91,8 | 18 | 25 | 50 |
| **Total:** | **1063** | **237.3** | **60** | **110** | **140** |

***Grab and dredge sampling.*** Quantitative sampling of bottom macrofauna (benthic animals which size exceeds 1 mm) was performed from the R/V "Darius" in all three project areas in spring of 2012, 2013 and 2014. Soft bottoms were sampled with a standard 0.1 m² Van Veen grab (50 kg), while hard bottoms were dredged with the bottom dredge (opening width 1.02 m., opening height 0.42). All samples were washed through a 0.5 mm mesh sieve on board and preserved with 4% formalin neutralised with $NaHCO_3$. Further treatment of material was performed according to HELCOM, (1988, 1997). Animals were identified to species level where practicable. Biomass was determined as formalin wet weight (g $m^{-2}$). Species which formed more than 40% of the total macrofauna biomass or abundance were considered as dominant. Grab samples were used for identification and quantitative description of benthic habitats, whereas sampling information from dredging was used for overall biodiversity assessment of hard bottom habitats.

***Underwater video inspections and data handling.*** Video data were collected with Mariscope remotely operated vehicle (ROV) (weight approx. 60 kg) equipped with two color cameras. Steering camera was mounted in tilted unit with practical resolution 320 TVL and used for navigation purposes and overview of the surrounding seabed (if visibility conditions allow). Main 3CCD fullHD (1920x1080) resolution camera served a main visual inspection unit, it was equipped with high quality Leica Dicomar lenses (10X optical zoom) and mounted vertically to the seafloor. Lights systems consisted of 18 bright LED's joined into 6 stations: 4x4 for main camera and 2x1 for steering camera. Additionally, ROV was equipped with compass, depth sensor, acoustical altimeter and acoustical USBL navigation system.

In the study sites ROV was descended to the bottom and its course was maintained using internal compass readings. In each station seabed was visually inspected and recorded for 5 min. or approx. 150 meters long distance, which was further converted into 10 transects (30 sec. each, distance of 15 m in average). ROV altitude has been chosen according to the main camera image to ensure the highest image quality and manually maintained using acoustical altimeter readings, typically between 0.8 and 1.2 m. above the seabed. ROV speed during the recording was maintained about 2 knots. No frames blurring appeared at this speed using main camera shutter speed fixed at 1/250. Main camera was set into progressive scan mode to avoid interlace artifacts and fullHD resolution video has been recorded into internal camera storage. Steering camera video image was transferred to the surface in real time and also recorded as 720x576 DV video, ensuring maximum possible quality. Screen of the control computer with synchronized data from steering camera, altimeter, ROV USBL navigation, ship navigation, ROV depth sensor and internal compass was logged into video file providing.

Video data was analyzed manually, dividing entire transect video record into 30 seconds intervals. All video records were analyzed by the same person. Visual features assessed during video analysis are listed in Table 4.2.

Table 4.2. Visual features assessed from ROV data.

| Geological features | | Biological features | |
|---|---|---|---|
| Clay | Cover, % | *Mytilus trossulus* | Cover, % |
| Sand (0-1cm) | Cover, % | *Balanus improvisus* | Presence, 1/0 |
| Gravel (1-5 cm) | Cover, % | *Saduria entomon* | Presence, 1/0 |
| Pebble (5-20 cm) | Cover, % | *Pygospio elegans* | Presence, 1/0 |
| Boulders (>20 cm) | Cover, % | *Hydroidea* | Presence, 1/0 |

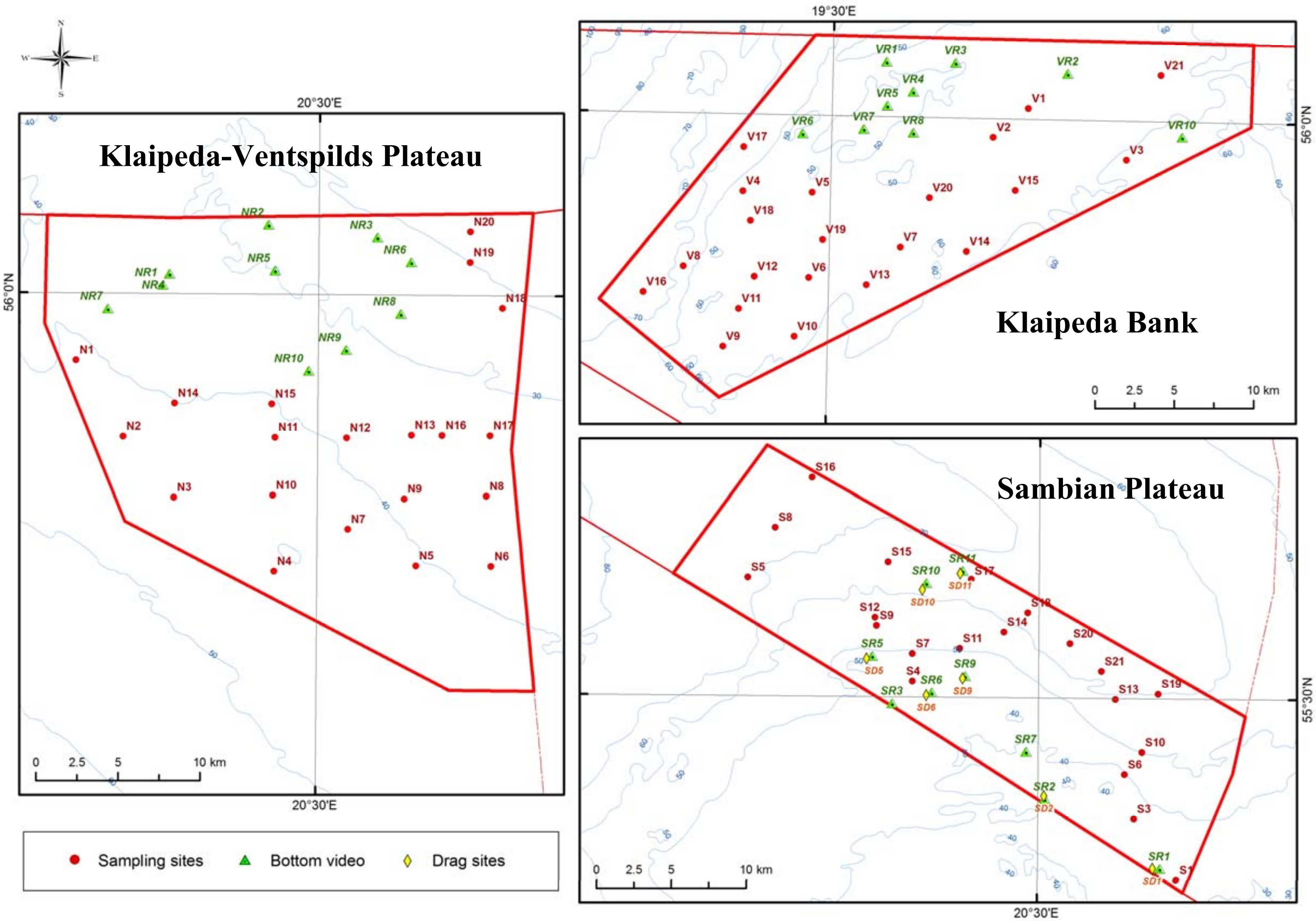



Figure 4.1. Distribution of sampling sites in three project areas. Green symbols denote sites inspected with ROV; red symbols – grab sampling sites for grain size and benthic macrofauna analysis, rombs – sites with combined sampling by ROV and grab/dredge.

***Acoustic methods.*** Two frequency (100 kHz and 500 kHz) high resolution digital side scan sonar (SSS) system Klein 3000 capable of transmitting and receiving both frequencies independently was used during acoustic surveys for sediment mapping. SSS provide data on acoustic backscatter, the strength of which directly depends on the geoacoustic properties of the seabed surface (porosity, density, etc.). Backscatter strength reflects how original acoustic signal is absorbed or scattered by the surface, what allows us to judge about surface physical properties and to map bottom features. Due to the size of study areas, series of non-overlapping lines of approx. 300 m width were collected initially (Fig. 4.2), their total length and area covered are provided in Table 4.1.

Position and altitude of a towed sonar body ("sonar fish") above the sea floor was controlled by vessel speed and amount of descended cable. Due to the angular nature of SSS acoustic signal, data resolution depends on transversal (perpendicular to track) and axial (along the track) resolutions. Both are range dependent, therefore the greater range typically result in a lower signal resolution. Since actual scanning range depends on the sonar fish altitude, which in turn is difficult to keep fixed in case of passively towed devices, large distance surveys in project areas with considerable depth gradients resulted in variable physical resolution of collected data.

On the other hand, there is a number of additional factors affecting backscatter. Backscatter strength is distance dependent – the longer sound wave had to travel, the stronger it attenuates due to the signal absorption in the water column. This results in the different backscatter strengths when going further from nadir. Returned signal strength is also affected by changes in the sonar fish altitude, pitch and roll. Changes in sonar fish may result in overlapping or too dispersed neighboring pings, which can be compensated during processing. Sudden changes in the sonar fish speed (e.g. due to wave action) can also result in data artifacts and inconsistency in the data resolution. Inconsistences and distortions in the acoustical backscatter data are also caused by salinity and temperature variation in the water column (result in changes of water density), acoustic noise (produced by e.g. passing ships), sub-surface echoes when signal penetrates the surface and geometric artifacts, when backscatter strength is affected by surface slope (e.g. surface angled towards transmitter gives stronger echo).

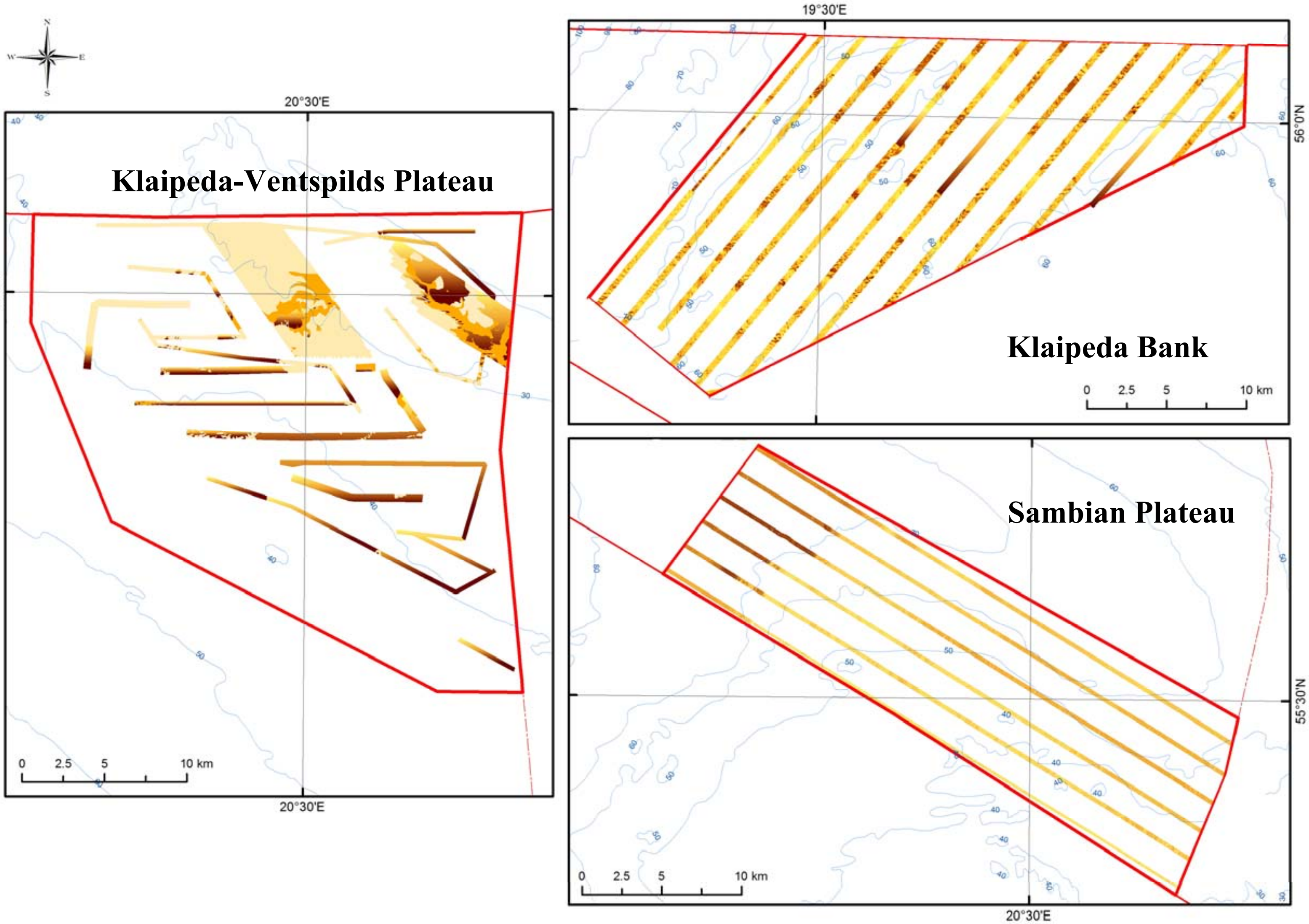



Figure 4.2. Distribution of acoustic transects in three project areas.

For this study SSS data was analyzed using DELPH and Fledermaus Pro software. 2D resolution of the SSS images was 20 cm per pixel, but due to variation in physical transversal and axial resolutions, actual resolution was in some cases significantly lower (for some features around 0.5-1 m). Using DELPH software two frequency data were analysed simultaneously to increase interpretation accuracy.

***Acoustic identification of habitats.*** Interpretation of SSS backscatter data is based on analysis of 2D image consisting of pixels having different gray levels, which represent backscatter strength. Image filters were applied in order to enhance objects visibility before automated interpretation (classification) process of backscatter images, however most frequently visual control and subjective interpretations were needed to judge the classification results. Hence, software based interpretation and its visual control was contour oriented, linking pixels together for optimal classification solution.

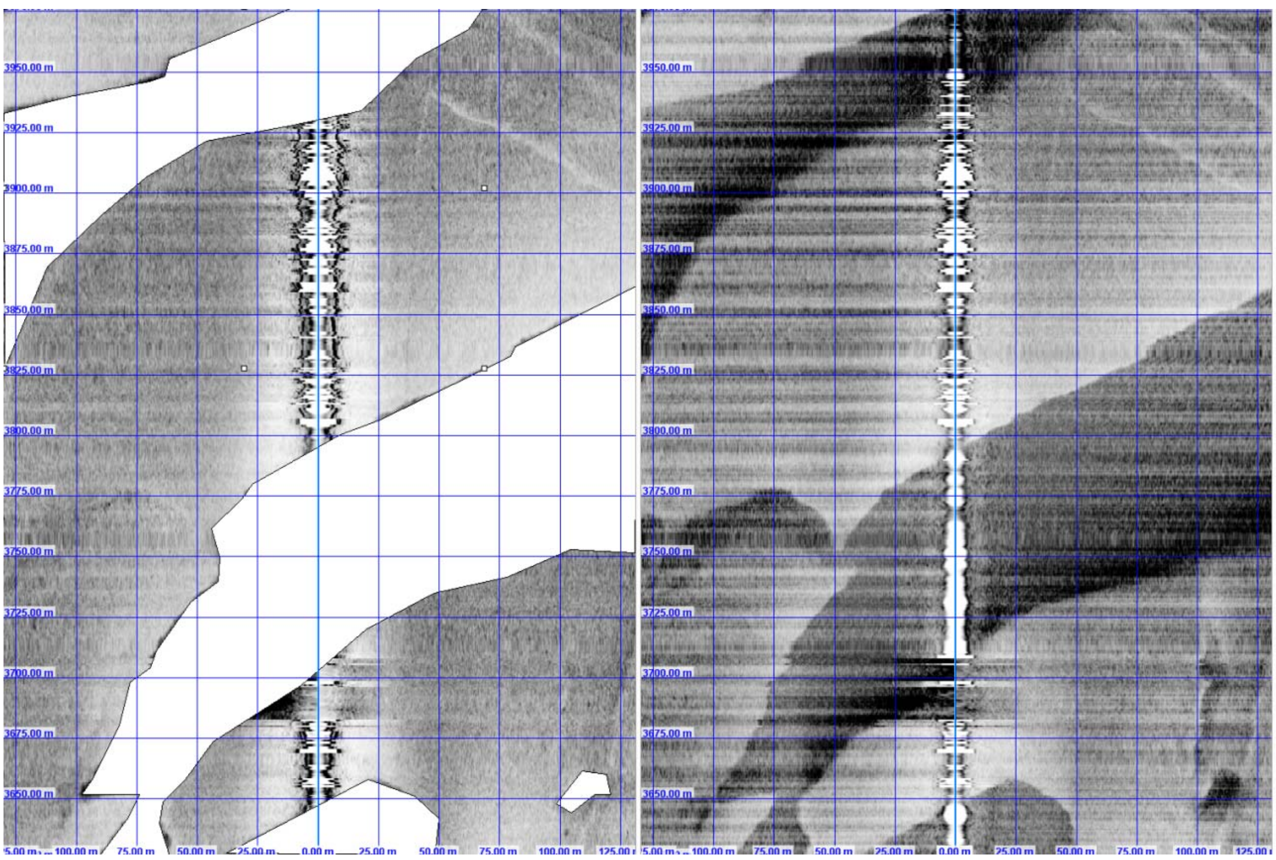


Figure 4.3. Comparison of 100 kHz (left) and 500 kHz (right) frequency side scan sonar images of soft bottom sediments.

For sandy bottoms two types of sediments were distinguished: softer (appear darker) and harder (appear brighter). Due to better penetration of lower frequency sonar signal, some features visible on high frequency image are masked by sub-bottom reflection and therefore not visible on lower frequency image. Because 100 kHz signal can only penetrate few centimeters into the sediments, and such thin layer may not be sufficiently stable over time, these features were ignored (Fig. 4.3).

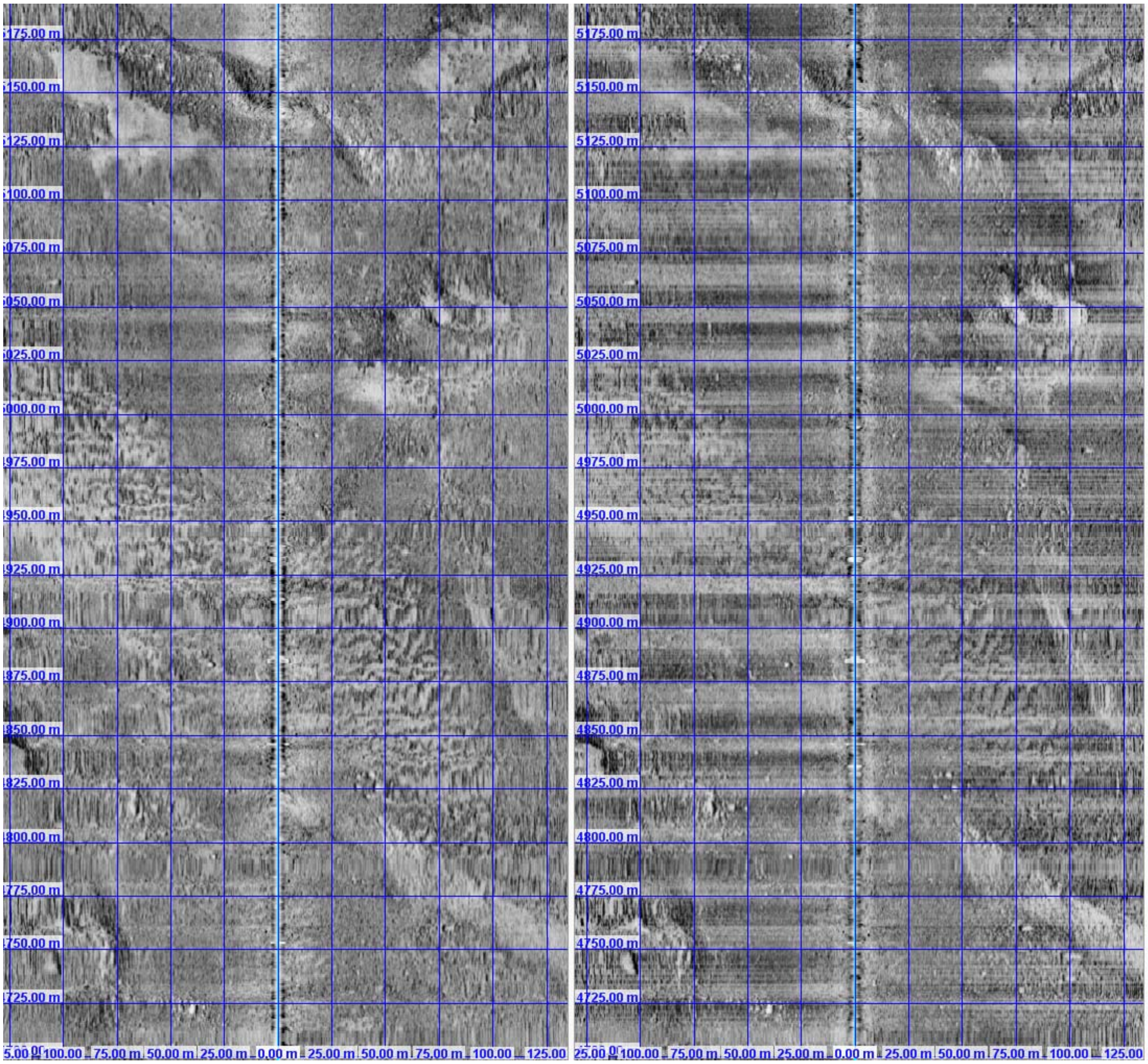



Figure 4.4. Typical complex mosaics of soft sediment and hard substrates with low number of individual boulders in 100 kHz (left) and 500 kHz (right) frequency images.

Boulders and cobbles in this study were not possible to distinguish by backscatter strength only due to presence of other types of hard substrates (e.g. pebble), which have relatively strong backscatter and form complex mosaics (Fig. 4.4). Therefore boulders have been mainly identified by acoustic shadows. Since mixture of soft sediment and hard substrates was usually present, reefs were identified by significant amount of boulders reflected in the acoustic image. We used criteria of acoustic hard bottom (boulders, cobbles, pebbles) with at least one acoustically detectable boulder in more than 50% of 10x10 m squares for the area to be classified as a hard (moraine) bottoms which should be further inspected for presence of boulder and cobble reefs with underwater video. High frequency 500 kHz sonar data were used for this analysis due to higher potential to distinguish individual boulders in comparison to 100 kHz sonar data (Fig. 4.4). Distribution boundaries of such hard substrates were adjusted and justified also using available historical sediment maps.

Muddy bottom was distinguished by backscatter strength (Fig. 4.5). Application of standard processing filters settings for this sediment type resulted in undersaturated picture with no surface details visible, therefore processing filters needed to be adjusted, making the rest of the data heavily oversaturated and little use.

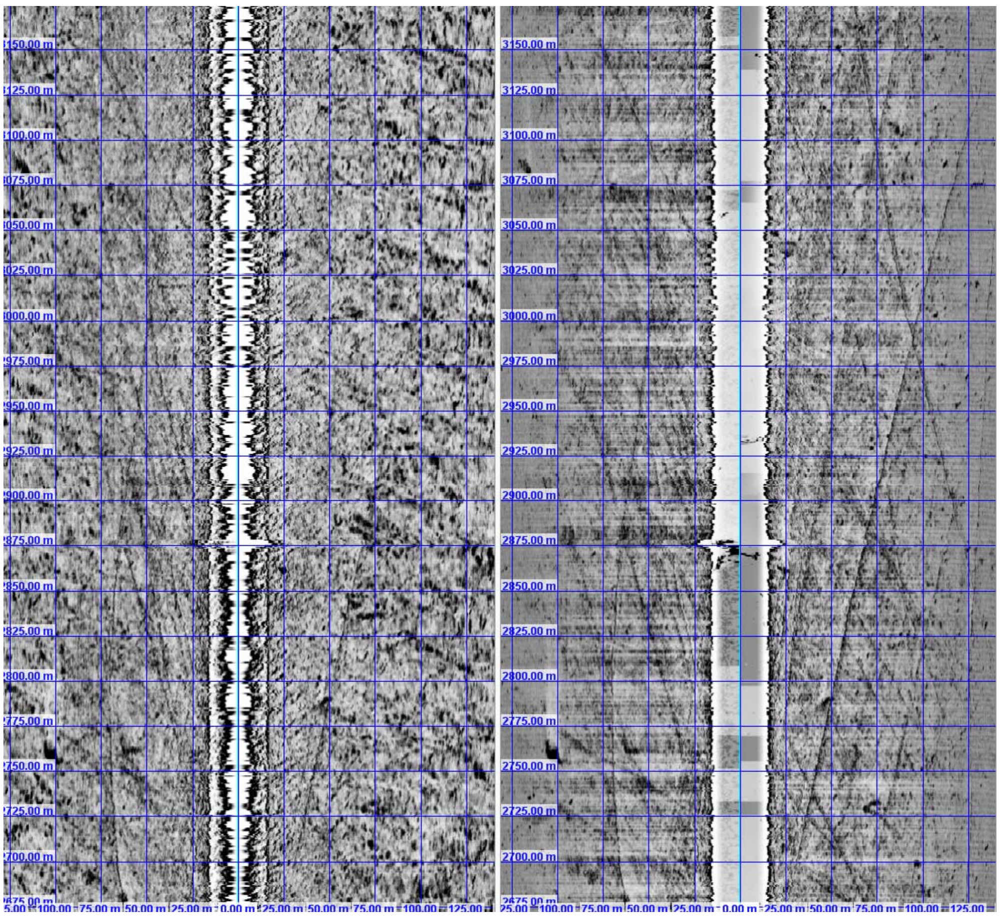


Figure 4.5. Muddy bottoms with trawling marks

Following acoustic bottom types were classified:

1. fine to medium sand which appears dark in SSS images.

2. coarse sand, appears lighter in the SSS images, but do not have distinguishable structures or objects within it.

3. mud with, low backscatter level compared to other types.

4. hard bottoms, distinguished by significant amount of boulders (at least one visible in majority (>50%) of 10x10 meters segments).

5. mixed bottoms with complex mixture of bottom sediments that could not be reliably classified as any of the classes above.

Grab sampling, dredging and seabed inspections with ROV were used for ground-truthing and further classification of different seabed types, which were detected and classified according to the acoustic features. Their applicability differed significantly in identification and characterization of various seabed types (Table 4.3)

Table 4.3. Level of applicability of different mapping and ground-truthing techniques for detection and characterization of benthic habitats (+++ - very high, ++ - medium, + - low; .”-“ - not applicable.

| **Seabed type** | **Side-scan sonar** | **Grab** | **Dredge** | **ROV** |
|---|---|---|---|---|
| Hard bottom with cobbles and boulders | ++ | - | +++ | +++ |
| Pebble dominated hard bottoms and mixed bottoms | ++ | | ++ | +++ |
| Coarse sand ripples and gravel | +++ | +++ | + | +++ |
| Silty and sandy bottoms | +++ | +++ | - | + |
| Soft clay bottoms | - | +++ | - | ++ |
| Muddy bottoms | +++ | +++ | - | - |

## 4.2 Sambian Plateau

### 4.2.1 Bathymetry and geomorphology

The project area is located on the Curonian-Sambian Plateau in the south and extending on the slopes of the Gdansk depression in the west and Nemunas Chanel in the north (Fig. 3.2). The shallow zone (<40 m depth) of Curonian-Sambian plateau, located in the south of the study area, comprises uplifted undulating surface oriented towards open sea in a northwest to southeast direction (Fig. 3.2). The seabed of the shallow zone gradually deepens to NW towards Gdansk depression up to 78 m water depth and NE towards Nemunas Chanel up to 68 m water depth. Steep slopes are observed in a NW direction (~ 0.19$^{o}$), more gentle (~ 0.09$^{o}$) towards NE (Fig. 4.6, 4.7). Overall, the water depth in the project area vary from 34 m in SE to 78 m in NW, with average water depth of 56 m. Different depth zones between 40 and more than 70 m depth occupy relatively similar areas (Table 4.4), whereas the depths lower than 40 m account for less than 10% of the total project area.

Table 4.4 Distribution of water depth zones in the project area.

| Depth zone | Area, km$^2$ | Percentage (%) of the project area |
|---|---|---|
| < 40 m | 33 | 8 |
| 40-50 m | 93 | 21 |
| 50-60 m | 123 | 28 |
| 60-70 m | 105 | 24 |
| >70 m | 82 | 19 |

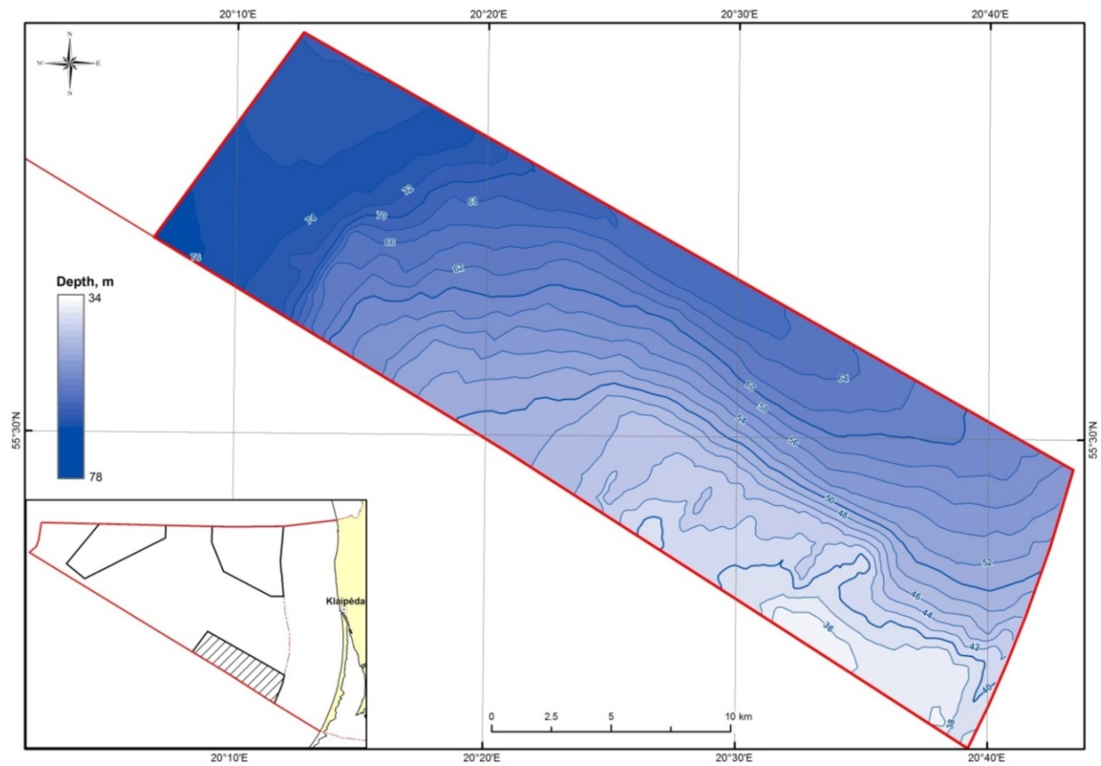



Figure 4.6. Bathymetry map of the project area.

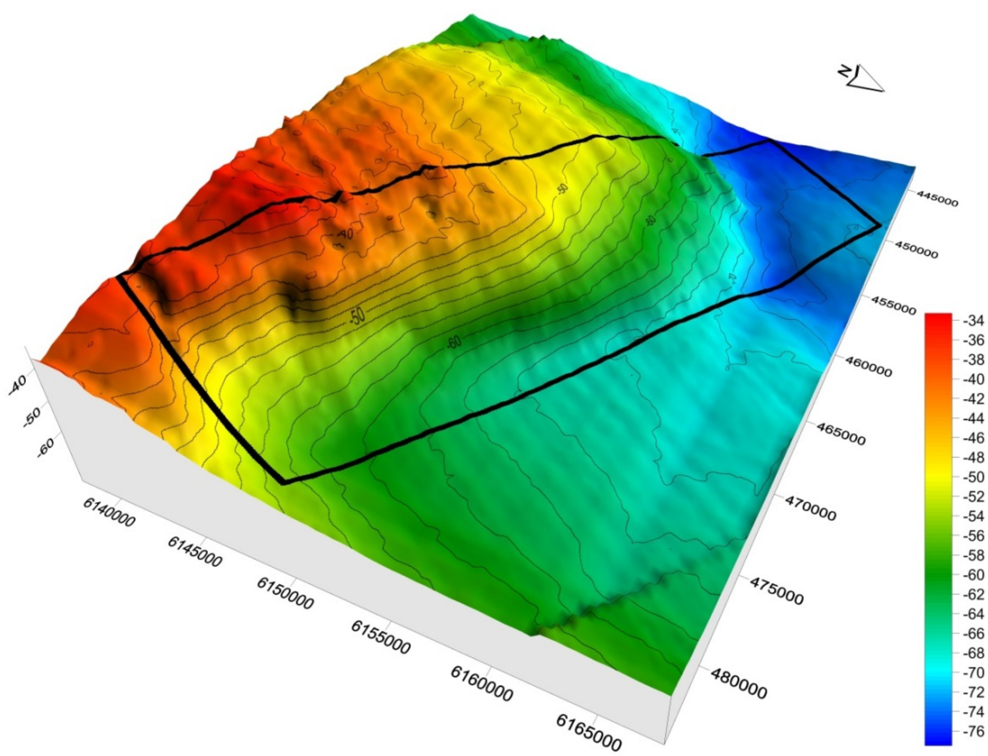



Figure 4.7. Seabed topography of the project area.

### 4.2.2 Sediment types

Seabed of the project area is covered by the Quaternary sediments that usually have approx. 10 m thickness at uplifted part of the Sambian plateau and up to 80 m thickness in Nemunas channel north-east from plateau. Quaternary sediments are represented by two lithological complexes: 1) glacial (till with gravel and boulders) and glacio-lacustrine (clayey silt, silty clay) sediments of Late Weichselian age; 2) not stratified Holocene marine deposits (fine sand, silty sand) and Littorina and Yoldia seas sediments (mud).

Glacial deposits located at the south-western part of the study area contain washed-out glacial till with gravel and boulders fields and patches of sand (Fig. 4.8). Boulder fields are mainly wide spread in the shallow zone with depth range from 34 to 44 m and the deeper part from 50 up to 70 m, in total these fields occupy 21% of the total study area (Table 4.5). Various grained sand of Holocene marine deposits occur along the Gdansk depression slope in the central part of the study area in the medium depth zone (50-60 m). Sandy deposits, predominantly fine sand, cover 47% of the project area. Silty and clayey deposit, such as clayey silt and silty clay, appear at 64 m water depth at Nemunas channel in the north-east of the study area. The deepest zone of the study area from 70 to 78 m is covered by pelitic mud. Predominance of various sands are observed at the intermediate depth zone (50-60 m), while mud, silt and clay are typical for the deeper parts.

Table 4.5. Distribution of surface sediments in the project area

| Sediment type | Area, $km^2$ | Percentage (%) of the project area |
|---|---|---|
| Aleuritic-pelitic mud | 70 | 16.1 |
| Pelitic mud | 6 | 1.4 |
| Silty clay | 21 | 4.8 |
| Clayey silt | 8 | 1.8 |
| Silty sand | 42 | 9.6 |
| Fine sand | 132 | 30.3 |
| Medium sand | 15 | 3.4 |
| Gravely sand | 16 | 3.7 |
| Morainic loam | 6 | 1.4 |
| Gravel | 28 | 6.4 |
| Boulders | 92 | 21.1 |

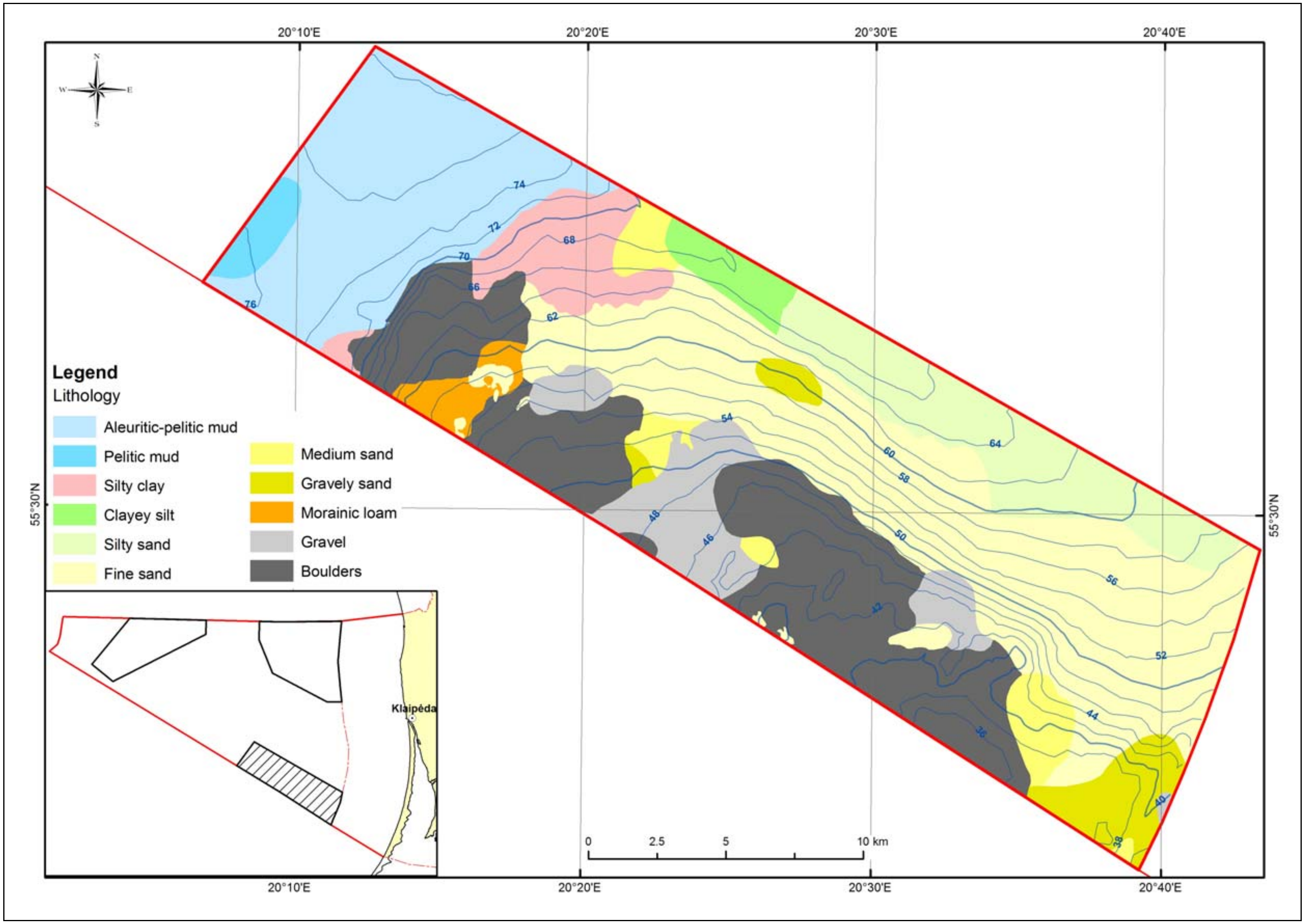



Figure 4.8. Diversity and distribution of bottoms sediment types in the Sambian plateau.

### 4.2.3 Diversity, structure and distribution of benthic habitats

*Species diversity.* In total 23 species and higher order taxa have been recorded in the area (Table 4.6). Half of them are typical infaunal species and another 8 are sessile epifaunal (*Mytilus trossulus*, *Balanus improvisus*, *Electra crustulenta* and *Cordylohora caspia*) or tightly associated with epibenthic species. Two recorded species (*Neomysis integer* and *Mysis mixta*) are purely pelagic. More than half of the recorded species belong to two large taxonomic groups: crustaceans is the most diverse group with 11 species and polychaetes is second the most diverse group with 4 species.

*Macoma balthica* and *Marenzelleria neglecta* are two very common species in grab samples with the occurrence above 90%, while other two species (*Bylgides sarsi* and *Mysis mixta*) were permanently found in dredge samples next to non-native spionid *M. neglecta*.

Dredge sampling delivered 12 unique species/taxa versus 2 unique species reported from grab samples. This indicates higher macrofauna patchiness in heterogeneous mixed and hard substrates.

*Bottom macrofauna communities.* Several major shifts in the structure of the soft bottom macrofauna were recorded along the environmental gradients in the area: 1. high variation of relative abundance of two spionid polychaetes *M. neglecta* and *Pygospio elegans* (from 40 to 90% dominance of *M. neglecta* and between 0 and 40% for *Pygospio elegans*); 2. changes in dominance of ostracod crustaceans (40-100% abundance dominance); 3. occasional presence of *Saduria entomon* (10-40% biomass dominance) and corresponding changes in biomass dominance of *Macoma balthica* (45-99%). Summarising these changes in terms of dominant macrofauna taxa, two different communities dominated either by ostracod crustaceans or bivalve *Macoma balthica* have been distinguished in the Sambian plateau (Table 4.7).

Ostracod community with only two taxa in samples on average typically has very low abundance and biomass (Table 4.7). Although ostracods can be the only taxa locally present in the sediment, usually this group takes approx. 76±11% and 56±19% of the total macrofauna abundance and biomass, respectively. Other species such as *Hediste diversicolor, M. neglecta, Monoporeia affinis, M. balthica* occur occasionally with no regular pattern, and their biomass and abundance are highly variable.

Table 4.6. Species composition from grab and dredge samples taken in the Sambian Plateau.

| Seabed type / sampling device | | Soft bottoms (grab samples) | | | | Hard and mixed bottoms (dredge) | | |
|---|---|---|---|---|---|---|---|---|
| Parameter, units | | Occurrence % | Biomass g $m^{-2}$ | Abundance ind $m^{-2}$ | Depth range m | Occurrence % | Abundance rank | Depth range m |
| Taxa | Species | | | | | | | |
| Nematoda | Nematoda undet. | | | | | 28,6 | 1-2 | 36-37 |
| Hydrozoa | *Cordylophora caspia* | 11,1 | | | 65-68 | | | |
| Priapulida | *Halicryptus spinulosus* | 55,6 | 0.93±0.99 | 48±40 | 48-68 | 14,3 | 3 | 68 |
| Polychaeta | *Bylgides sarsi* | 38,9 | 0.18±0.23 | 54±97 | 55-68 | 100 | 1-5 | 36-68 |
| | *Hediste diversicolor* | 5,6 | 0,02 | 18 | 40 | | | |
| | *Marenzelleria neglecta* | 94,4 | 2.6±2.7 | 1038±975 | 40-77 | 100 | 1-3 | 36-68 |
| | *Pygospio elegans* | 77,8 | 0.13±0.18 | 209±197 | 40-68 | 57,1 | 1 | 48-68 |
| Oligochaeta | Oligochaeta undet. | 27,8 | 0.05±0.06 | 162±220 | 40-77 | 42,9 | 1-5 | 36-48 |
| Hirudinea | *Piscicola geometra* | | | | | 28,6 | 1 | 37-47 |
| Crustacea | Ostracoda undet. | 44,4 | 0.03±0.04 | 102±118 | 54-77 | 14,3 | 5 | 68 |
| | *Balanus improvisus* | | | | | 14,3 | 3 | 37 |
| | *Jaera albifrons* | | | | | 57,1 | 1-3 | 37-52 |
| | *Saduria entomon* | 61,1 | 12.3±11.1 | 91±171 | 53-68 | 57,1 | 1-5 | 48-68 |
| | *Gammarus duebeni* | | | | | 14,3 | 1 | 52 |
| | *Gammarus salinus* | | | | | 42,9 | 1-2 | 37-48 |
| | *Monoporeia affinis* | 66,7 | 0.19±0.32 | 13±11 | 40-77 | 85,7 | 1-2 | 36-63 |
| | *Mysis mixta* | | | | | 100 | 2-5 | 36-68 |
| | *Neomysis integer* | | | | | 14,3 | 1 | 48 |
| | *Praunus inermis* | | | | | 14,3 | 1 | 37 |
| | *Crangon crangon* | | | | | 28,6 | 1 | 36-48 |
| Bivalvia | *Macoma balthica* | 94,4 | 73.8±89.3 | 369±373 | 40-77 | 42,9 | 1-2 | 52-68 |
| | *Mytilus trossulus* | | | | | 71,4 | 1-5 | 36-52 |
| Bryozoa | *Electra crustalenta* | | | | | 42,9 | 2-5 | 37-48 |

Table 4.7. Main average characteristics (± standard errors) of macrofauna communities in the Sambian plateau.

| Community (dominant species) | Total abundance | Total biomass | Richness | Total taxa |
|---|---|---|---|---|
| Ostracoda | 121.8±32.6 | 0.08±0.05 | 2.2±0.7 | 6 |
| *M. balthica* [with *S. entomon*] | 1909.5±343.6 | 74.2±31.7 | 6.3±0.3 | 9 |
| *M. balthica* [without *S. entomon*] | 1894.4±738.0 | 66.3±25.5 | 5.7±0.4 | 11 |

Community dominated by *M. balthica* has two very distinct variations in the structure, while species diversity, total macrofauna biomass and abundance remain relatively similar. If isopod *Saduria entomon* is present, this species takes approx. 20% of the total macrofauna biomass and spionid polychaetes account for 76% of the total macrofauna abundance (Fig. 4.9). Higher contribution of *Saduria entomon* biomass in the macrofauna community is within a narrow depth range of 53-66 m (Fig. 4.10). In areas where *S. entomon* is absent, spionid polychaetes are the main contributors to the total macrofauna biomass and abundance.

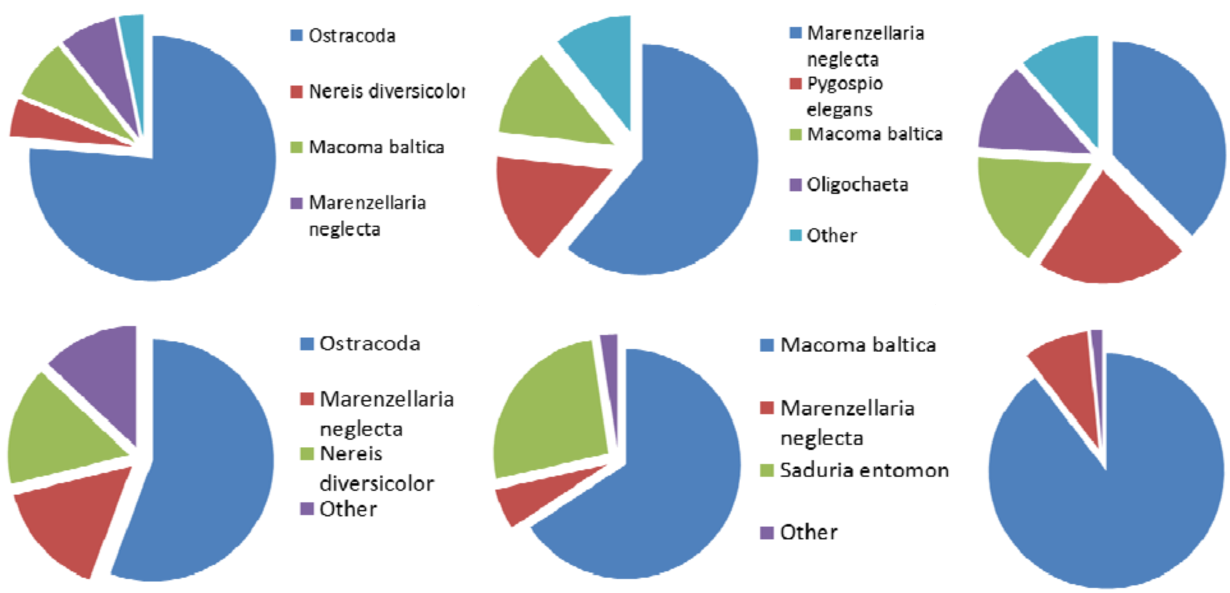



Figure 4.9. Structure of the macrofauna communities in the Sambian plateau based on relative abundance (upper figure) and relative biomass (lower figure): community dominated by Ostracoda (left, left hand legend); community dominated by *Macoma balthica* with *Saduria entomon* (middle, right hand legend); community dominated by *M. balthica* without *Saduria entomon* (right, right hand legend)

The relative abundance of spionid polychaetes is mainly substrate dependent (Fig. 4.10). The share of *M. neglecta* in the total macrofauna abundance is highly variable in silts within the halocline area at depths of 68-76 m, but its proportion decreases from 80-90% in very fine sands to 30-50% in fine to coarse sands.

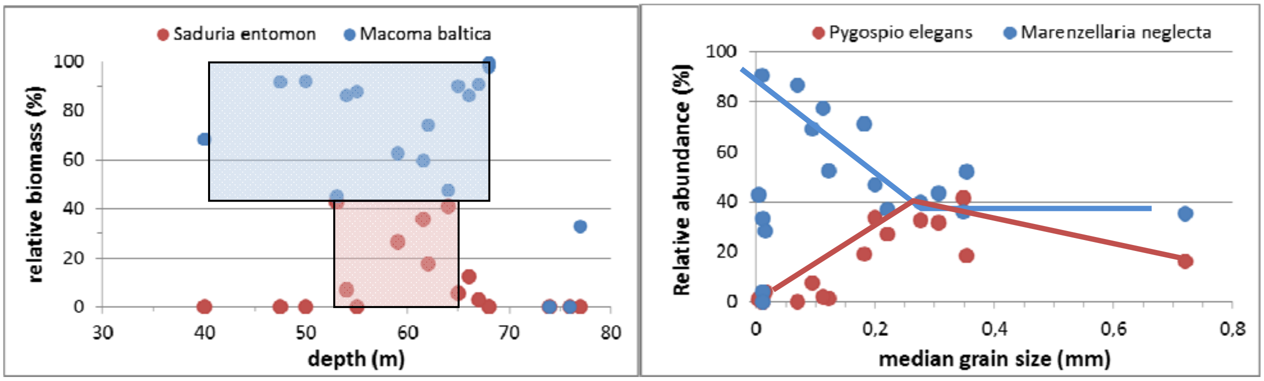


Fig. 4.10. Level of dominance of *M. balthica* and *S. entomon* for a sampling depth range and relative abundance of spionid polychaetes depending on the median grain size.

Relative abundance of another spionid polychaete *Pygospio elegans* is usually below 10% in silt and very fine sands, while remains relatively stable and varies between 20 and 40% in coarser sands.

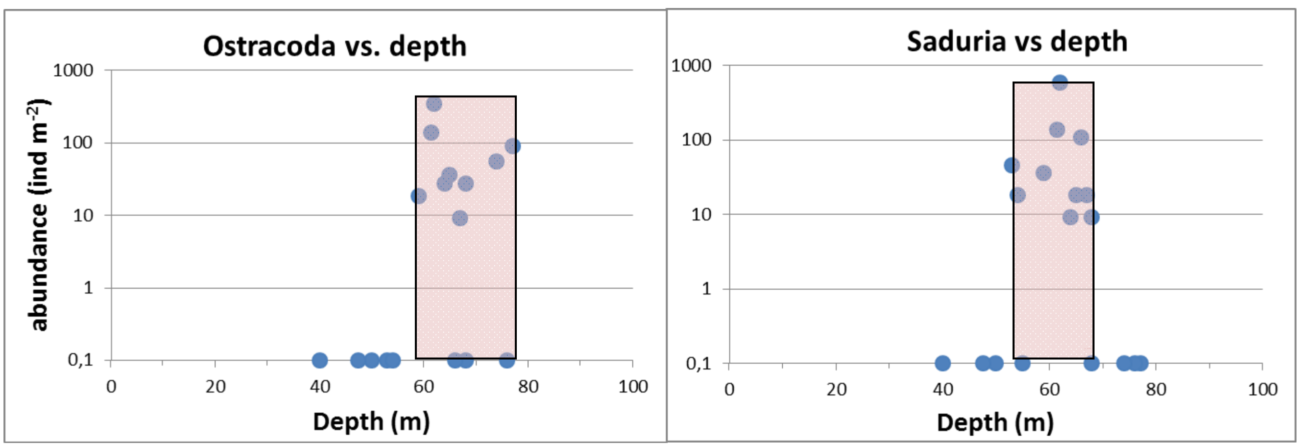


Figure 4.11. Abundance of two numerous macrofauna species versus depth in the Sambian plateau.

The structure of *Macoma balthica* community in the soft bottoms depends on substrate and depth. Priapulid *Halicryptus spinulosus*, isopod *Saduria entomon* and ostracods obviously prefer finer sediment fractions and tend to be more numerous at greater depths. Oligochaetes positively correlated with coarser sediment fractions, while *Hediste diversicolor* showed highly negative relationship with depth (Fig. 4.12).

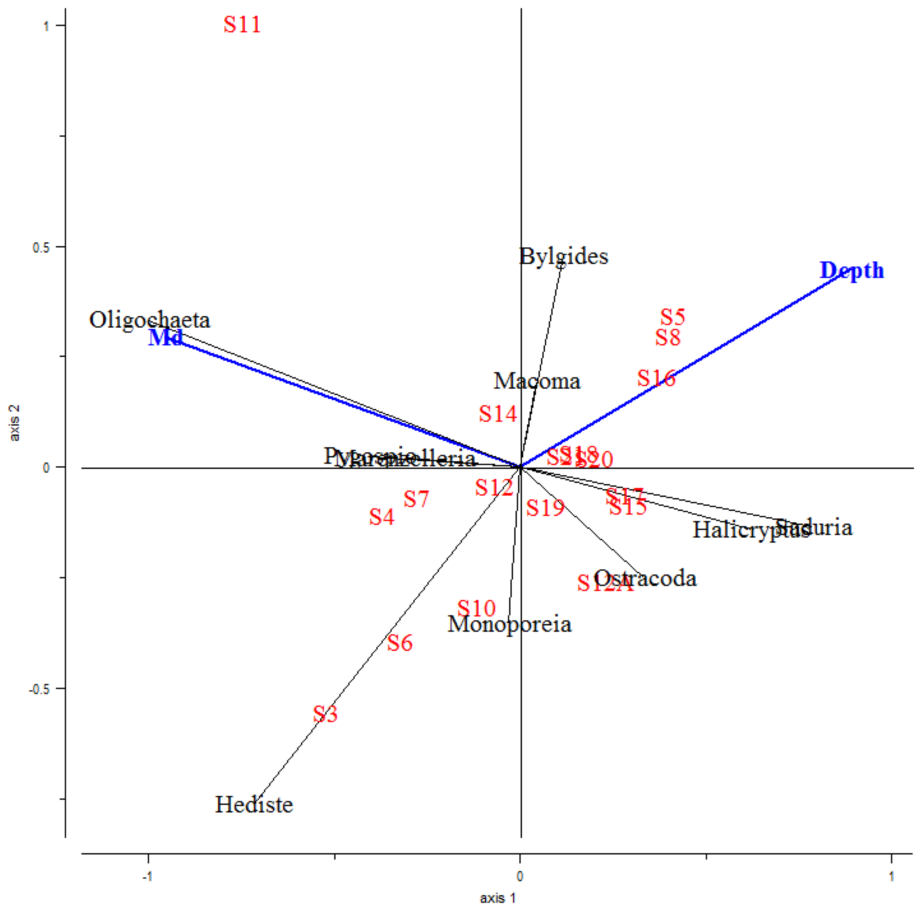



Figure 4.12. Relationship between macrofauna abundance and selected environmental factors according to the results of redundancy analysis.

Five biotopes are distinguished in the Sambian plateau depending on the relationships between bottom types, depth and macrofauna communities (Table 4.8, Fig. 4.13):

<u>1. Cobbles and boulders dominated by *Mytilus sp.*</u> Presence of hard substrate with boulders of variable size in depths from 35 to 70 m. is a key feature of the habitat, which defines presence of epibenthic community dominated by *Mytilus sp.* These features are in accordance with characteristics listed in the updated interpretation of European Union habitats (European Commssion, 2007) and therefore habitat qualifies as a reef habitat type (1170) listed in the Annex I of the Habitats Directive. In addition to qualitative criteria set at the national and European levels, coverage of hard bottoms (cobble and boulders) higher than 30% was determined as supplementary criteria for this study.

Application of acoustic methods (side scan sonar) indicate approx. 72% of the total surveyed reef area occupied by detectable hard substrate, which includes all gravel fractions from pebble to cobbles and boulders. According to visual inspections of the seabed, approximately half of video fragments (30 sec. each, seabed transect length of 15 m) in this habitat are characterized with the hard bottom (pebbles and boulders) coverage higher than 50%, whereas hard bottoms with more than 80% or less than 20% hard bottom coverage account for another 25% each. Visual coverage of hard substrate is 50% in average, while mussel colonies occupy from 10 to 30% of the hard bottom surface. Coverage of mussels is highly dependent on the extent of hard bottoms, and reaches the highest values at boulder coverage higher than 50%. Habitat is colonized with at least 15 benthic macrofauna species, approx. 9 being mobile epibenthic species (mysids, amphipods, leeches). Gammarids and isopods *Jaera albifrons* are typically associated with mussel colonies down to 50-55 m depth, whereas deeper areas are predominantly occupied by mobile mysids *Mysis mixta*, amphipods *Monoporeia affinis* and isopod *Saduria entomon*. In contrast to coastal reefs, barnacles *Balanus improvisus* do not spread below 40 m depth.

2. Gravel bottoms with scarse epibenthic communities. High dominance of pebble and absence of boulders is the main habitat feature preventing from development of reach infaunal or epibenthic macrofauna communities. Coverage of pebble is typically higher than 60% of the seabed surface, but frequently it may reach 80-90%, whereas coverage of sand rarely accounts for more than 10%. This transitional habitat stretches between cobble and boulder reef areas, and only rarely is surrounded by typical soft bottom habitats. Benthic macrofauna has no clear characteristic species since it consist of a mixture of epibenthic (*M. trossulus*, *B. improvisus*, *E. crustulenta*), surface sediment dweeling (*M. neglecta*, *Bylgides sarsi*, *Pygospio elegans*) and mobile crustacean species. Mussels (single individuals) are only present if patches of cobble substrate exist on sites.

3. Silt and sand dominated by bivalve *Macoma balthica* and spionid polychaetes. This widespread habitat covers approximately half of the project area down to the depths of 60-70 m. Silty sand and fine sand are the most frequently found sediment types in the habitat, occupied by widespread *M. balthica* community. Species diversity varies between 6 and 8 species per sample, with typical abundance of 1 to 4 thous. individuals per square meter. Macrofauna biomass is usually less than 100 g per square meter, but increases up to 200-400 at larger depths of 60-70 m reflecting changes in abundance *M. balthica* and *Saduria entomon*. Community structure remains highly stable, with common presence of two spionid polychaetes *Marenzelleria* spp. and *Pygospio elegans* as well as amphipod *Monoporeia affinis*. Other taxa, such as priapulid *Halicryptus spinulosus*, oligochaetes, polychaetes *Bylgides sarsi* and *Hediste diversicolor* may be present at sites, but do not attain high densities.

4. Deep mud dominated by ostracod crustaceans and polychaetes. This habitat stretches in the halocline area and below starting from depths of 70 m. The characteristic feature of the habitat is

aleuritic/pelitic mud inhabited by low numbers of ostracod crustaceans. Macrofauna biomass and abundance are extremely low, usually less than 0.1 g $m^{-2}$ and 100 ind $m^{-2}$ respectively and only locally can reach half a gram biomass and few hundreds of individuals per square meter. There are no permanently found species next to ostracod crustaceans, which might be the only taxa on sites. Occasionally polychaetes *Marenzelleria* sp. and *Hediste diversicolor*, as well as scarce *Monoporeia affinis*, oligochaetes and bivalve *Macoma balthica* may occur. Heterogeneity of this habitat in respect to both sediment types and local diversity of benthic macrofauna is very low.

5. Soft clay and silt dominated by bivalve *Macoma balthica* and spionid polychaetes. This habitat is located in the upper halocaline area (60-70 m depths) and characterized by very fine sediment containing clay fraction (clayey silt and silty clay), as well as high dominance of *Macoma balthica* reaching about half of the total macrofauna in terms of number of individuals and more than 95% of the total macrofauna biomass. Such high dominance is not at the expense of decreased numbers of othe macrofauna species, but rather due to the doubled abundance and biomass of *M. balthica*. Number of species per sample is similar to that found in sandy sediment with typical *Macoma balthica* dominated community and reaches 6-8 species or higher taxa. The habitat is relatively homogenous with relatively low variation in macrofauna structure.

Table 4.8. Distribution extent of habitats in the Sambian plateau.

| **Habitat** | **Area, km$^2$** | **Percentage (%) of the project area** |
|---|---|---|
| Deep mud dominated by ostracods and polychaetes | 75 | 17.2 |
| Soft clay and silt dominated by bivalve *Macoma balthica* and spionid polychaetes | 28 | 6.4 |
| Silt and sand dominated by bivalve *Macoma balthica* and spionid polychaetes | 204 | 46.8 |
| Pebble bottoms with boulders and scarse epibenthic communities | 31 | 7.1 |
| Cobble and boulders dominated by epifaunal *Mytilus trossulus* and *Balanus improvisus* | 98 | 22.5 |

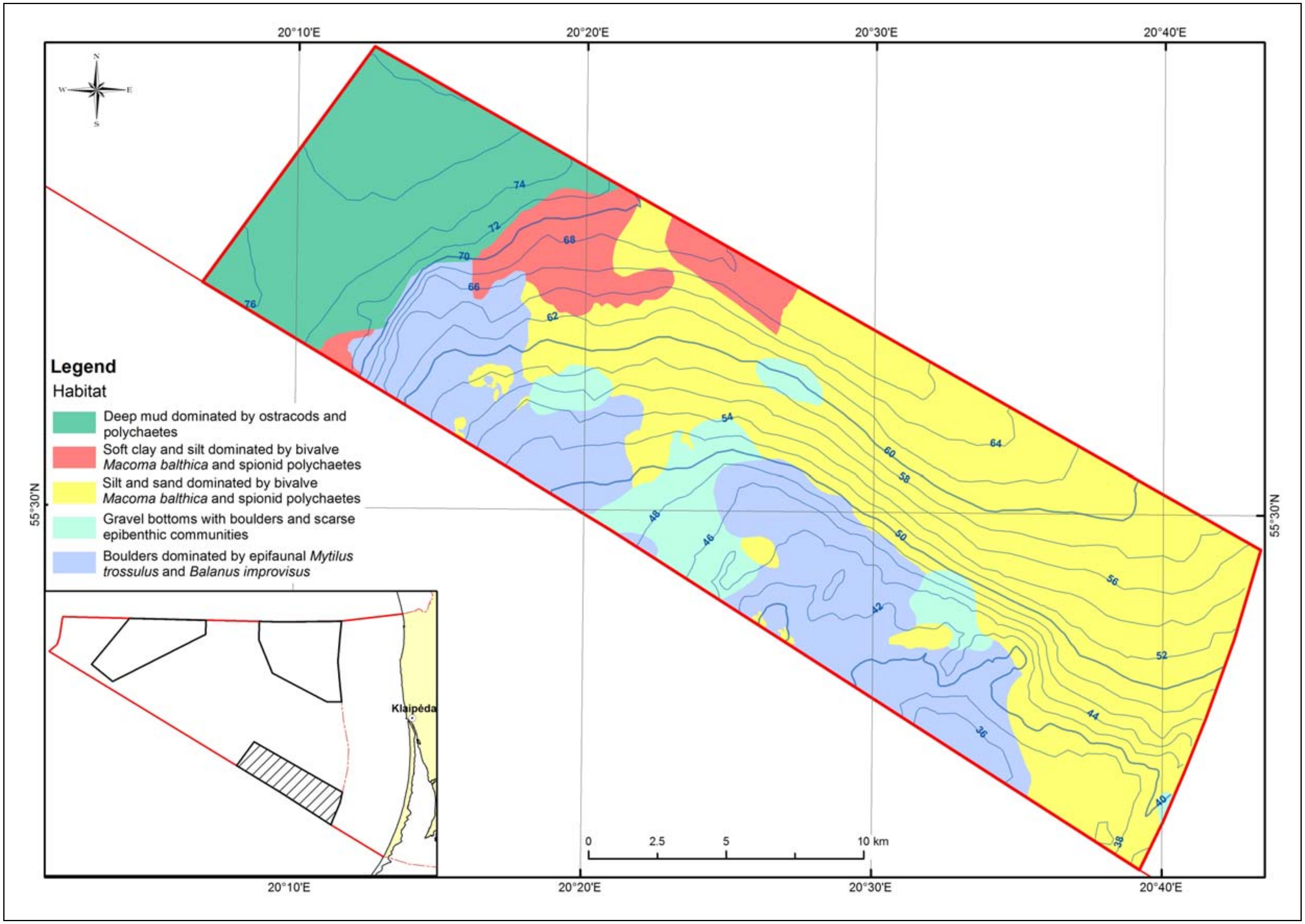



Figure 4.13. Distribution of benthic habitats in the Sambian Plateau.

## 4.3 Klaipeda-Ventspils plateau

### 4.3.1 Bathymetry and geomorphology

The project area covers part of the Klaipėda-Ventspils plateau and its slope to the Gdansk Deep in the SE (Fig. 4.14). The area is relatively shallow (24 - 50 m), with water depth averaging 35 m. According to the depth distribution the area could be divided into zones: shallow part with depths less than 30 m, intermediate depth zone between 30 and 40 m, and the deeper part with depths greater than 40 m. The intermediate depth zone with areal extension of 358 $km^2$ covers approximately half of the area (54%), while another one third (32%) of the area extending for 215 $km^2$ belongs to the deeper part.

The shallow zone with depths less than 30 m in the NE part of the area extends for 90 $km^2$ (approx. 14% of the project area). It comprises a belt of uplifted, undulating - hilly surface oriented towards open sea in a northwest - southeast direction. The seabed of the shallow zone gently deepens in NE direction up to 35 m water depth and SW direction up to 50 m depth towards Gdansk depression. Steeper slopes are observed in SW direction (~ $0.07^o$) and more gentle (~ $0.04^o$) in direction towards W.

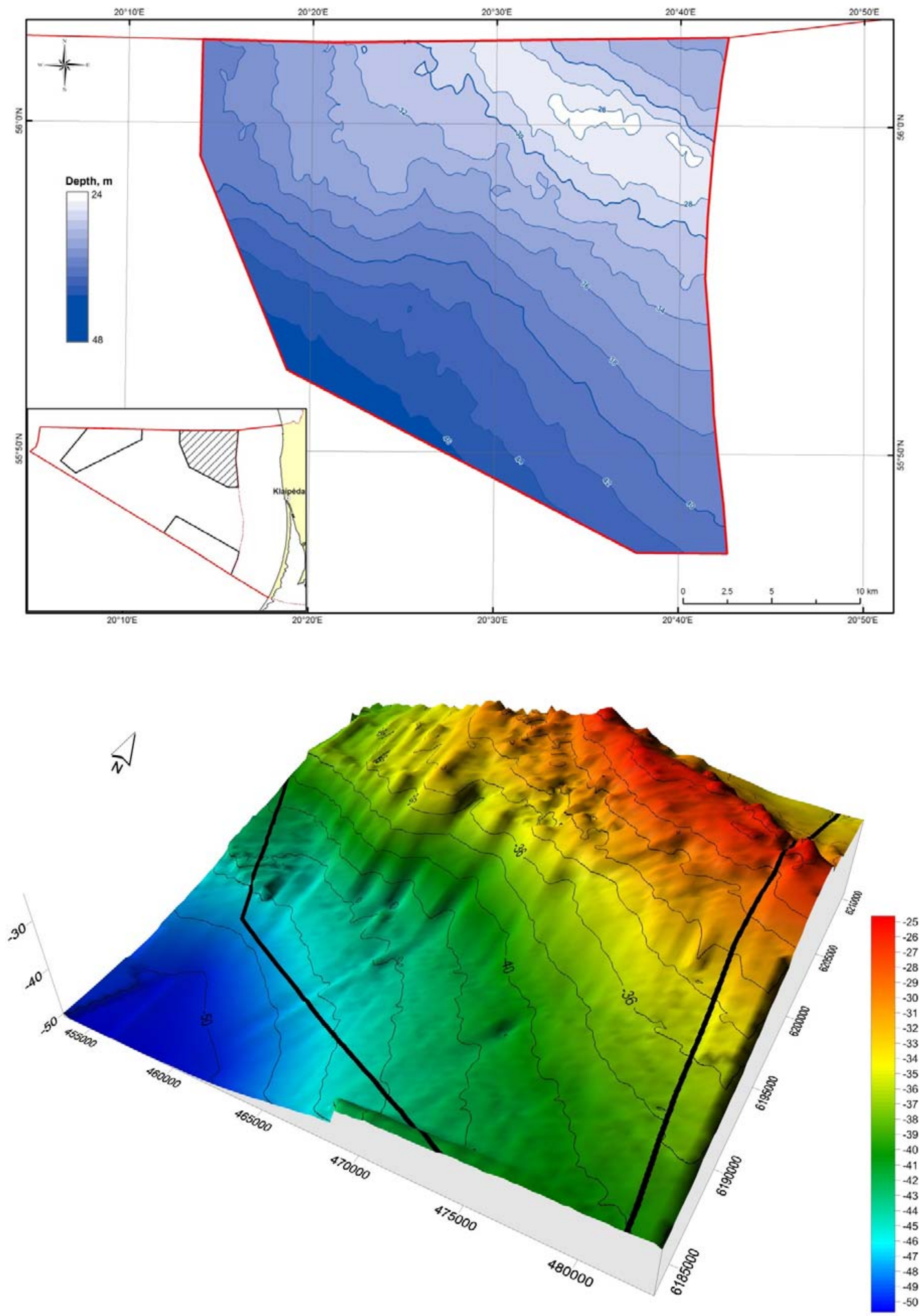



Figure 4.14. Bathymetry and seabed geomorphology of the Klaipeda-Ventspils plateau.

### 4.3.2 Sediment types

Seabed of the Klapėda-Ventspilis plateau in the project area is covered by the Quaternary sediments that usually have 5-10 m thickness. Quaternary sediments are mainly represented by two lithological complexes– glacial sediments of Late Weichselian age (till with admixture of gravel, pebble and boulders) and recent marine deposits (not stratified) composed of heterograined sand and silt.

Glacial deposits located in the northern part of the study area contain gravel, pebble and boulders with patches of sand (Table 4.9, Fig. 4.15). They were washed-out from glacial till in wave action zone during the Holocene. Boulder fields are mainly wide spread in shallow zone with water depth range from 24 to 34 m and occupy 25 % of the total study area. Various grained sand of recent marine deposits occur along the Gdansk depression slope in the central part of the study area, as well at the NE in the mid depth zone (28-34 m). Sandy deposits, predominantly medium sand, cover 35% of the project area. Silty deposit, such as coarse and sandy silt, appear at 38 m water depth and cover the deepest part of the study area on the SW. Evident predominance of fine terrigenous material (sand and silt) up to 70% is observed in this project area.

Table 4.9. Distribution of surface sediments in the project area

| Sediment type | Area, km2 | Percentage (%) of the project area |
|---|---|---|
| Sandy silt | 222 | 33.5 |
| Silty sand | 101 | 15.2 |
| Fine sand | 107 | 16.1 |
| Medium sand | 21 | 3.2 |
| Coarse sand | 8 | 1.2 |
| Gravel | 23 | 3.5 |
| Pebble | 16 | 2.4 |
| Boulders | 165 | 24.9 |

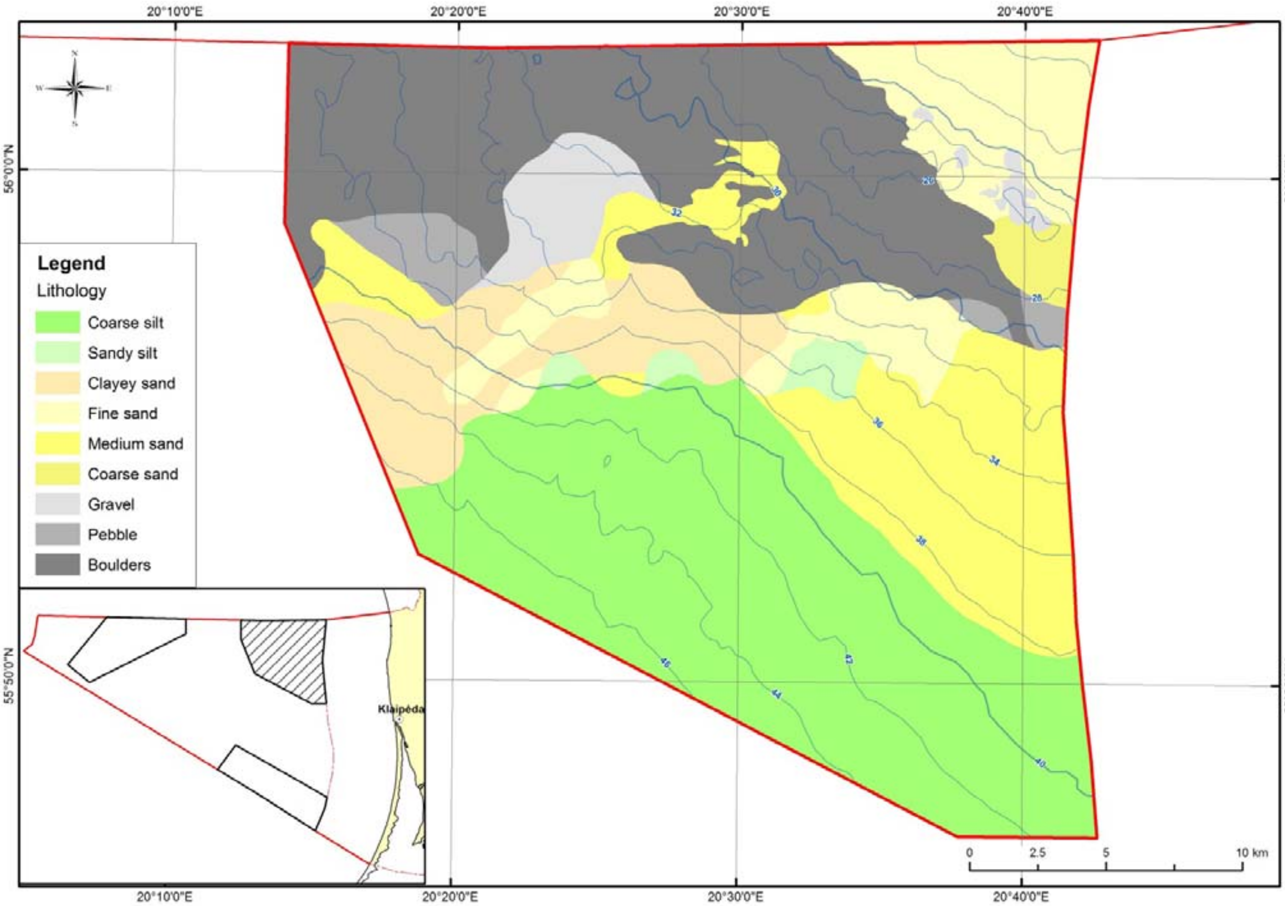



Figure 4.15. Diversity and distribution of sediment types in the Klaipeda-Ventspils plateau.

### 4.3.3 Diversity, structure and distribution of benthic habitats

*Species diversity.* In total 29 species and higher order taxa have been recorded in the area, 8 of them being exclusively recorded in the dredge samples. Approx. 80% of the recorded species belong to three large taxonomic groups: crustaceans are the most diverse group with 12 species/taxa followed by 6 species of molluscs and 5 species of polychaetes. Approx. one third of species belong to the sessile infaunal organisms (e.g. *Mya arenaria, M. balthica, Cerastoderma glaucum, Hydrobia sp., Bylgides sarsi*, etc.) and another 9 species are mobile surface or sub-surface soft bottom species (e.g. *Crangon crangon, Monoporeia affinis, Corophium volutator, Saduria entomon, etc.*). Approximately 5 mobile species or higher order taxa (e.g. *Jaera albifrons, Gammarus salinus, Fabricia sabella,* Turbellaria undet., etc.) are tightly associated with sessile epifaunal species (*Mytilus sp.*, *Balanus improvisus* and *Electra crustulenta*) in hard bottoms. Five taxa (*Halicryptus spinulosus, Marenzelleria sp.*, *Pygospio elegans*, *M. balthica* and oligochaetes) are very common in the soft bottoms and characterized by occurrence higher than 90% (Table 4.10).

Table 4.10. Species composition from grab and dredge samples taken in the Sambian Plateau.

| Seabed type / sampling device | | Soft bottoms (grab) | | | | Hard bottoms (dredge) |
|---|---|---|---|---|---|---|
| Parameter, units | | Occurrence | Depth range | Biomass | Abundance | Abundance |
| Taxa | Species | % | m | g $m^{-2}$ | ind $m^{-2}$ | rank |
| Nematoda | Nematoda undet. | 12,5 | 31-32 | <0.01 | 11,7±7,3 | - |
| Turbellaria | Turbellaria undet. | 4,2 | 39 | <0.01 | 0.4±0.4 | 1 |
| Priapulida | *Halicryptus spinulosus* | 90,9 | 28-46 | 0.45±1.15 | 147±84 | - |
| Polychaeta | *Bylgides sarsi* | 68,2 | 28-46 | 0.02±0.02 | 35±17 | 1-2 |
| | *Hediste diversicolor* | 40,9 | 26-35 | 2.7±2.3 | 412±354 | 1 |
| | *Marenzelleria sp.* | 100 | 26-46 | 2.3±1.5 | 2065±1076 | 1-2 |
| | *Pygospio elegans* | 95,5 | 26-46 | 0.27±0.16 | 740±504 | - |
| | *Fabricia sabella* | | - | - | - | 1 |
| Oligochaeta | Oligochaeta undet. | 90,9 | 26-46 | 0.41±0.79 | 770±832 | 1 |
| Crustacea | Ostracoda undet. | 36,4 | 39-46 | 0.02±0.03 | 92±136 | - |
| | *Balanus improvisus* | | 28-39 | - | - | 3 |
| | *Jaera albifrons* | | 29-34 | - | - | 2 |
| | *Diastylis rathkei* | 13,6 | 31-46 | 0.02±0.02 | 12±5 | 1 |
| | *Saduria entomon* | 68,2 | 34-46 | 9.4±10.7 | 113±314 | - |
| | *Gammarus salinus* | | - | - | - | 1-2 |
| | *Gammarus sp.* | 13,6 | 29-39 | 0.08±0.12 | 64±79 | 1-3 |
| | *Corophium volutator* | 27,3 | 32-38 | 0.57±0.67 | 195±242 | 1 |
| | *Monoporeia affinis* | 40,9 | 33-45 | 0.45±0.92 | 386±859 | - |
| | *Mysis mixta* | | - | - | - | 1 |
| | *Neomysis integer* | | - | - | - | 1 |
| | *Praunus inermis* | | - | - | - | 1 |
| | *Crangon crangon* | | - | - | - | 1 |
| Gastropoda | *Hydrobia sp.* | 18,2 | 28-34 | 0.31±0.37 | 204±187 | 1 |
| | *Theodoxus fluviatilis* | - | - | - | - | 1 |
| Bivalvia | *Cerastoderma glaucum* | 13,6 | 32-34 | 1.8±3.0 | 24±14 | - |
| | *Macoma balthica* | 90,9 | 28-46 | 66.8±29.7 | 614±647 | - |
| | *Mya arenaria* | 22,7 | 28-41 | 7.4±9.9 | 22±20 | - |
| | *Mytilus sp.* | 18,2 | 28-39 | 0.1±0.08 | 18±13 | 5 |
| Bryozoa | *Electra crustulenta* | 18,2 | 28-39 | - | - | 5 |

*Macoma balthica* and *Marenzelleria sp.* are two very common species in grab samples (occurrence higher than 90%), while two other species (*Bylgides sarsi* and *Mysis mixta*) were permanently found in dredge samples next to non-native spionid *M. neglecta*.

Dredge sampling delivered 12 unique species/taxa versus 2 unique species reported from grab samples indicating higher macrofauna diversity in heterogeneous mixed and hard substrates.

*Bottom macrofauna communities.* Two bottom macrofauna communities are classified according to the biomass dominant taxa: community of *Macoma balthica* and community of *Marenzelleri*a sp. and oligochaetes. The later community is characterized by very low diversity and biomass, however abundance can be as high as in Macoma dominated soft bottoms. Distinguishing feature of this community is absence of widespread *Macoma balthica*, while *Pygospio elegans* occur on sites only.

Table 4.11. Main average characteristics (± standard errors) of macrofauna communities in the Klaipeda-Ventspils plateau.

| **Community (dominant and characteristic species)** | **Total abundance** | **Total biomass** | **Richness** | **Total taxa** |
|---|---|---|---|---|
| *Marenzelleria* spp. and Oligochaeta | 2355 ±1864 | 5.6± 2.5 | 4.5± 0.5 | 6 |
| *M. balthica* [with *M. affinis*] | 10207± 41 | 50.5 ± 7.8 | 9.5± 0.3 | 10 |
| *M. balthica* [with *H. diversicolor*] | 5385± 569 | 82.9± 9.8 | 10.8± 0.6 | 16 |
| *M. balthica* [with spionid polychaetes and *Saduria entomon*] | 4054± 430 | 82.3± 10.9 | 8.5± 0.4 | 16 |

*Macoma balthica* community has three different forms depending on characteristic species, which regularly occur in samples with relatively high densities and contribute significantly to the overall structure (Table 4.11). In deeper areas Macoma community has exclusively high *Monoporeia affinis* densities reaching approx. 2.5 thous. ind. $m^{-2}$, although density of *M. balthica* and *Saduria entomon* can be as high as 3 thous. and 1.2 thous. ind. $m^{-2}$ respectively. Other deep water species such as *Diastylis rathkey* can occur on sites as well. The more shallow form of *M. balthica* community is typically inhabited by ostracods and isopod *S. entomon*, while *M. affinis* never exceeds few hundreds individuals per square meter. Average biomass, density and species diversity of this community form are similar to those found in shallow waters, where *Hediste diversicolor* and *Hydrobia* sp. are replacing mobile glacial crustaceans. The average biomass remains approx. 80 g $m^{-2}$, while abundance is twice lower than in deeper waters (Table 4.11).

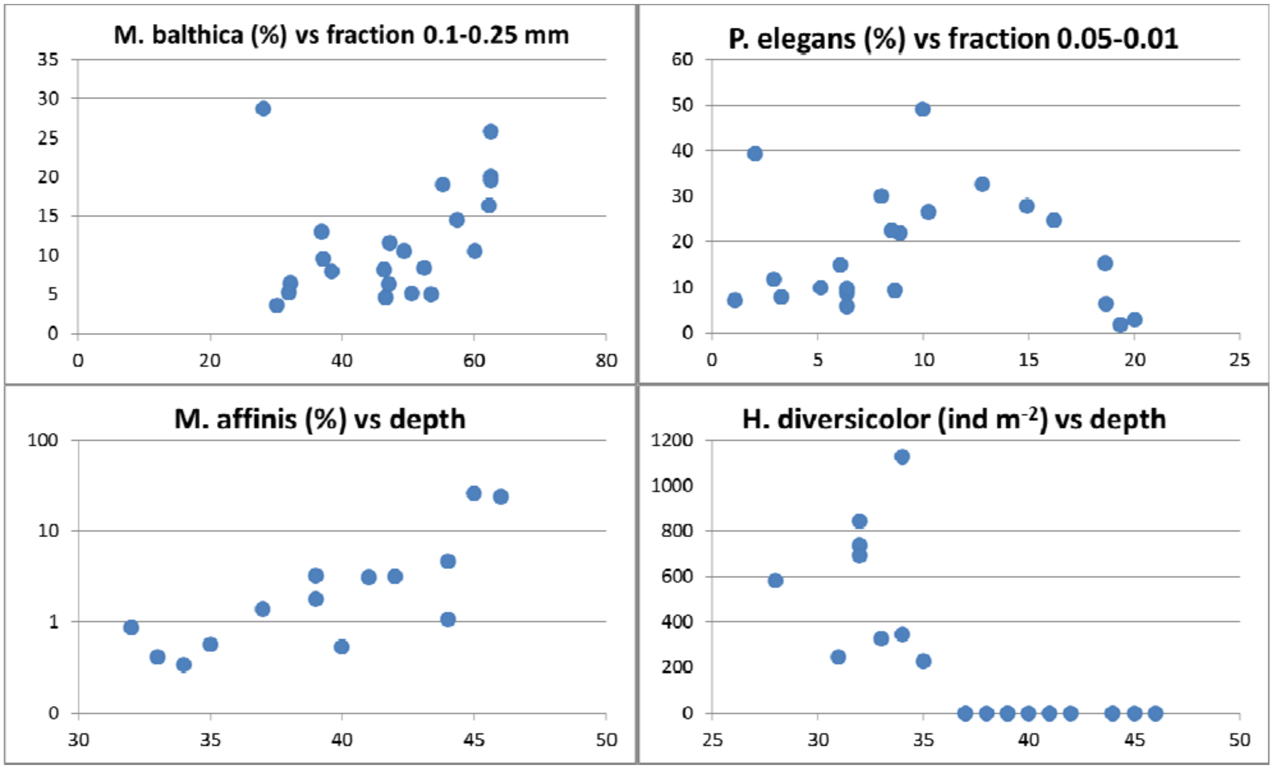



Figure 4.16. Relationships between abundance of characteristic macrobenthic species and key environmental variables in the Klaipeda-Ventspils Plateau.

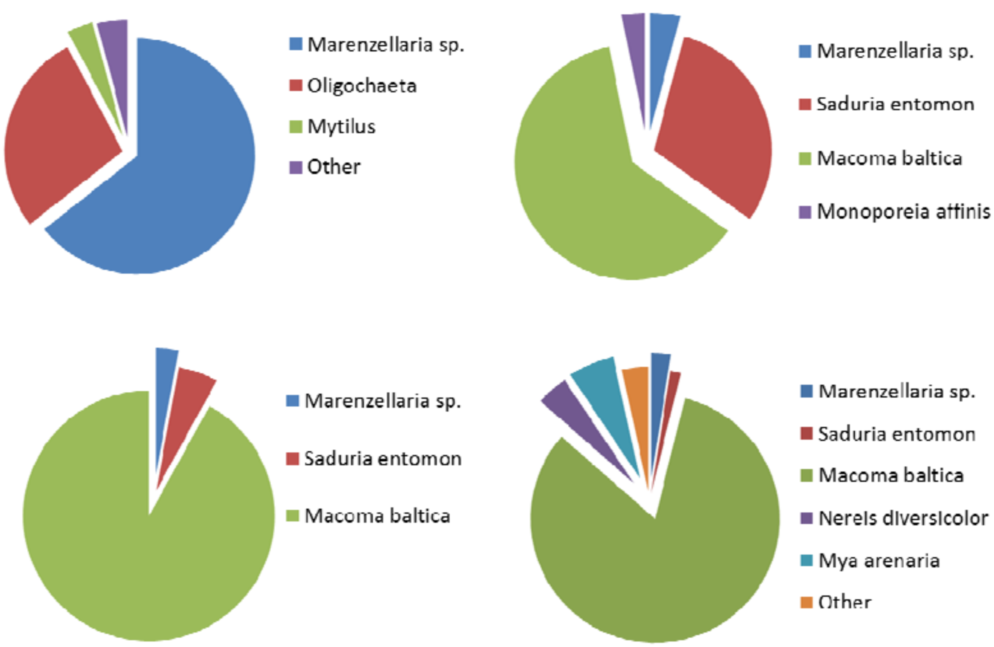



Figure 4.17 Structure of the macrofauna communities in the Klaipeda-Ventspils plateau based on relative biomass: community dominated by Marenzelleria spp. (upper left figure); community dominated by *Macoma balthica* with spionid polychaetes and *Saduria entomon* (lower left figure); community dominated by *M. balthica* with *M. affinis* (upper right figure); and community dominated by *M. balthica* with *H. diversicolor* (lower right figure).

*Saduria entomon, Ostracoda, Monoporeia affinis and H. diversicolor* showed clear relationships with the depth (Fig. 4.18), first three being positively related and the last species getting extinct in depths greater than 35 m depth.

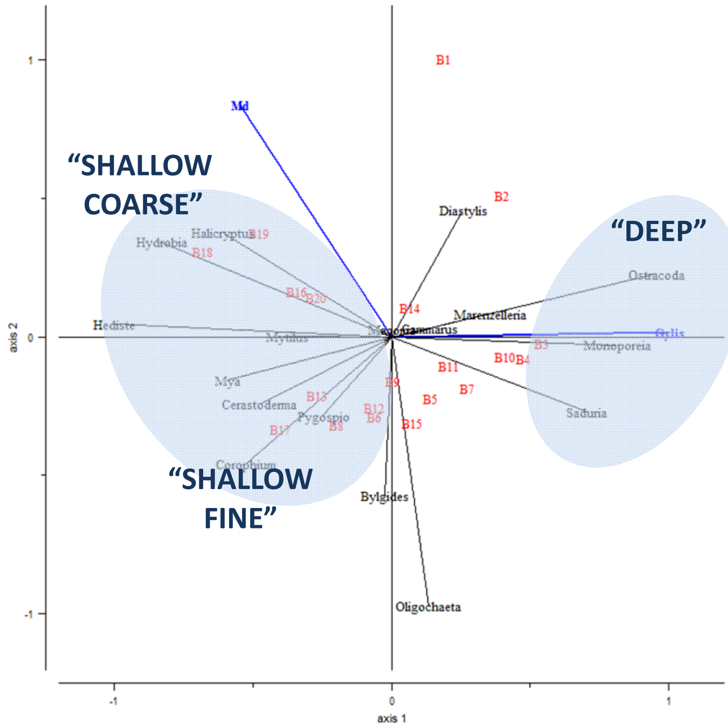



Figure 4.18 Relationship between macrofauna abundance and selected environmental factors within three groups according to the results of redundancy analysis.

*Benthic habitats*. Six biotopes were distinguished in the Klaipeda-Ventspils Plateau depending on the relationships between bottom types, depth and macrofauna communities (Table 4.12, Fig. 4.19):

<u>1. Silty to fine sand dominated by bivalve *Macoma balthica* and spionid polychaetes.</u>

This widespread habitat covers almost a half of the project area and is situated mainly in 35-45 m depth range. Silty sand and fine sand are the most frequently found sediment types in the habitat, occupied by widespread *M. balthica* community. Species diversity varies between 7 and 12 species per sample, with typical abundance of 2 to 6 thous. individuals per square meter. Two spionid polychaetes *Marenzelleria sp.* and *P. elegans* are the most abundant and can constitute 50 and 25 % of total abundance respectively. Macrofauna biomass is usually close to 100 g per square meter where *M. balthica* constitutes more than 75 % of total biomass. Other common species in this habitat are priapulids *H. spinulosus*, isopods *S. entomon*, polychaetes *B. sarsi* and oligochaetes while species such as crustaceans *M. affinis*, *C. volutator* and ostracods are found less frequently.

2. Sand dominated by *Macoma balthica* and *Hediste diversicolor*. This habitat covers 13 % of the project area (87 sq. kilometers) and is situated above 35 m isobath. Sands of different fractions are the most frequently found sediment types in the habitat, occupied by *M. balthica* community. Species diversity varies between 8 and 12 species per sample, with typical abundance of 3 to 8 thous. individuals per square meter. Three polychaete species (*H. diversicolor, Marenzelleria sp.* and *P. elegans*) are the most abundant and can constitute from 50 to 75 % of total abundance. Macrofauna biomass is usually close to 100 g per square meter where *M. balthica* can comprise up to 90 % of total biomass. Furthermore, this habitat is characterized by relatively high biomass of *H. diversicolor* and can reach more than 7 g per square meter. Other common species in this habitat are shallow dwelling clams *M. arenaria* and *C. glaucum*, mud snails *Hydrobia sp.*, priapulids *H. spinulosus* and amphipods *C. volutator*.

3. Sandy silt dominated by *Macoma balthica* and crustaceans *Monoporeia affinis* and *Saduria entomon*. This habitat covers almost 10 % of the project area (58 sq. kilometers) and is situated the deepest part with depths ranging from 44 to 46 m. Sandy silt is the most frequently found sediment types in the habitat, occupied by *M. balthica* community. Species diversity varies between 9 and 10 species per sample, with typical abundance of 10 thous. individuals per square meter. Macrofauna biomass is usually close to 50 g per square meter where *M. balthica* and isopod *S. entomon* comprise more than 80 % of total biomass. Moreover, this habitat is characterized by abundant amphipod *M. affinis* (more than 2 thous. individuals per square meter). Other common species are polychaetes *Marenzelleria sp.* and *B. sarsi,* ostracods, oligochaets and priapulids *H. spinulosus*.

4. Coarse sand ripples and gravel dominated by scarce polychaete community. This habitat is the smallest in size, covers less than 4 % of the project area (25 sq. kilometers) and is situated in transition between reef and sandy habitats. Coarse sand and gravel are the most frequently found sediment types in the habitat, occupied by scarce polychaete community. The distinct feature of this habitat – relatively large sand ripples which are detectable even with acoustic methods. Species diversity varies between 4 and 5 species per sample, with abundance up to 4 thous. individuals per square meter. Polychaetes *H. diversicolor, Marenzelleria sp.*, *P. elegans* and oligochaetes are the most abundant. Macrofauna biomass is less than 10 g per square meter where *Marenzelleria sp.* can comprise more than 50 % of total biomass.

5. Pebble dominated bottoms with scarce epibenthic communities. This habitat covers less than 6 % of the project area (38 sq. kilometers). High dominance of pebble and absence of boulders and larger soft bottom patches is the main habitat feature preventing from development of rich infaunal or epibenthic macrofauna communities. Coverage of pebble is typically higher than 60% of the seabed surface, but frequently it may reach 80-90%, whereas coverage of sand rarely accounts for more than 10%. Typically, this habitat is transition between reef and soft bottom habitats with very scarce biological features from each of them. On occasional larger hard substrates mussels and barnacles can be found only in low numbers, however dominant pebble fraction usually is entirely without visible macrofauna, probably due to intensive sand abrasion. On the other hand, patches of sandy areas are less diverse in comparison to rich *M. balthica* communities in sand or sandy silt habitats, with only species tolerant to harsh environments present in low abundance, i.e. oligochaetes and polychaetes *Marenzelleria sp.* and *H. diversicolor*.

6. Cobble and boulders dominated by epifaunal *Mytilus sp.* and *Balanus improvisus*. This habitat is second largest and covers 25% of the project area (165 sq. kilometers). Presence of hard substrate with boulders of variable size in depths from 25 to 40 m is a key feature of the habitat, which defines presence of epibenthic community dominated by *Mytilus sp* and *Balanus improvisus*. These features are in accordance with characteristics listed in the updated interpretation of European Union habitats (European Commssion, 2007) and therefore habitat qualifies as a reef habitat type (1170) listed in the Annex I of the Habitats Directive. In addition to qualitative criteria set at the national and European levels, coverage of hard bottoms (cobble and boulders) higher than 30% was determined as supplementary criteria for this study.

According to visual inspections of the seabed, more than 60 % of video fragments (30 sec. each, seabed transect length of 15 m) in this habitat are characterized with the hard bottom (pebbles and boulders) coverage higher than 50%, whereas hard bottoms with more than 80% or less than 20% of soft bottom coverage comprise 25% of video fragments. Hard substrates are occupied by blue mussel colonies with bottom surface coverage up to 60 % (approx. 40 % on average). Coverage of mussels is highly dependent on the extent of hard bottoms, and reaches the highest values at boulder coverage higher than 50%. On the other hand, the percentage of hard substrate and mussels decreases nearing the border with soft bottom habitats. Habitat is colonized with at least 19 benthic macrofauna species that includes epifaunal *Mytilus sp*. and *B. improvisus*, gastropods *Theodoxus fluviatilis*, mobile mysids and sand shrimps, also species associated with mussel colonies: crustaceans *Jaera albifrons* and gammarids, polychaete *Fabricia sabella*. Sandy patches of the habitat are occupied by typical infaunal species such as polychaetes *Marenzelleria sp.* and *H. diversicolor*, oligochaetes, amphipods *C. volutator* or even mud snails *Hydrobia sp.*

Table 4.12. Distribution of habitats in the project area.

| **Habitat** | **Area, km$^2$** | **Percentage (%) of the project area** |
| --- | --- | --- |
| Sand dominated by *Macoma balthica* and *Hediste diversicolor* | 87 | 13.1 |
| Silty to fine dominated by bivalve *Macoma balthica* and spionid polychaetes | 290 | 43.7 |
| Sandy silt dominated by *Macoma balthica* and crustaceans *Monoporeia affinis* and *Saduria entomon* | 58 | 8.7 |
| Coarse sand ripples and gravel dominated by scarce polychaete community | 25 | 3.8 |
| Pebble dominated bottoms with scarse epibenthic communities | 38 | 5.7 |
| Cobble and boulders dominated by epifaunal *Mytilus sp.* and *Balanus improvisus* | 165 | 24.9 |

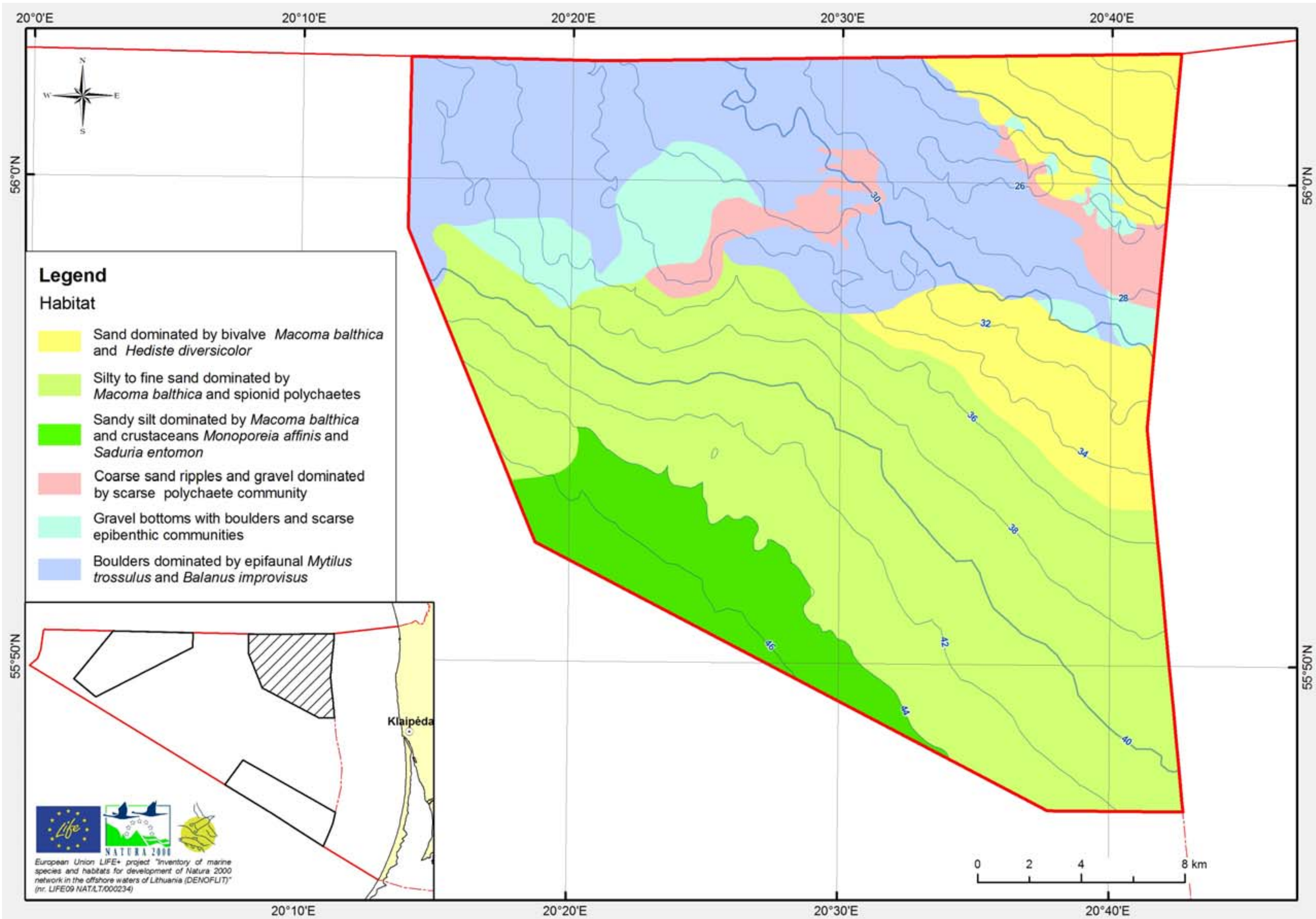



Figure 4.19. Distribution of benthic habitats in the Klaipeda-Ventspils plateau.

## 4.4 Klaipeda bank

### 4.4.1 Bathymetry and geomorphology

The project area is situated on the Klaipeda bank in the western part of Lithuanian marine area (Fig. 3.2). The shallow zone (<50 m depth) of Klaipeda bank, located in the north part of the study area, comprises a belt of uplifted, undulating - hilly surface oriented in a southwest direction with very steep slopes in the NW (~ 0.5$^{o}$) and gentle slopes (~ 0.05$^{o}$) in the SE (Fig. 4.20). The seabed of the shallow zone gradually deepens to NW towards Gotland depression up to 75 m water depth and SE towards Gdansk depression up to 64 m water depth. Overall, the water depth in the project area varies from 46 m in the north to 75 m in SW, with average water depth of 61 m. This area is the relatively deepest project area with occurrence of very steep slopes (Fig. 4.20). The area could be relatively divided into four water depth zones (Table 4.13). The medium depth zone (50-60 m) is evidently dominating in the project area.

Table 4.13. Distribution of water depth zones in the project area.

| Depth zone | Area, km2 | Percentage (%) of the project area |
|---|---|---|
| < 50 m | 24 | 5 |
| 50-60 m | 394 | 77 |
| 60-70 m | 66 | 13 |
| >70 m | 24 | 5 |

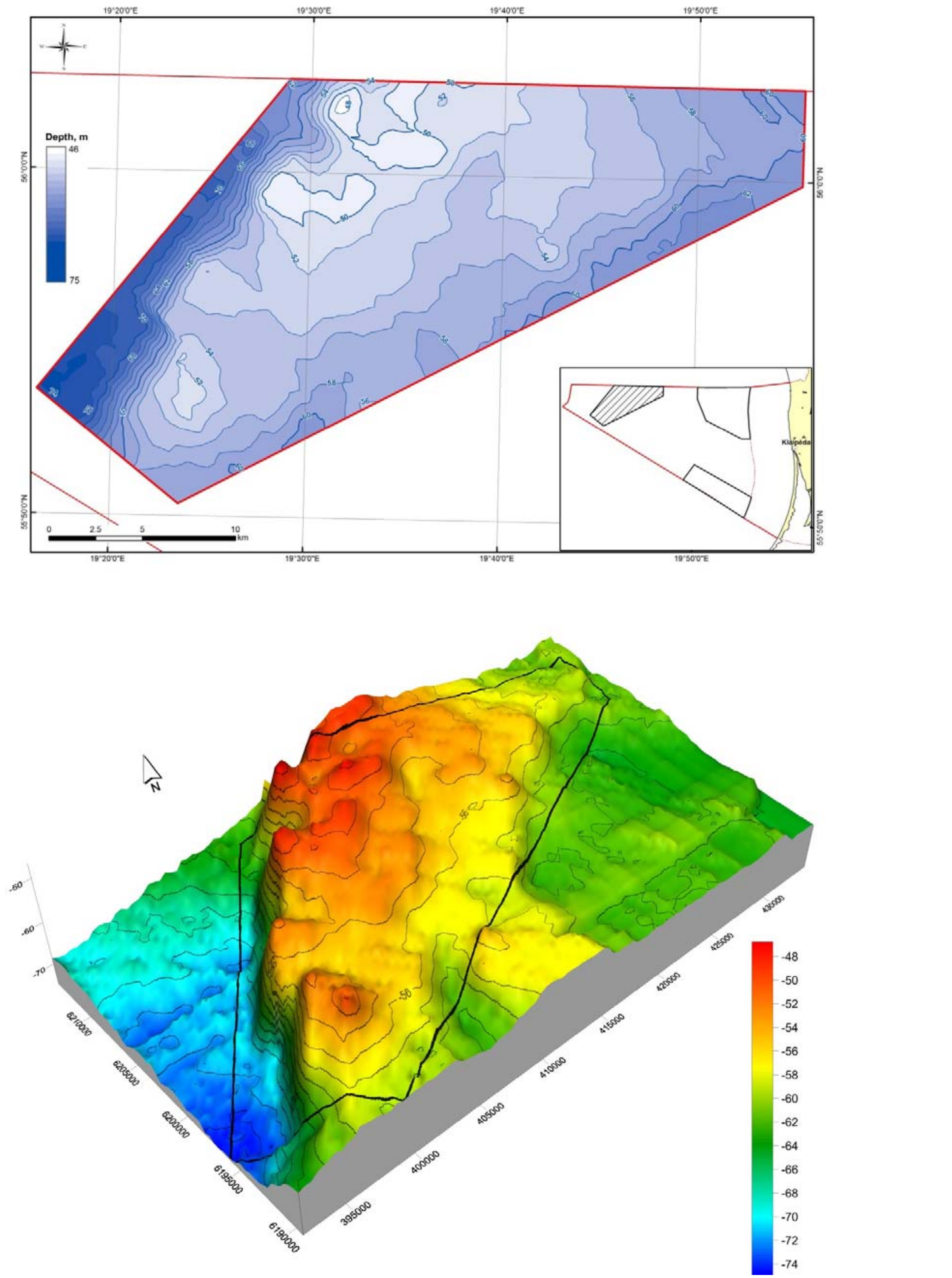



Figure 4.20. Bathymetry (top) and seabed geomorphology (bottom) of the Klaipeda Bank.

### 4.4.2 Sediment types

Seabed of the project area is covered by the Quaternary sediments that usually have 10 meters of thickness at uplifted part of Klaipeda bank and up to 80 m thickness in the deepest part of the study area located in the NW. Uppermost layer of quaternary sediments are represented by two lithological complexes: sediments of Late Weichselian age - glacial (till with gravel and boulders), glaciolacustrine (sandy silty, silty clay) and not stratified marine sediment of Holocene age (various sand). Glacial deposits are evenly distributed in the entire study area. They contain sandy and clayey loam and washed-out glacial till with gravel, pebble and boulders fields (Fig. 4.21). The most extensive gravel and pebble fields are mainly situated in the shallow zone with water depth range from 46 to 54 m. Overall, glacial sediment occupy ~36 % of the total study area (Table 4.14). Various grained sand of recent marine deposits are wide spread in various depth zones and occupy ~62% of the study area. Patches of silty clay, mostly appear at 52-60 m water depth at western part of the study area. Field of pre-Quaternary deposits appear in abrasive slope deepen towards Gotland depression in the SW of the study area, it occupy only 0.4%. Predominance of sandy sediment is observed in the project area.

Table 4.14. Distribution of surface sediments in the project area

| Sediment type | Area, km$^2$ | Percentage (%) of the project area |
|---|---|---|
| Silty clay | 7 | 1.4 |
| Silty sand | 18 | 3.6 |
| Heterograined sand | 69 | 13.6 |
| Fine sand | 155 | 30.5 |
| Medium sand | 3 | 0.6 |
| Coarse sand | 70 | 13.8 |
| Morainic sandy loam | 78 | 15.4 |
| Morainic clayey loam | 12 | 2.4 |
| Gravel | 79 | 15.6 |
| Pebble | 12 | 2.5 |
| Boulders | 2 | 0.4 |
| preQuaternary deposits | 2 | 0.4 |

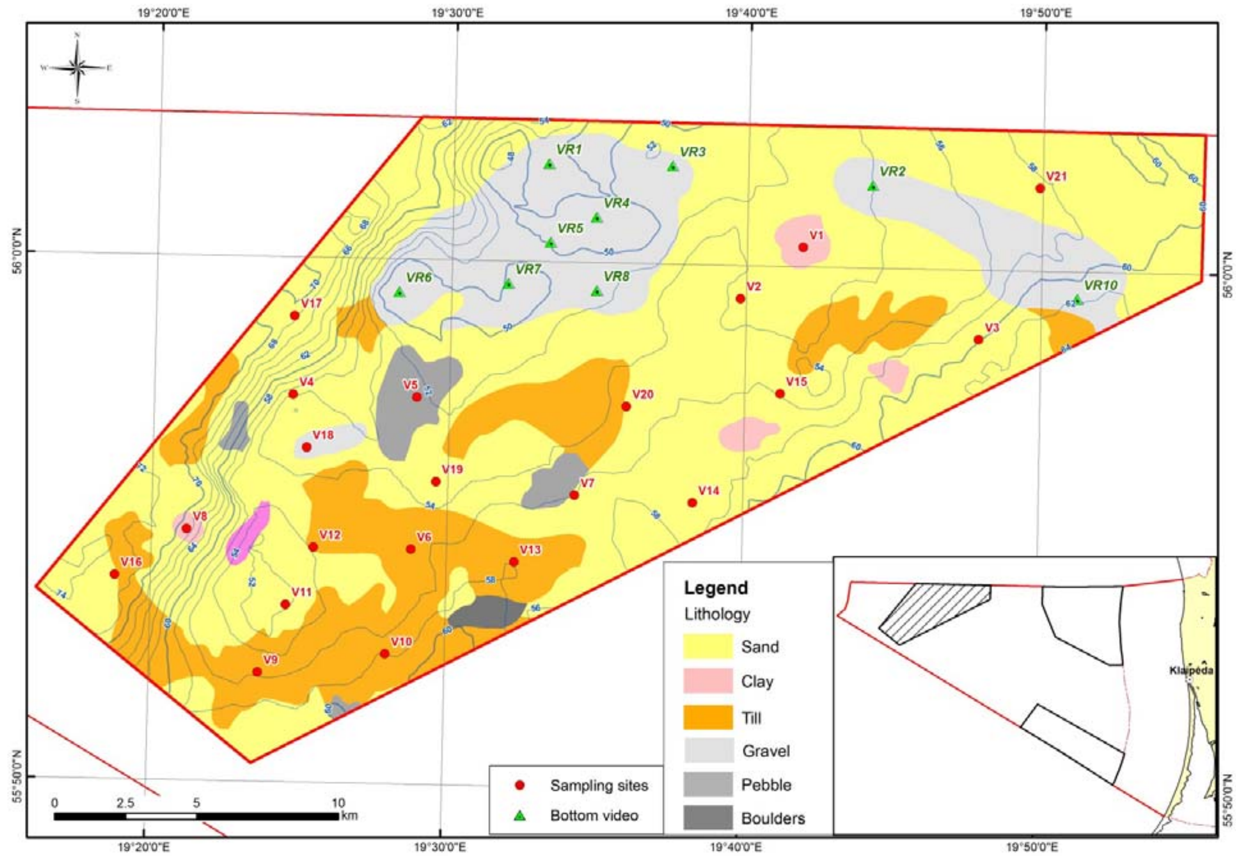



Figure 4.21. Diversity and distribution of sediment types in the Klaipeda Bank.

### 4.4.3 Diversity, structure and distribution of benthic habitats

*Species diversity.* In total 12 species and higher order taxa have been recorded in the Klaipeda Bank research area (Table 4.15). Two thirds of species belong to two large taxonomic groups – crustaceans (5 species) and polychaetes (3 species). Most of the species are typical soft bottom dwellers, only two species are usually associated with hard substrates: *Gammarus sp.* (found exclusively on morainic substrates on two occasions) and *Mytilus sp.* Invasive polychaete *M. neglecta* was found in all studied sites, while *M. balthica*, *M. affinis* and *S. entomon* were also frequent (>75% occurrence).

Table 4.15. Species composition from grab samples taken in the Klaipeda Bank.

| Seabed type / sampling device | | Soft bottoms (grab samples) | | | |
|---|---|---|---|---|---|
| Parameter, units | | Occurrence | Biomass | Abundance | Depth range |
| Taxa | Species | % | g $m^{-2}$ | ind $m^{-2}$ | m |
| Priapulida | *Halicryptus spinulosus* | 31.3 | 0.63±0.45 | 13±13 | 58-74 |
| Polychaeta | *Bylgides sarsi* | 50 | 0.37±0.75 | 29±34 | 54-74 |
| | *Marenzelleria neglecta* | 100 | 2.8±3.94 | 667±727 | 52-74 |
| | *Pygospio elegans* | 68.8 | 0.18±0.16 | 548±487 | 54-74 |
| Oligochaeta | Oligochaeta undet. | 43.8 | 0.04±0.03 | 37±32 | 52-71 |
| Crustacea | Ostracoda undet. | 37.5 | 0.01±0.02 | 170±226 | 57-74 |
| | *Diastylis rathkei* | 6.3 | 0.23 | 18 | 57 |
| | *Saduria entomon* | 75 | 8.84±7.72 | 115±192 | 52-62 |
| | *Gammarus sp.* | 12.5 | 0.03±0.03 | 27±26 | 54-59 |
| | *Monoporeia affinis* | 81.3 | 0.78±1.0 | 217±246 | 52-71 |
| Bivalvia | *Macoma balthica* | 87.5 | 35.7±33.5 | 459±374 | 52-74 |
| | *Mytilus trossulus* | 6.3 | 1.85 | 9 | 52 |

*Bottom macrofauna communities*. Two variations of *M. balthica* community were present in soft sediments. In shallower areas (54-57 m) *M. balthica* dominated macrofauna together with *S. entomon* (89.1±7.5% of total macrofauna biomass), while in deeper areas macrofauna was dominated exclusively by *M. balthica* (83.5±13.4% of total biomass) (Fig. 4.22).

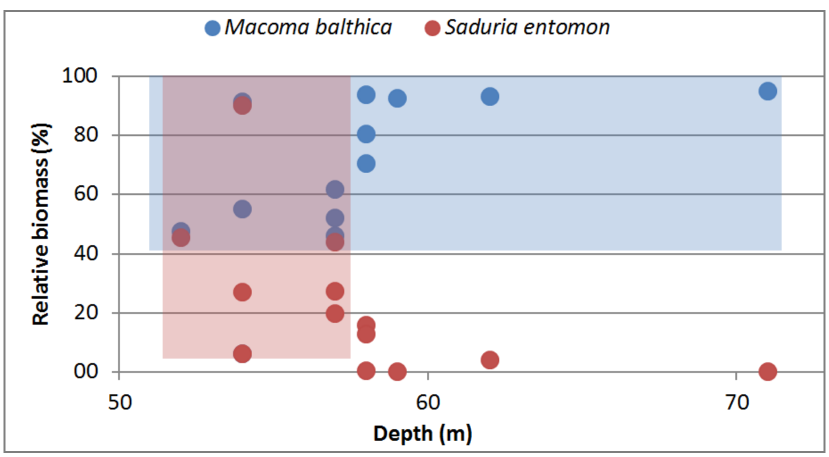



Figure 4.22. Biomass dominance of *M. balthica* and *S. entomon* in soft sediments.

Deep *M. balthica* community consisted of more species, higher macrofauna abundance and biomass (Table 4.16).

Table 4.16. Main average characteristics (± standard deviations) of macrofauna communities in the Klaipeda bank.

| Community (dominant species) | Total abundance ind. $m^{-2}$ | Total biomass g $m^{-2}$ | Richness | Total taxa | Depth m | Median grain size mm |
|---|---|---|---|---|---|---|
| ***M. balthica*** | 2514±344 | 75.3±18.4 | 6.9±1.1 | 11 | 60.4±4.9 | 0.19±0.10 |
| ***M. balthica* and *S. entomon*** | 1749±193 | 23.4±4.3 | 5.8±0.4 | 10 | 54.7±2.0 | 0.30±0.17 |

While total macrofauna biomass was approximately 3 times higher in the deeper community, patterns of relative biomass and abundance were also different (Fig. 4.23). *M. balthica* and *S. entomon* shared equal parts of biomass in shallow areas, leaving less than 10% of biomass for other species, while in deeper areas the share of *M. balthica* relative biomass was almost 10 times bigger that *S. entomon*. Relative biomass of *M. neglecta* was similar, however the relative biomass of *M. affinis* was two times higher in shallow areas. Several differences in relative abundance of two communities can be noted: 1. abundance of *M. affinis* and *S. entomon* was significantly higher in *M. balthica* and *S. entomon* community (respectively 16.6±13.2 and 11.8±12.7% versus 4.2±5.6 and 2.0±1.8%); 2. abundance of *P. elegans* was higher in *M. balthica* community (23.6±16.4% versus 8.7±11.7%).

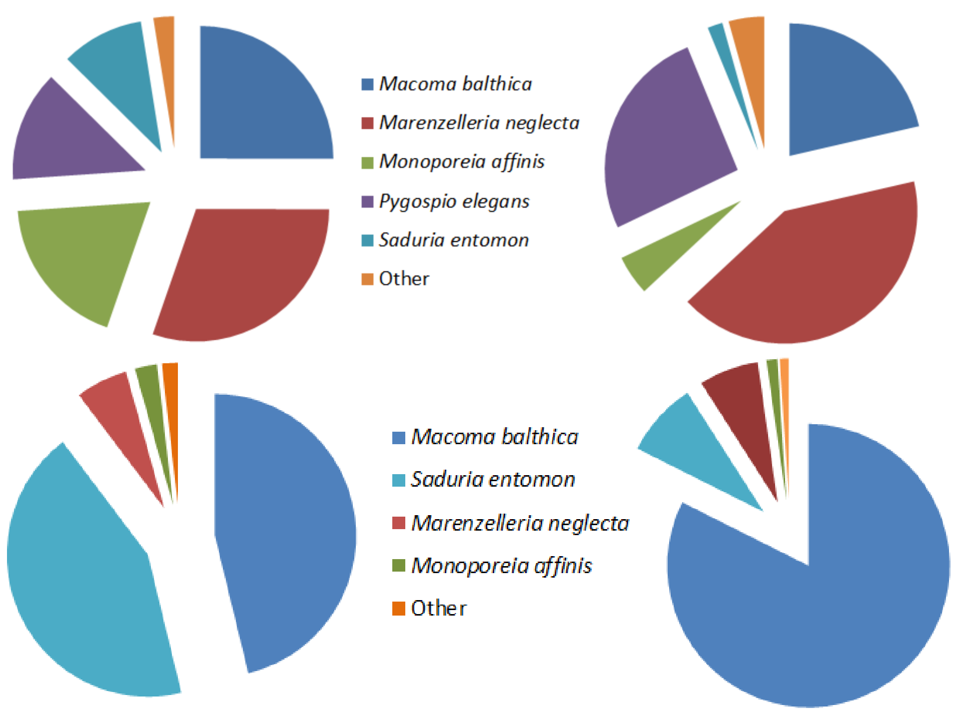



Figure 4.23. Structure of the macrofauna communities in the Klaipeda bank based on relative abundance (upper figure) and relative biomass (lower figure): community dominated by *Macoma balthica* and *Saduria entomon* (left); community dominated exclusively by *Macoma balthica* (right).

The relationship between the structure of macrofauna communities and two environmental variables (depth and median grain size) in the Klaipeda bank based on RDA analysis is shown in Fig. 4.24. The biomass of *M. balthica* increased with depth and finer sediments, while *S. entomon* biomass and abundance decreased with depth. The abundance of *H. spinulosus* and ostracods were increasing along the depth gradient, while biomass and abundance of *M. affinis* was higher in shallower areas with coarser sediments.

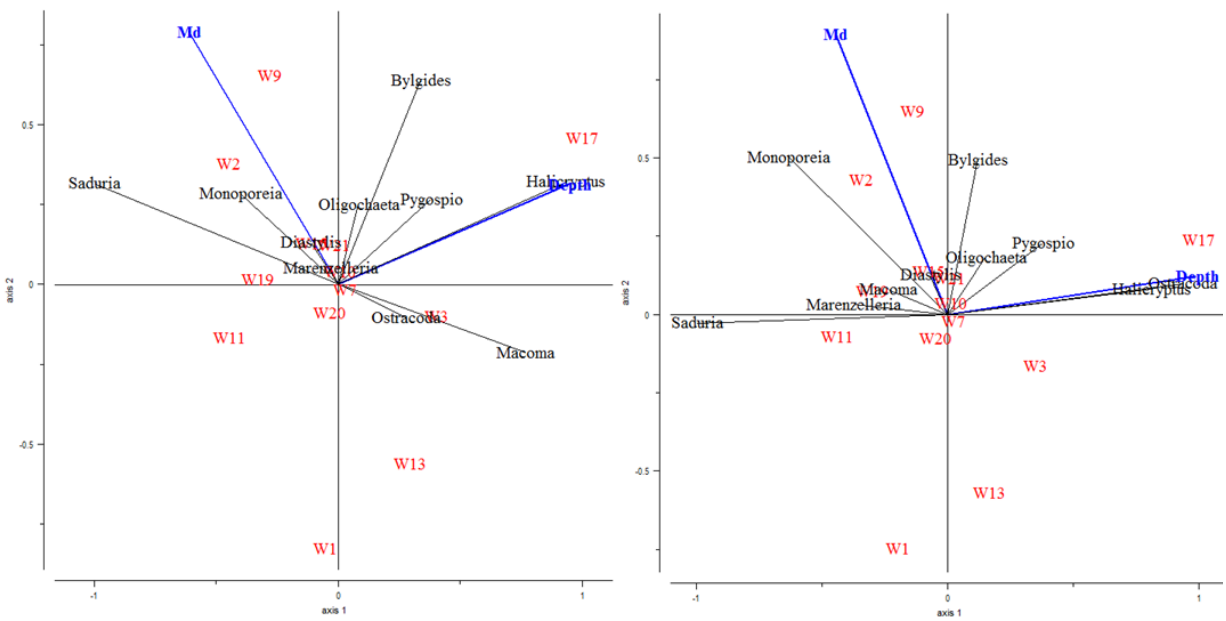



Figure 4.24. Relationship between selected environmental variables (depth and median grain size) and macrofauna biomass (left) and abundance (right) according to redundancy analysis.

According the grab sampling of benthic macrofauna, soft bottom areas in the Klaipeda bank can be classified into two biotopes: 1. medium sand dominated by *M. balthica* and *S. entomon* (depths between 54 and 57 m); 2. fine sands dominated by *M. balthica*.

Video analysis of the Klaipeda bank area resulted in additional substrate classes: substrates dominated by morainic clay (40-80%); substrates dominated by gravel (70-80%); mixed substrates with no dominant fraction (could be separated into two subclasses with the presence of boulders and without); substrates dominated by sand and gravel (could be separated into three groups with ratios of sand/gravel 40-70/20-30%, 40-60/40-60% and 20-30/50-70%).

Video also provided information on presence/absence of *S. entomon, P. elegans* and epifauna. Combination of sediment types and biological features resulted in following classification of biotopes in the Klaipeda Bank:

1. Shallow (54-57) medium sands dominated by *Macoma balthica* and *Saduria entomon*.

This biotope covers the upper area of Klaipeda bank up to 57 m depth. Medium to coarse sands are the dominate fraction of sediments. The bivalve *M. balthica* and isopod *S. entomon* dominates in the benthic community. Species diversity varies between 5-6 species per sample, with typical abundance of 0.5 to 2 thous. individuals per square meter. Macrofauna biomass is usually 10-30 g per square meter. Common species in the biotope are *M. balthica*, *S. entomon* and amphipod *Monoporeia affinis* and polychaete *Marenzelleria neglecta*, found in all samples. Other taxa, such as oligochaetes, polychaetes *Bylgides sarsi* and *Pygospio elegans* may be present at sites, but do not attain high densities.

2. Fine sands dominated by *Macoma balthica*.

This biotope occupies the lower area of Klaipeda bank from 57 to 70 m depth. Fine sands are the dominate fraction of sediments. The bivalve *M. balthica* exclusively dominates in the benthic community. Species diversity varies between 5-8 species per sample, with typical abundance of 1 to 3 thous. individuals per square meter. Macrofauna biomass is usually 40-100 g per square meter. Common species in the biotope are *M. balthica*, *S. entomon*, *M. affinis*, *M. neglecta*, *P. elegans* found in most samples. Other taxa, such as priapulid *Halicryptus spinulosus*, oligochaetes, polychaetes *B. sarsi*, ostracods and cumaceans *Dyastilis rathkei* may be present at sites, but do not attain high densities.

3. Shallow (48-57 m) sediments dominated by sand and gravel with *Saduria entomon.*

This biotope covers the upper area of Klaipeda bank up to 57 m depth. The main characteristic of the biotope – sediments dominated by sandy gravel (gravel fraction amounts up to 70%) and isopods *S. entomon* (Fig. 4.25). Other soft bottom zoobenthos species, such as polychaete *Pygospio elegans* are also present, while on scarce boulders only hydroids *Cordylophora caspia* can be found.

Figure 4.25. Shallow sediments dominated by sand and gravel with *S. entomon*.

4. Morainic clay with *Saduria entomon* and no epifauna.

This biotope is present at 52-70 m depths in the Klaipeda bank. The main feature of this biotope – sediments consisting of morainic clay (Fig. 4.26), which is unfavourable for burrowing of infaunal species, but also unsuitable for epifauna. The only biological feature is opportunistic isopod *S. entomon* with rare occasions of polychaete *P. elegans*.

Figure 4.26. Morainic clay with *S. entomon*.

# 5. FISH INVENTORY

## 5.1 Material and methods

**Fish inventory using gillnets.** Fish sampling was carried out using multi-mesh bottom gillnets (14-17-21-25-30-33-38-45-50-60-70-90 mm mesh sizes, 30 m each section). Nets were set out in evening (18-20 p.m.) and taken up next morning (7-9 a.m.). All caught fish were sorted by mesh size and species, individual total length and weight was measured, sex and maturation stage determined; during each survey at each project area subsample of approx. 100 fish otoliths per species and length group for age determination of caught fish was collected.

Surveys using gillnets have been completed during 2011-2013 spring, summer and autumn. Gillnetting surveys were carried out in 7 locations in each territory in 2011; however following recommendations of the project advisory board the number of sampling sites was increased up to 10 per each sampling survey in each project territory in 2012; the increase was achieved by skipping winter season as many fish species are inactive during this period. 114 sites (175 sampling cases in total using standard set of nets) were surveyed during the implementation of the action in all three project areas in total (Fig. 5.1); 37 different sites were surveyed at Sambian plateau and Klaipeda Bank (58 sampling cases in the each area), 40 sites at Klaipeda-Ventspils plateau (59 sampling cases).

Patterns of demersal and bottom living fish distribution in the project areas depending on project area, depth, habitat, bottom structure, slope and season was analyzed using Brodgar redundancy analysis. For variables Cod CPUE (Catch per Unit Effort: 14-17-21-25-30-33-38-45-50-60-70-90 mm x 30 m each section x night), Flounder CPUE, Other fish CPUE, Percent of Cod juveniles and Percent of Flounder juveniles square root transformation was used.

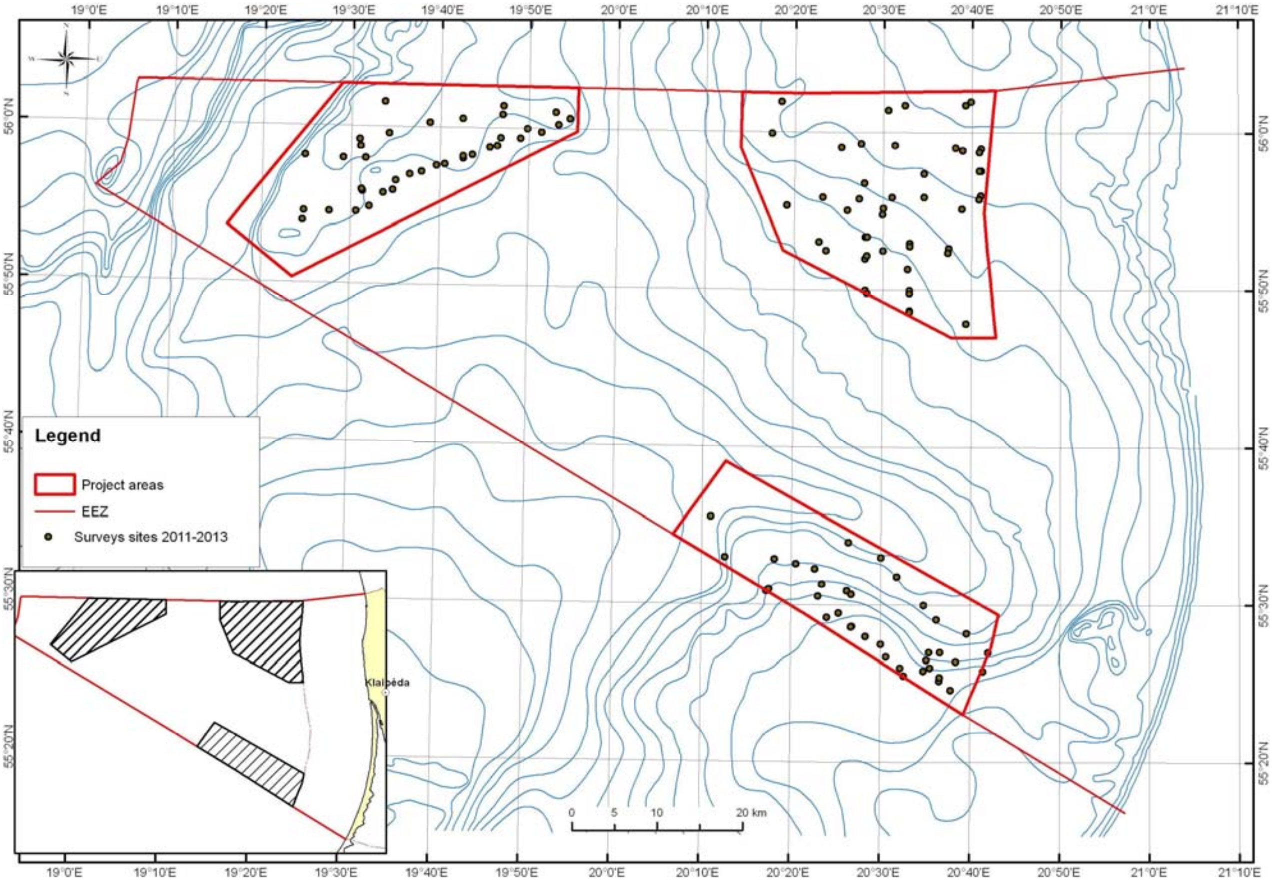



Figure 5.1. Sampling sites of gillnet surveys during 2011-2013.

**Fish inventory using hydroacoustics and trawling.** Hydroacoustic method in combination with pelagic trawling has been used in pelagic fish survey while specifically targeting on pelagic-neritic species – twaite shad. Night sampling strategy has been chosen considering the biological traits and life strategy of clupeid fishes. In the shallow water areas a great part of the clupeid fish concentrations are close to the bottom during daytime as the result of predator avoidance strategy and therefore not visible for the echosounder. While at the night-time clupeids and other pelagic species rise from the bottom and disperse in the water column to feed what makes them easier to register by echosounder. Day-time survey leads to an underestimation of fish and therefore project areas were surveyed only during the night-time. Data were recorded from the sunset till the 2:00-3:00 AM (early spring or late autumn) or till the sunrise (from late spring to early autumn). However, later in data analysis only records of the dark time were used: from one hour after the sunset till one hour before the sunrise.

Parallel hydroacoustic transects were spaced on a regular rectangle or zigzag basis at a distance of about 2.5-5 nautical miles (Fig. 5.2). For one particular survey area one night survey was dedicated. Consequentially, due to the seasonal daytime length (and in some cases due to declining weather conditions) the duration of different survey occasions was different. Therefore the length of hydrocoustic transect per territory were different. The average night acoustic track for Northern survey area was 65 nautical miles and 57-58 nautical miles for Western and Southern survey areas.

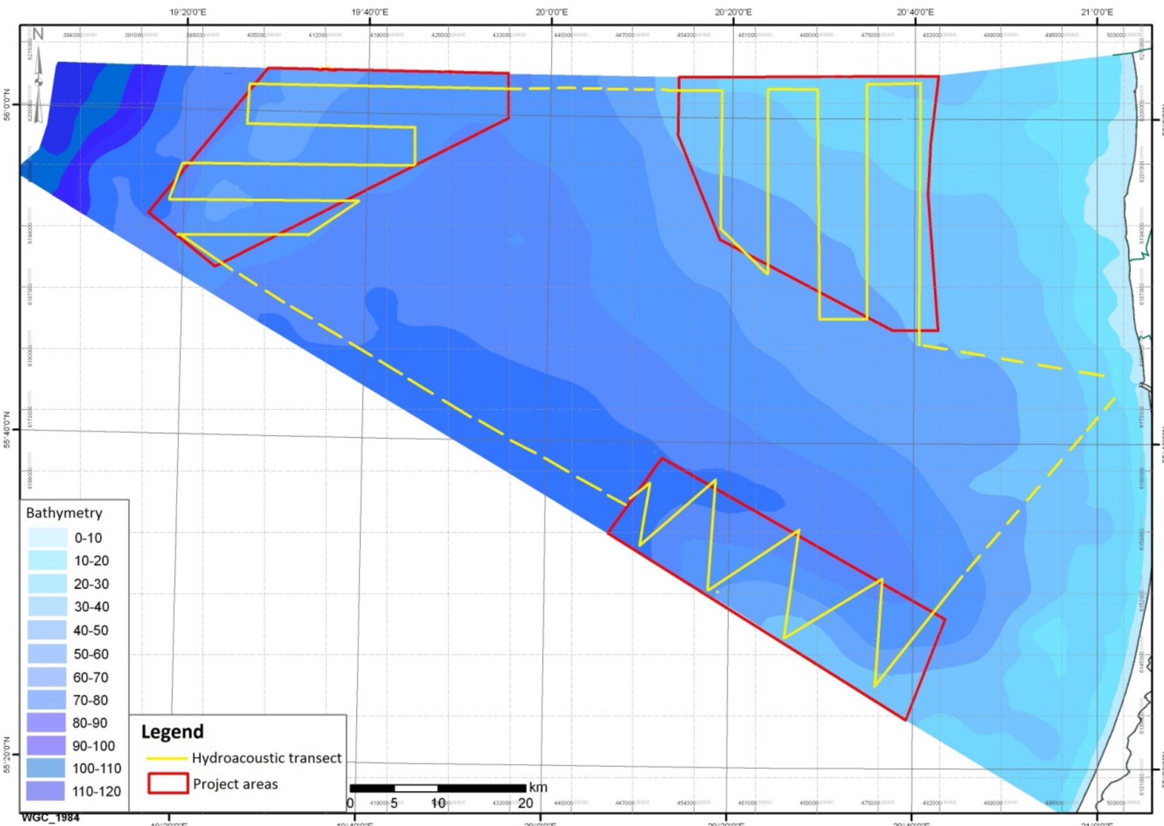


Figure 5.2. Principal layout of hydroacoustic survey transects in the project areas.

10 particular expeditions have been performed to cover all seasons twice during fish inventory actions (A.2.) in years 2011-2013 (Table 5.1). One seasonal survey covers all three survey areas. Seasonal assignment of the survey was based on hydrometeorological and hydrological conditions (air and sea surface temperature, water column stratification), therefore last survey on 2013 September 4-6 is considered as the summer survey. No winter surveys have been made.

Table 5.1. Seasonal coverage of pelagic fish inventory actions in 2011-2013.

| Year/Season | **Spring** | **Summer** | **Autumn** | **Winter** |
|---|---|---|---|---|
| **2011** | April-May | August | November | - |
| **2012** | March | - | October-November | - |
| **2013** | April-May | September | - | - |

The hydroacoustic surveys were performed from R/V "Darius" which has Simrad EK60 multi-frequency acoustic system with 38 and 70 kHz split-beam echosounders mounted on the hull of vessel. The sampling followed standard ICES pelagic fish survey protocol BIAS (Baltic International Acoustic Survey) (ICES, 2008). System was calibrated with the copper spheres of known target strength once per year in the spring.

The basis for the estimation of total fish density F and abundance N in area is the measured area scattering cross section $S_a$ ($m^2/nmi^2$): $N=F*A=(S_a/<\sigma>)*A$, where $A$ - surveyed area, $nm^2$. The mean cross section $\sigma$ of an individual fish of species $i$ should be derived from a function which describes the length-dependence of the target-strength: $TS=a_i+b_i*L$, where $a_i$ and $b_i$ are constants for the $i^{th}$ species and $L$ is the length of the individual fish in cm; and for the herring and sprat σ is $20*log(L) – 71.2$ (ICES, 2008).

Biomass for the species and the age group is calculated from the abundance N and the mean weight per age group. The Elementary Sampling Distance Unit (ESDU) is the length of cruise track, where acoustic measurements are averaged to give one sample. It was averaged to 1 nautical mile.

To get species composition, weight, length and age distribution pelagic trawling in the midwater as well as in the near bottom (>5 m) were performed for the biological sample. The stretched mesh size in the codend of the trawl is 20 mm. Minimum 3 trawls per study area were performed when possible; trawling time was 30 min. Due to trawl operational characteristics the trawling was limited for sites where the depth was <30-35 m. CTD measurements at the end of every trawling haul were performed.

Acoustic data processing was done with Echoview 4 and Sonar 5 softwares. The Elementary Sampling Distance Unit (ESDU) is the length of cruise track, where acoustic measurements are averaged to give one sample. It was averaged to 1 nautical mile. Pelagic fish distribution mapping was performed with ArcMap 10.1. Acoustic data spatial interpolation done by kriging method. Prediction errors provided by cross validation, were used to select which model provides best predictions.

## 5.2 Overview of historical data

**Twaite shad (*Alosa fallax*).** According to statistics on the commercial fisheries Twaite shad was abundant and common species in Lithuanian coastal waters and spawning sites at the Curonian lagoon in a historical perspective. However, data collected during the last 15 years suggest strong decline in the abundance of the population recently (Fig. 5.3). According to data provided by Fishery Research Service for 1995-2010 surveys (bottom trawling at day time) Twaite shad in the Lithuanian EEZ and coastal waters were caught only occasionally and in low numbers: 83 cases (one fish in 30 cases) of Twaite shad catch out of 910 trawling surveys (0.018% by weight and 0.013 % by numbers of total catch; Fig. 5.3). The caught fish, in most cases, were juveniles (an average weight 66 g). The overview of historical data suggests that Twaite shad might be most abundant at Sambian plateau and Klaipeda-Ventspils plateau (Fig. 5.5).

The drastic decline in the abundance of Twaite shad may be related to the impact of commercial fishing at spawning sites in the Curonian lagoon (see Fig. 5.4). Commercial catches of Twaite shad accounting for 221 and 44 tons in 2011 at Russian and Lithuanian parts of the Curonian Lagoon respectively might be the key factor for the species decline at spawning sites in the later years. Such a high fishing mortality at spawning sites might influence the species abundance at the marine habitats as well as overall results of the current survey at the Lithuanian EEZ.

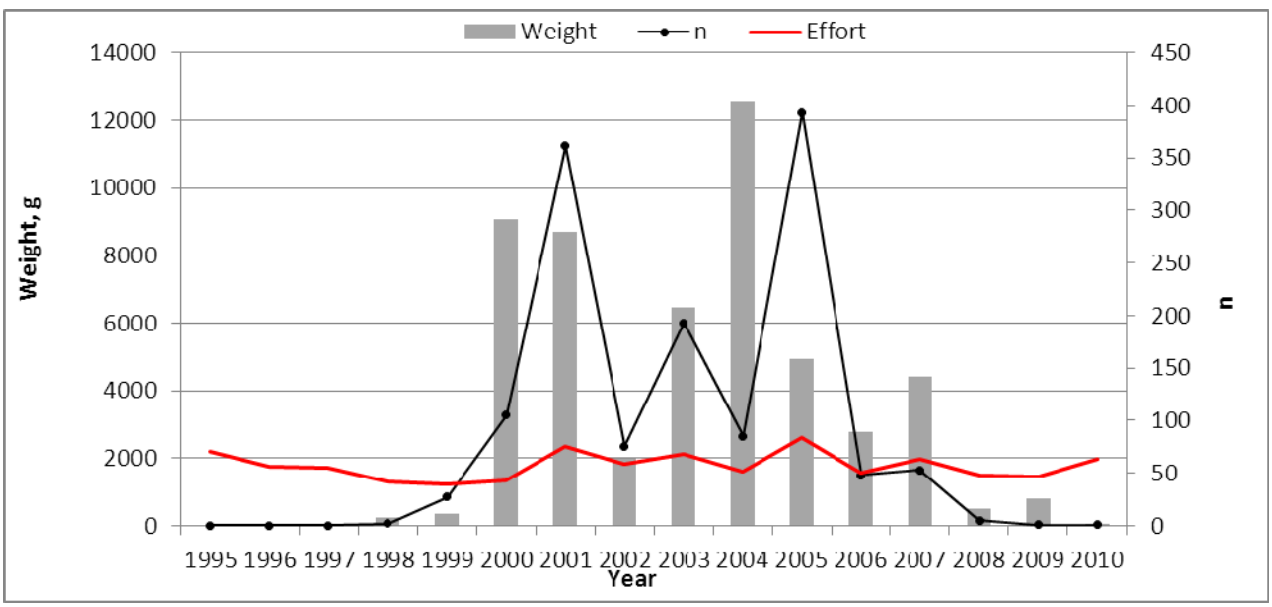



Fig. 5.3. Abundance and biomass of Twaite shad during 1995-2010 in bottom trawl surveys.

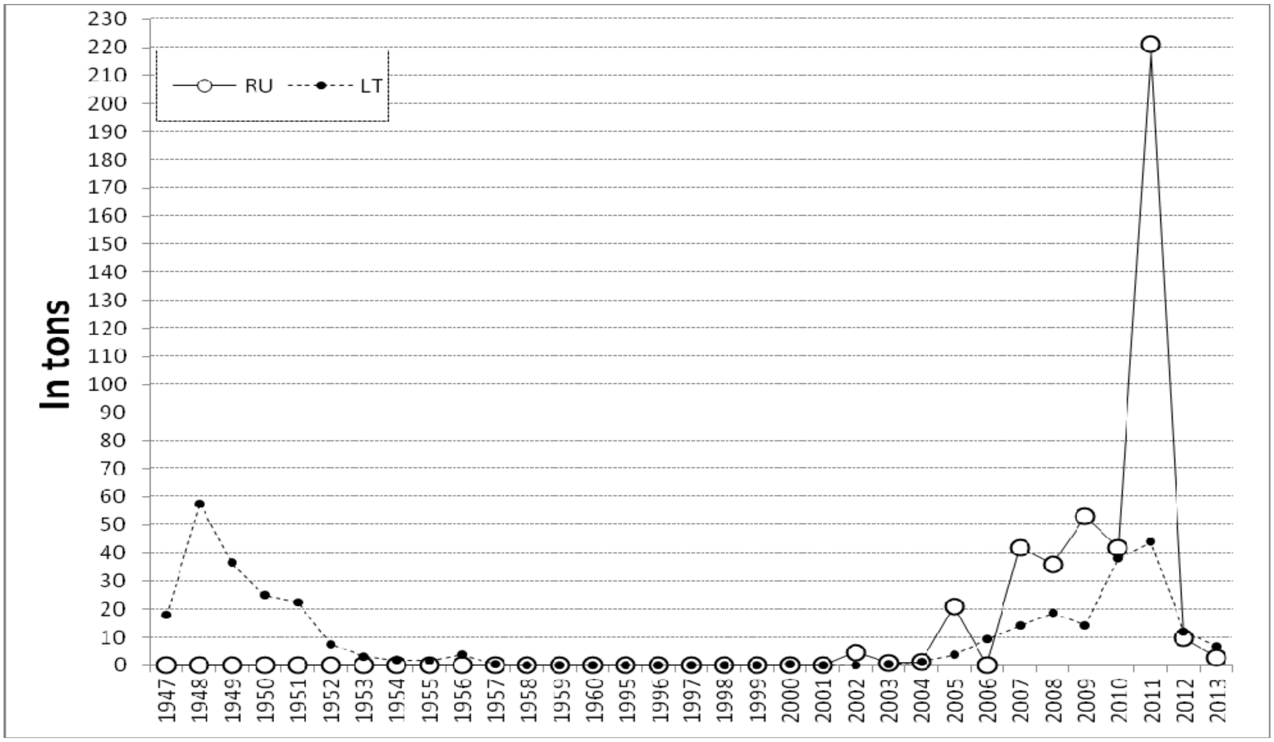


Figure 5.4. Commercial catches of Twaite shad in the Curonian Lagoon during 1947-2013.

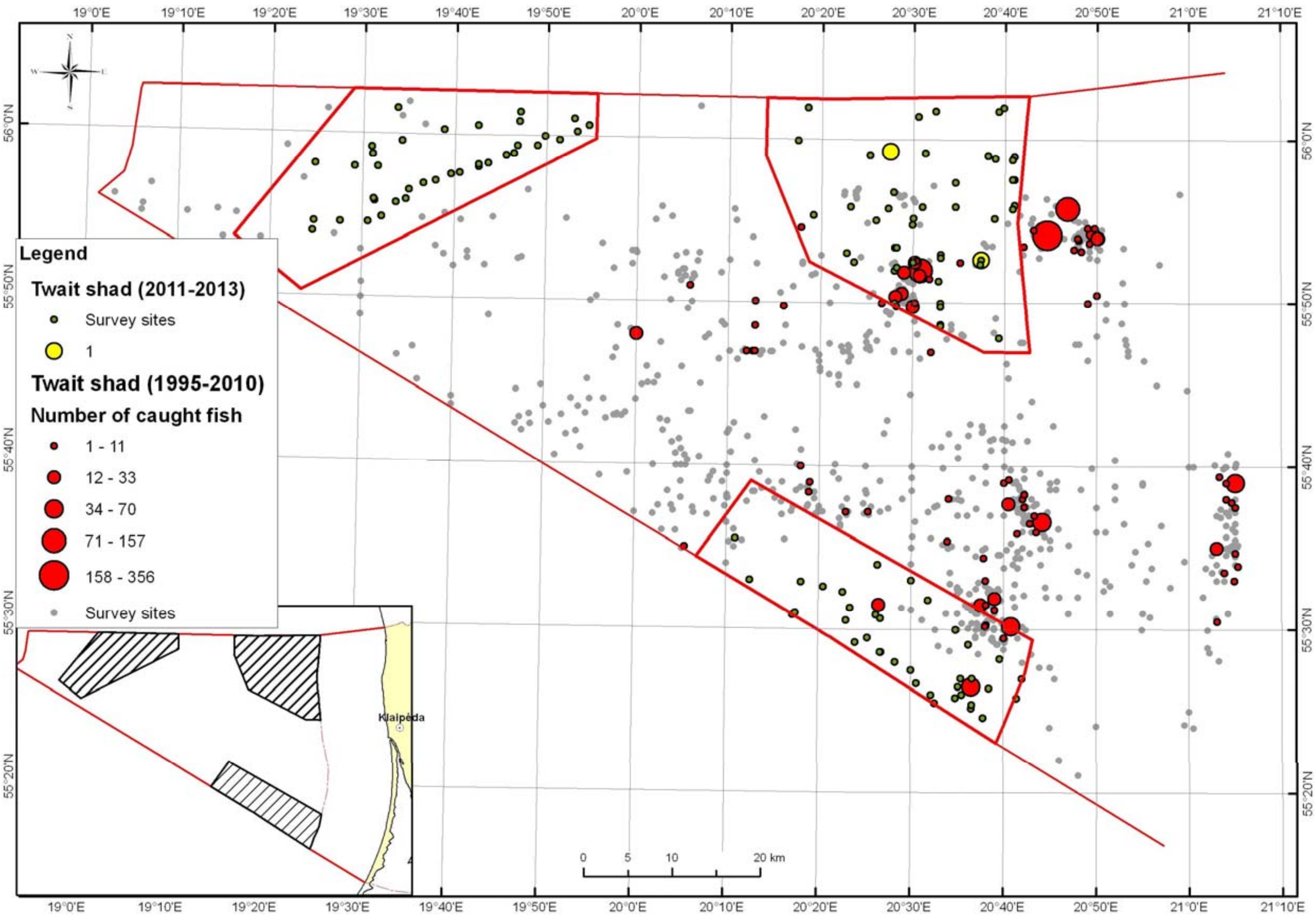



Figure 5.5. Abundance of Twaite shad in bottom trawl (day time, 1995-2010) and project gillnet (2011-2013) surveys.

**Common whitefish (*Coregonus lavaretus*)**

According to data provided by Fishery Research Service for 1995-2010 surveys (bottom trawling at day time) Common whitefish were caught very rare and in low numbers (average weight 631 g) (Fig. 5.6). The data suggest that Common whitefish are most abundant in coastal waters, while in offshore area were caught only twice (Fig. 5.8). It was also observed drastic decline of whitefish in commercial catches in Lithuanian coastal waters (Fig. 5.7). However, reasons of such decline are not clear but might be related to overfishing at Baltic sea and spawning sites in the Curonian lagoon, as well as eutrophication of spawning sites and climate change.

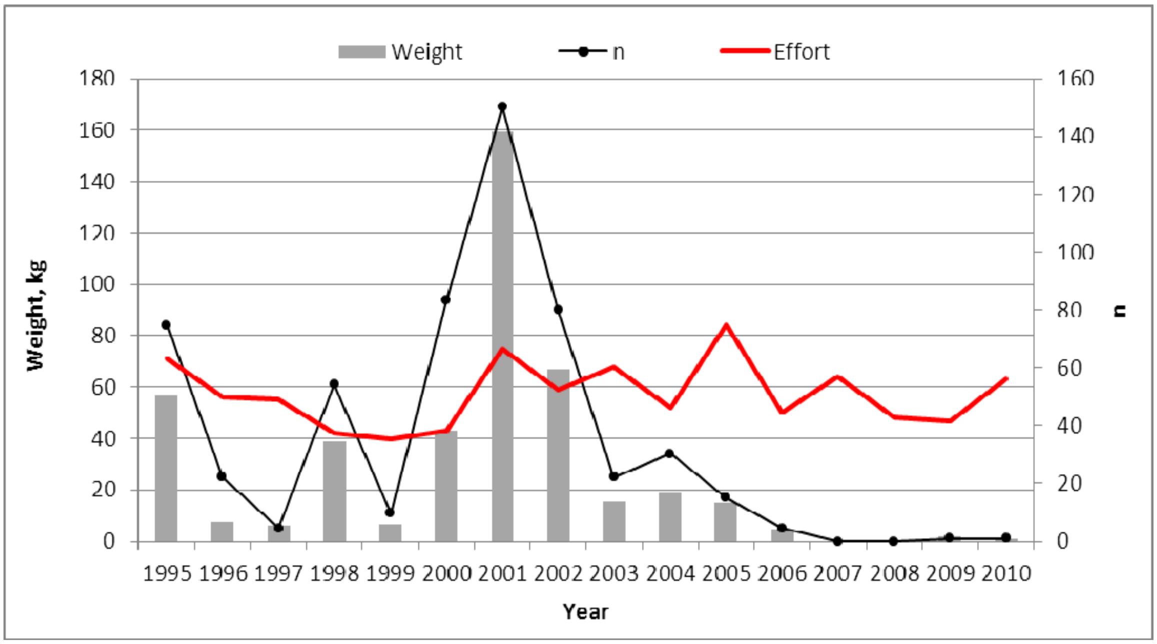



Figure 5.6. Abundance and biomass of Common Whitefish during 1995-2010 in bottom trawl surveys.

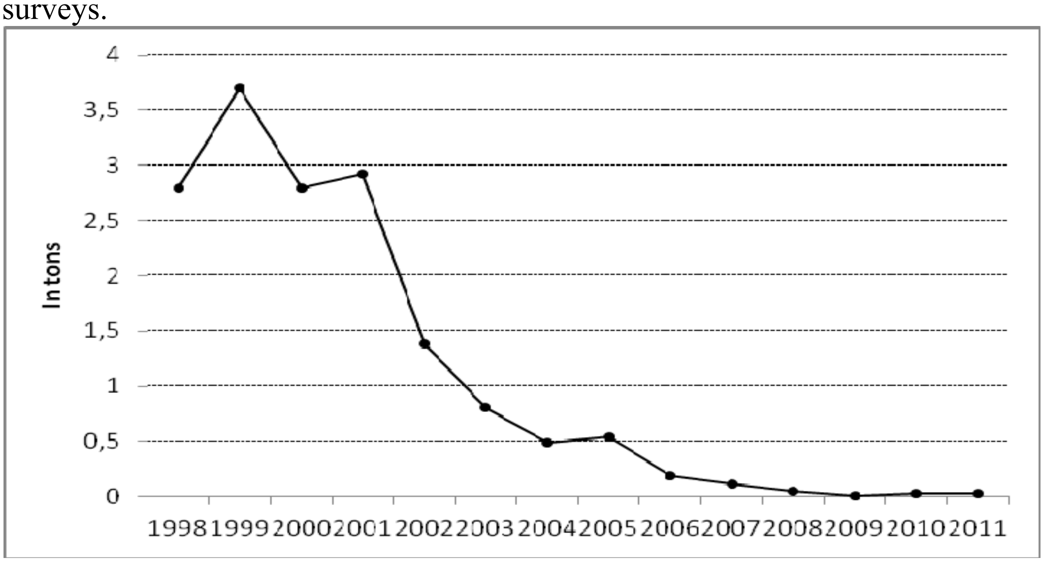



Figure 5.7. Commercial catches of Whitefish in Lithuanian coastal waters during 1998-2011.

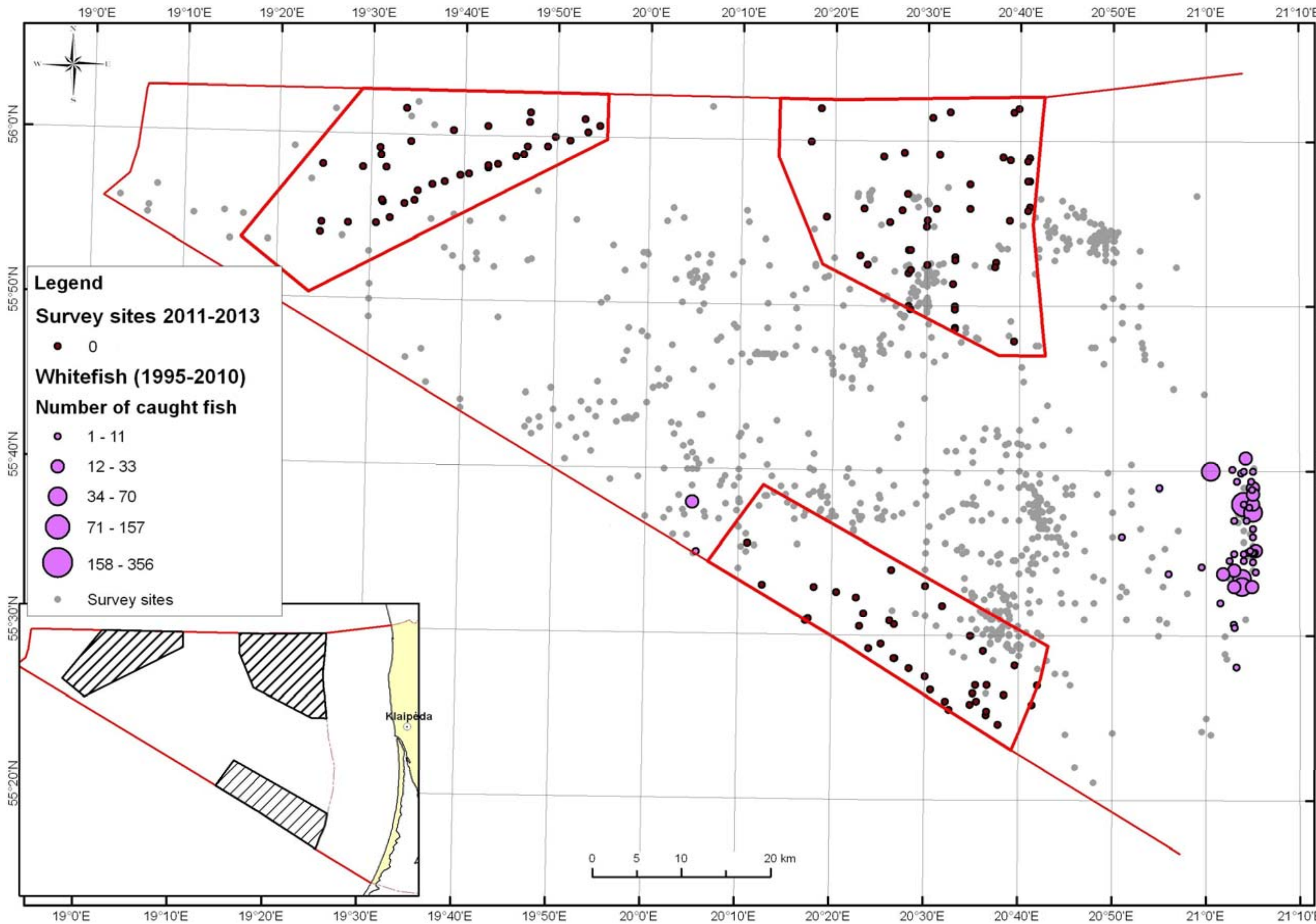


Figure 5.8. Abundance of Common whitefish in bottom trawl (day time, 1995-2010) and project gillnet (2011-2013) surveys.

**Other common fish species (Cod, Flounder, Herring and Sprat*)***

An overview of historical data based on bottom trawling during day time in 1995-2010 suggests the highest Cod abundances at Sambian plateau among project areas and even higher numbers in other parts of the Lithuanian EEZ. However, the greatest concentrations of Cod were registered in relatively short distances from the Sambian plateau area. According to Kruskal-Wallis ANOVA test Cod relative abundance (CPUE) in coastal waters and Klaipeda bank is significantly lower compared to Klaipeda-Ventspils, Sambian plateau and the rest part of EEZ (Table 5.2).

The overview of the historical trawling data reveals high importance of coastal waters as a habitat for Flounder. Klaipeda bank is of little importance as a habitat for Flounder comparing to two other project areas, the rest EEZ and coastal waters. There is no statistically significant difference in Flounder abundance between Sambian plateau, Klaipeda-Ventspils plateau and the rest part of EEZ.

According to the historical data distribution of Herring is most even in Lithuanian marine waters: there is no statistically significant difference in Herring numbers at all three project areas, the rest EEZ and coastal waters.

The analysis suggests that Sprat abundance is significantly lower in the coastal waters and Sambian plateau comparing to the EEZ outside project areas, Klaipeda-Ventspils plateau and Klaipeda bank. Lower abundance of Sprat at Sambian plateau might be negatively affected by high Cod abundance.

Table 5.2. Concentrations of main commercial species in project sites and other parts of Lithuanian Baltic Sea waters

| | Cod CPUE | Flounder CPUE | Herring CPUE | Sprat CPUE |
|---|---|---|---|---|
| Sambian plateau | 150 | 42,2 | 1949 | 4679 |
| Klaipeda-Ventspils plateau | 90 | 53,8 | 2747 | 13933 |
| Klaipeda bank | 9,1 | 0,7 | 1341 | 12650 |
| LT EEZ outside project areas | 182 | 44 | 2580 | 11055 |
| LT coastal waters | 51,3 | 319,3 | 1883 | 3387 |

## 5.3 Gillnet sampling results

During gillnet surveys in 2011-2013 eleven species were caught (N=13189): Atlantic cod (*Gadus morhua*), European flounder (*Platichthys flesus*), Atlantic herring *(Clupea harengus),* Shorthorn sculpin (Myoxocephalus *scorpius),* Eelpout (*Zoarces viviparus*), Lumpfish (*Cyclopterus lumpus),* European plaice (*Pleuronectes platessa)*, European smelt (*Osmerus eperlanus),* Twaite shad (*Alosa fallax*), Turbot (*Scophthalmus maximus*) and Round goby (*Neogobius melanostomus).*

Most abundant were two species - Atlantic cod (N=7125, 54%) and European flounder (N=4235, 32%), other species were caught only occasionally, some of them (Turbot, Twaite shad and Lumpfish) only in few cases.

Species distribution differ between project areas: only five fish species were caught in Klaipeda Bank - Atlantic cod, European flounder, Atlantic herring, Shorthorn sculpin, and European plaice. Biodiversity index in this area was the lowest – 0.38 compared to 0.4 in the Sambian plateau and 0.7 in Klaipeda-Venspils plateau, where all 11 species were caught. Relative abundance of two dominating fish species in the gillnet survey differ: abundance of Cod was highest at Sambian plateau, while Flounder was most numerous at Klaipeda-Ventspils plateau (Table 5.3). Moreover, the analysis suggests significant lower abundance of Cod at Klaipeda-Ventspils plateau comparing to two other project areas, while Flounder is significantly most abundant at Klaipeda-Ventspils plateau.

Redundancy analysis of fish spatial distribution suggests statistically significant positive correlation between Cod abundance and sediments size, as well as cod abundance and presence of Boulder reefs with *Mytilus trossulus*, (Fig. 5.9). Flounder abundance and abundance of other species negatively correlates with depth and habitat Hc (mixed bottom with scarse epibentic fauna). Flounder and other species abundance negatively correlates with Season (Summer), while cod abundance is highest in autumn. Cod abundance is negatively correlated with the presence of a Fine sand with *Macoma balthica*.

Table 5.3. Relative abundance (CPUE) of Cod, Flounder and other fish species (Herring, Shorthorn sculpin, Eelpout, Lumpfish, Plaice, Smelt, Twaite shad, Turbot and Round goby) in gillnet surveys in project areas during 2011-2013.

| | Cod CPUE | Flounder CPUE | Other sp. CPUE |
|---|---|---|---|
| | Sambian plateau | | |
| Spring | 33.75 | 15.13 | 3.4 |
| Summer | 51.6 | 13.9 | 2.8 |
| Autumn | 67.3 | 35.2 | 0.7 |
| | Klaipeda-Ventspils plateau | | |
| Spring | 15.6 | 27.0 | 52.6 |
| Summer | 32.4 | 39.3 | 2.3 |
| Autumn | 60.2 | 50.1 | 9 |
| | Klaipeda bank | | |
| Spring | 37 | 32.8 | 1.4 |
| Summer | 33.6 | 4.3 | 0.5 |
| Autumn | 53.1 | 0.5 | 2.2 |

Statistical analysis suggests that the abundance of Cod juveniles positively correlates with sediments and Summer Season (Fig. 5.10), while abundance of flounder juveniles negatively correlates with depth. Abundance of Flounder juveniles is negatively correlated with area (Sambian plateau) as well. It was not observed statistically significant differences in the abundance of Flounder juveniles between all three project areas (Kruskal-Wallis ANOVA, $p>0.05$). However, the abundance of Cod juveniles is significantly higher at Sambian Plateau comparing to Klaipeda bank.

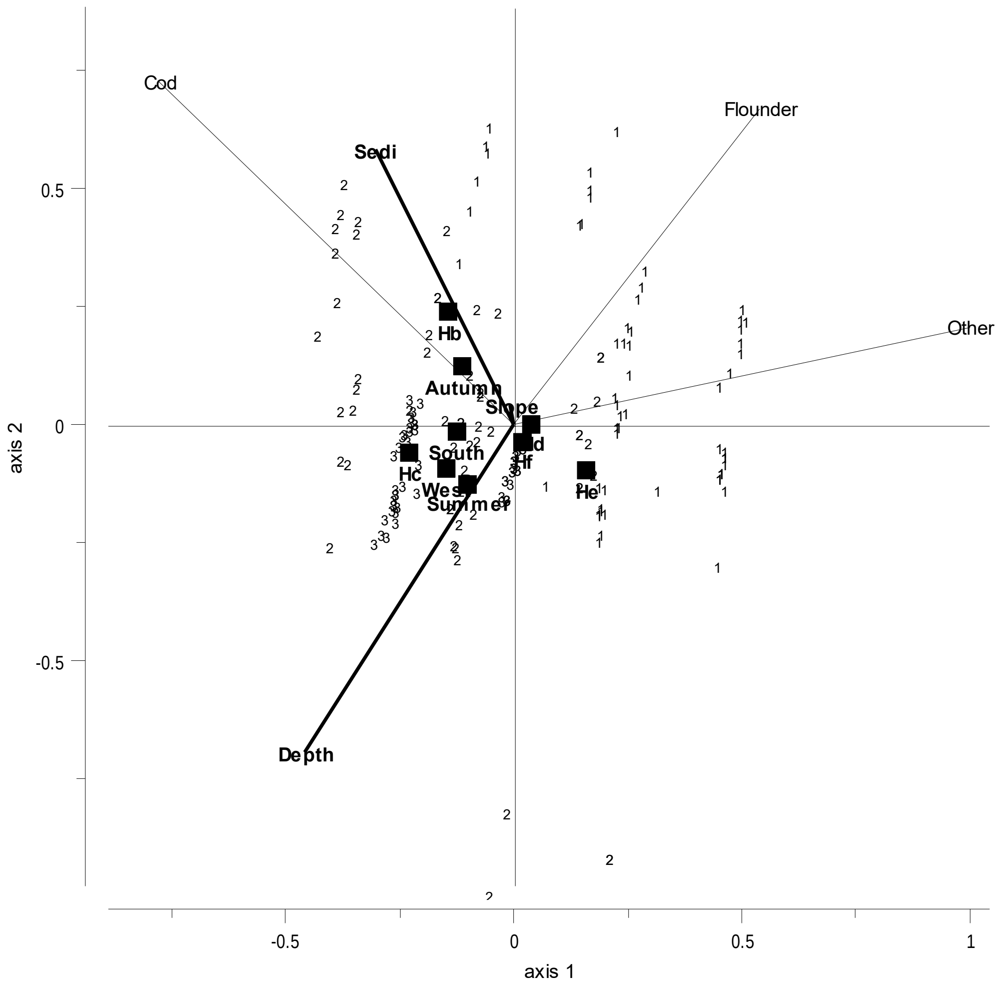



Figure 5.9. Results of redundancy analysis of dominant (in gillnet surveys) fish species (Cod and Flounder) and other fish species (Herring, Shorthorn sculpin, Eelpout, Lumpfish, Plaice, Smelt, Twaite shad, Turbot and Round goby) distribution in relation to environmental factors: depth, habitat (Deep mud with scarce infaunal community – Ha; Boulder reefs with *Mytilus trossulus* – Hb; Mixed bottom with scarce epibenthic community – Hc; Fine sand with *Macoma baltica* – Hd; Silt with Macoma baltica and spionid polychaetes – He; Gravel bottom with scarce epibethic community dominated by *Ballanus* sp. – Hf), season (Spring, Summer, Autumn), slope, sediments and area (1 - Klaipeda-Ventspils plateau, 2 - Sambian plateau, 3 - Klaipeda bank)

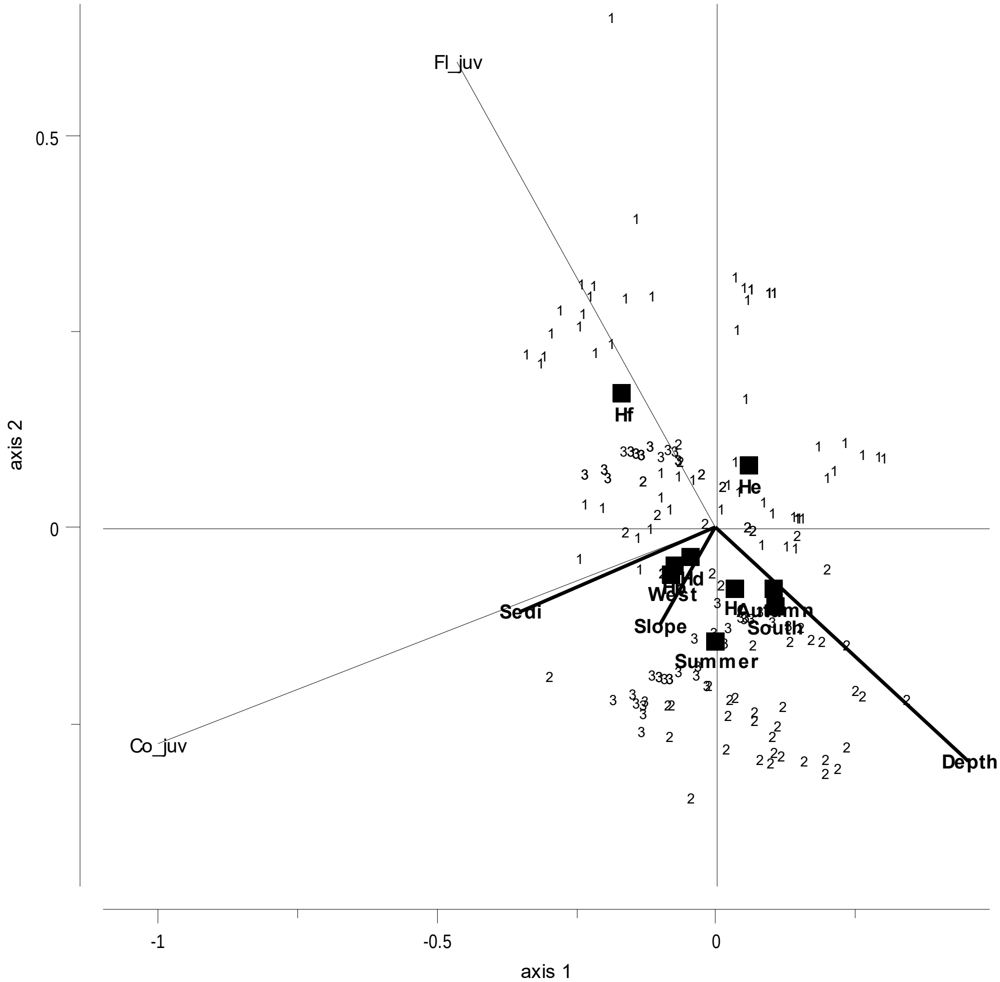


Fig. 5.10. Redundancy analysis of fish juveniles (Cod and Flounder) distribution (in gillnet surveys) in relationship with environmental factors: depth, habitat (Deep mud with scarce infaunal community – Ha; Boulder reefs with *Mytilus trossulus* – Hb; Mixed bottom with scarce epibenthic community – Hc; Fine sand with *Macoma baltica* – Hd; Silt with Macoma baltica and spionid polychaetes – He; Gravel bottom with scarce epibethic community dominated by *Ballanus* sp. – Hf), season (Spring, Summer, Autumn), slope, sediments and area (1 - Klaipeda-Ventspils plateau, 2 - Sambian plateau, 3 - Klaipeda bank)

During gillnet surveys only two Twaite shad individuals were caught (on 2011.08.26 and 2012.09.13, both in Klaipeda-Ventspils plateau) (Fig. 5.5). Both fish were caught at sites with sandy bottoms, however, sites differ by habitats: the first fish was found at the habitat called “silt with *Macoma baltica* and spionid polychaetes”, second at the “fine sand with *Macoma baltica*” habitat. Total length of the first fish was $L_T$=46,5 cm, weight – 1216 g; fish was caught in gillnet of 70 mm mesh size. Total length of the second fish was $L_T$=35 cm, weight – 432 g; fish was caught in gillnet of 17 mm mesh size. No whitefish were caught during project surveys in 2011-2013.

### 5.3.1 Sambian plateau

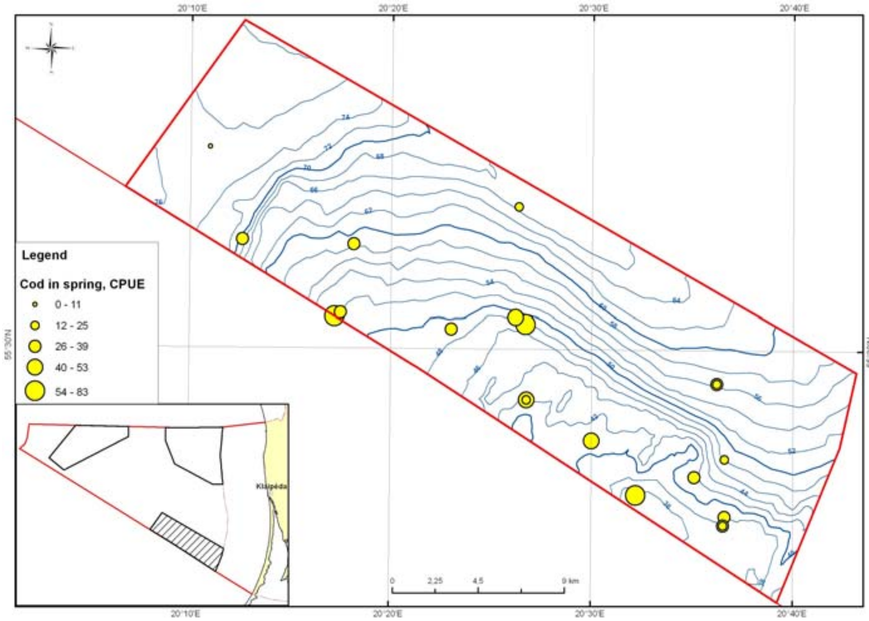
Distribution of Cod in this project area may be well explained by the results of the redundancy analysis of fish spatial distribution. Cod is negatively influenced by *Fine sand with Macoma baltica habitat* which is located in Northern part of Sambian plateau and takes up one third of territory. *Boulder reefs with Mytilus trossulus* habitat is located in the Southern part of the Sambian plateau; this type of habitat positively influences abundance of cod. Cod was most numerous in this project area in summer and autumn and overall abundance of Cod was the highest at Sambian plateau (Fig. 5.11). *Mixed bottom with scarce epibenthic community*, which has negative influence on Flounder abundance, is situated fragmentally in central and southern part of Sambian plateau. The abundance of Flounder negatively correlates with the depth, therefore Sambian plateau with its mean depth (at survey sites) 51.5 m and its maximum depth 80 m is not attractive area for Flounder comparing to more shallow Klaipeda-Ventspils plateau. Overall the highest numbers of Flounder were observed in most shallow parts of Sambian plateau.

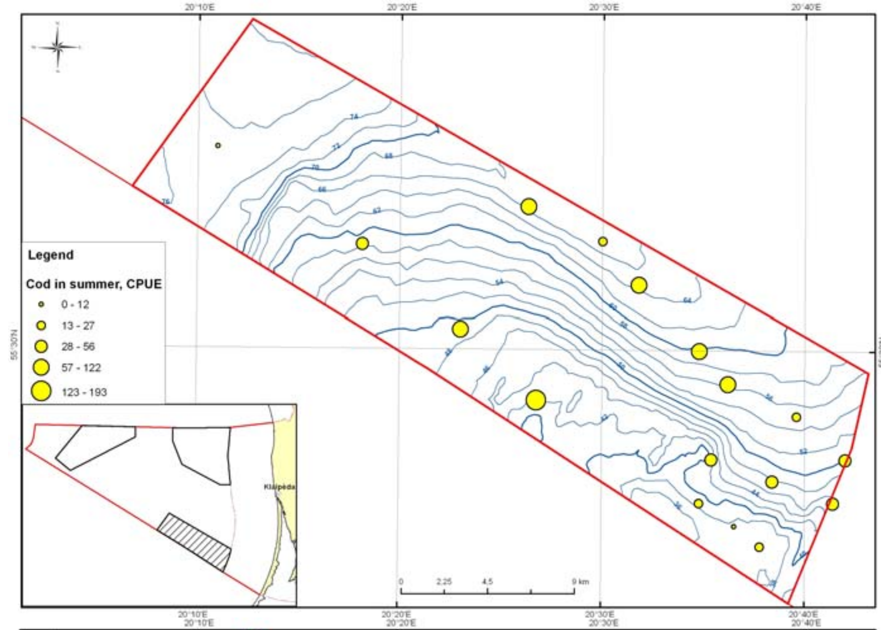
Flounder was not numerous in this project area during spring, moreover, numbers of Flounder CPUE declined even further during summer (Table 5.4, Fig. 5.12). The statistical analysis suggests negative correlation of Flounder abundance and Season (Summer). This effect might be related to reduced oxygen concentrations in deep areas.

Granulometric composition of the bottom is dominated by gravel and boulders in the central-southern part of the area; such structure of the bottom positively correlates with Cod abundance. Large boulders serve as an attractive habitat for shelter and forage. On the other hand such structure of the bottom is not suitable for bottom trawling and therefore impact of commercial fishery is lower compared to other areas with more even bottom structure. Remaining part of the area is covered by sand and silt; abundance of Cod on such areas is lower.

Table 5.4. Relative abundance (CPUE) of Cod, Flounder and other fish species (Herring, Shorthorn sculpin, Plaice, Smelt) in gillnet surveys at Sambian plateau during 2011-2013.

| | Cod CPUE | Flounder CPUE | Other sp CPUE |
|---|---|---|---|
| Spring | 33.75 | 15.13 | 3.4 |
| Summer | 51.6 | 13.9 | 2.8 |
| Autumn | 67.3 | 35.2 | 0.7 |



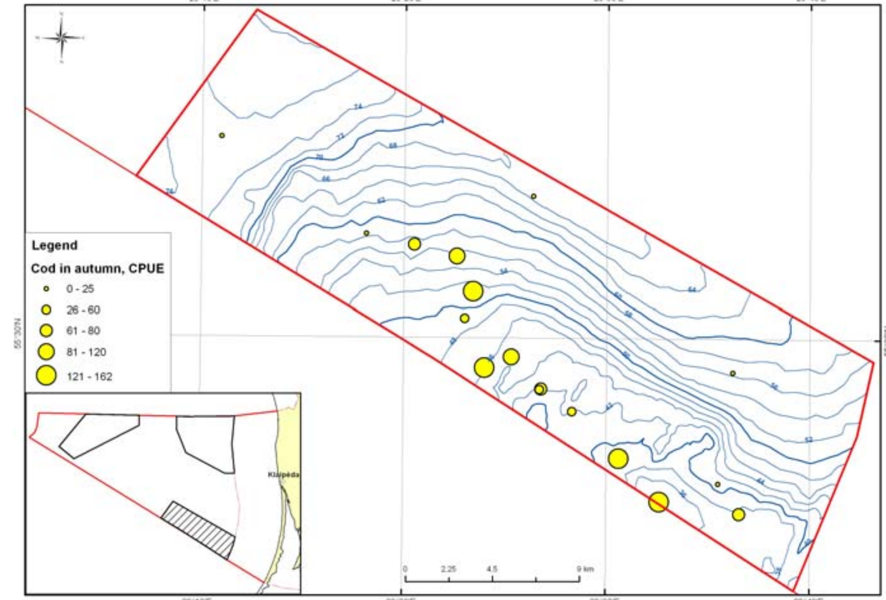
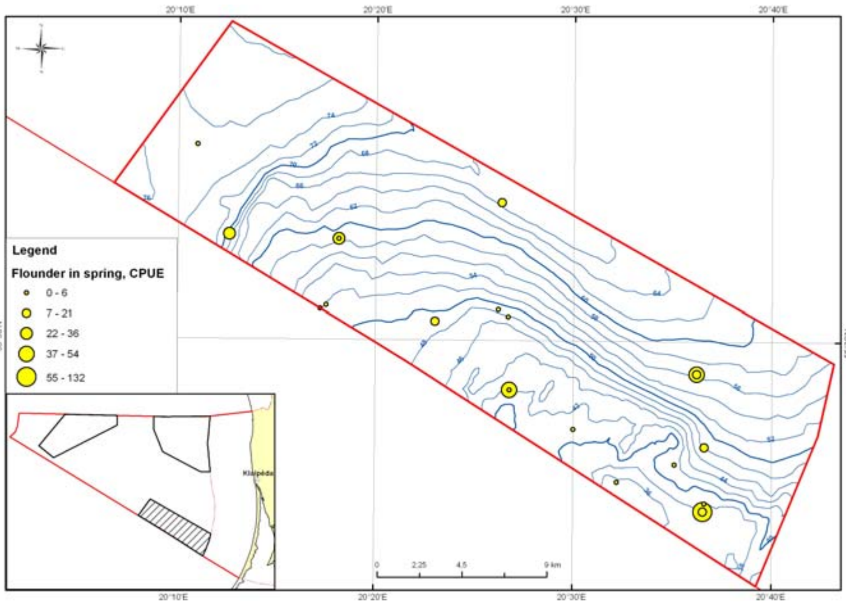
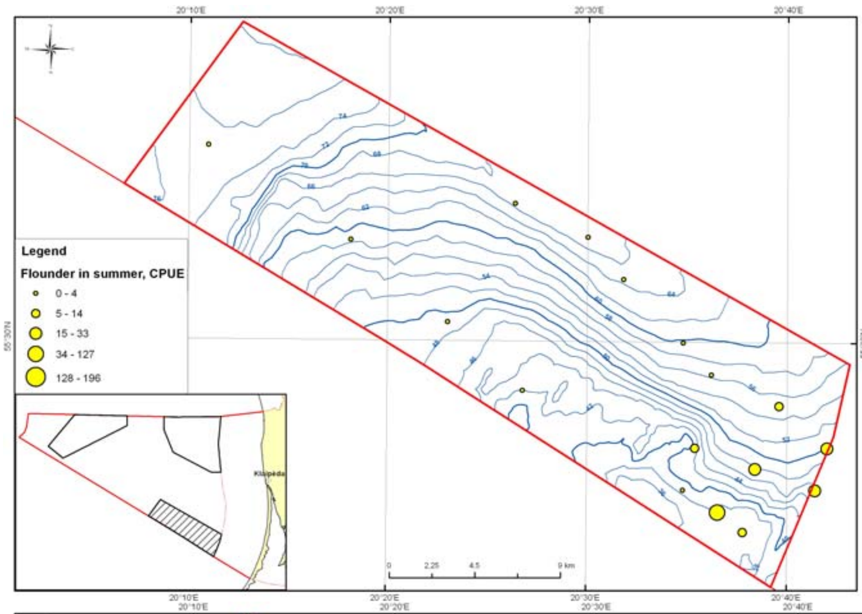




Figure 5.11. Distribution of Cod in gillnet surveys at Sambian plateau during different seasons in 2011-2013.



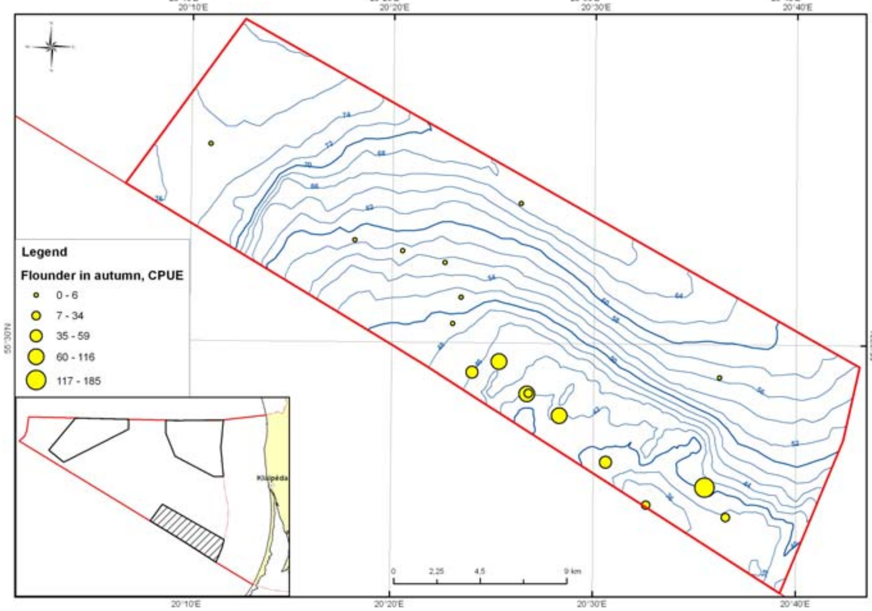




Figure 5.12. Distribution of Flounder in gillnet surveys at Sambian plateau during different seasons in 2011-2013.

### 5.3.2 Klaipeda-Ventspils plateau

The results of gillnet survey suggest that Cod is not numerous in the Southern part of the Klaipeda-Ventspils plateau during all seasons including even autumn (Fig. 5.13) despite the results of the redundancy analysis of fish spatial distribution demonstrated positive correlation between Cod abundance and Season (Autumn). The low numbers of Cod in this part of the area can be caused by *Fine sand with Macoma balthica* habitat, which negatively correlates with Cod abundance in the analysis. This type of habitat takes up approximately half of Klaipeda-Ventspils plateau. *Boulder and cobble reefs with Mytilus trossulus* are situated in the northern part of the area; this type of habitat positively correlates with Cod abundance. As the result the highest abundance of Cod in this area was observed in autumn. Southern part of Klaipeda-Ventspils plateau is covered by sediments of small granulometric composition – silt and sand. Large granulometric composition sediments positively correlate with Cod abundance, therefore Northern part is more attractive for cod as is dominated by gravel, boulders and pebble.

The highest abundance of Flounder among all three project areas was observed in Klaipeda-Ventspils plateau (Fig. 5.14). Mixed bottom with scarce epibentic community habitats absent at Klaipeda-Ventspils plateau; only this type of habitat negatively correlates with Flounder abundance. Moreover, this project area is relatively shallow (mean depth of survey sites in this area is 36.5 m, compared to 51.5 in Sambian plateau and 55.6 m in Klaipeda plateau) while the redundancy analysis suggest that increasing depth negatively affects numbers of Flounder. Season (Summer) negatively correlates with Flounder abundance and as the result it was observed some decline in Flounder numbers during summer season. However, abundance of Flounder is the highest during the summer season if to compare to the rest two project areas (Table 5.5).

Table 5.5. Relevant abundance (CPUE) of Cod, Flounder and other fish species (Herring, Shorthorn sculpin, Eelpout, Lumpfish, Plaice, Smelt, Twaite shad, Turbot and Round goby) in gillnet surveys at Klaipeda-Ventspils plateau during 2011-2013.

| | Cod CPUE | Flounder CPUE | Other sp CPUE |
|---|---|---|---|
| Spring | 15.6 | 27.0 | 52. 6 |
| Summer | 32.4 | 39.3 | 2.3 |
| Autumn | 60.2 | 50.1 | 9 |

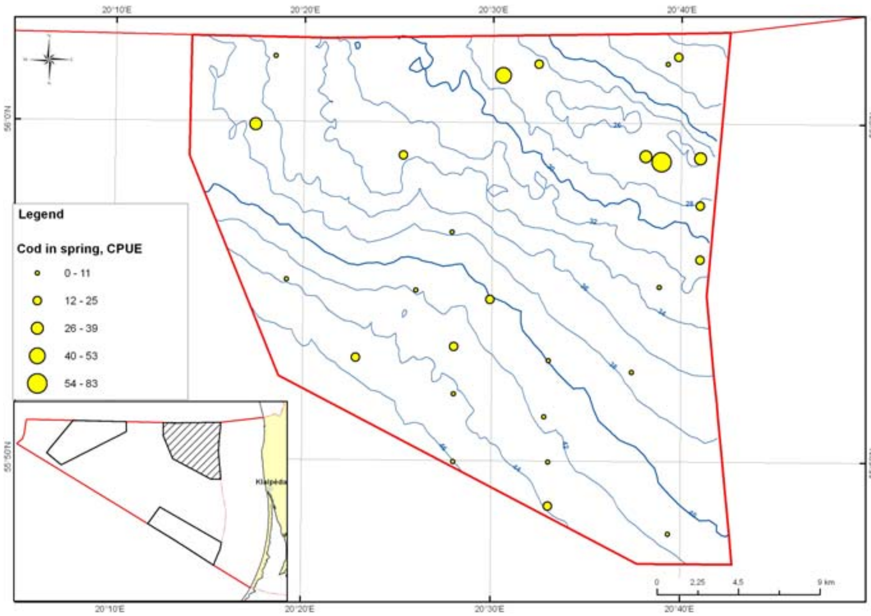
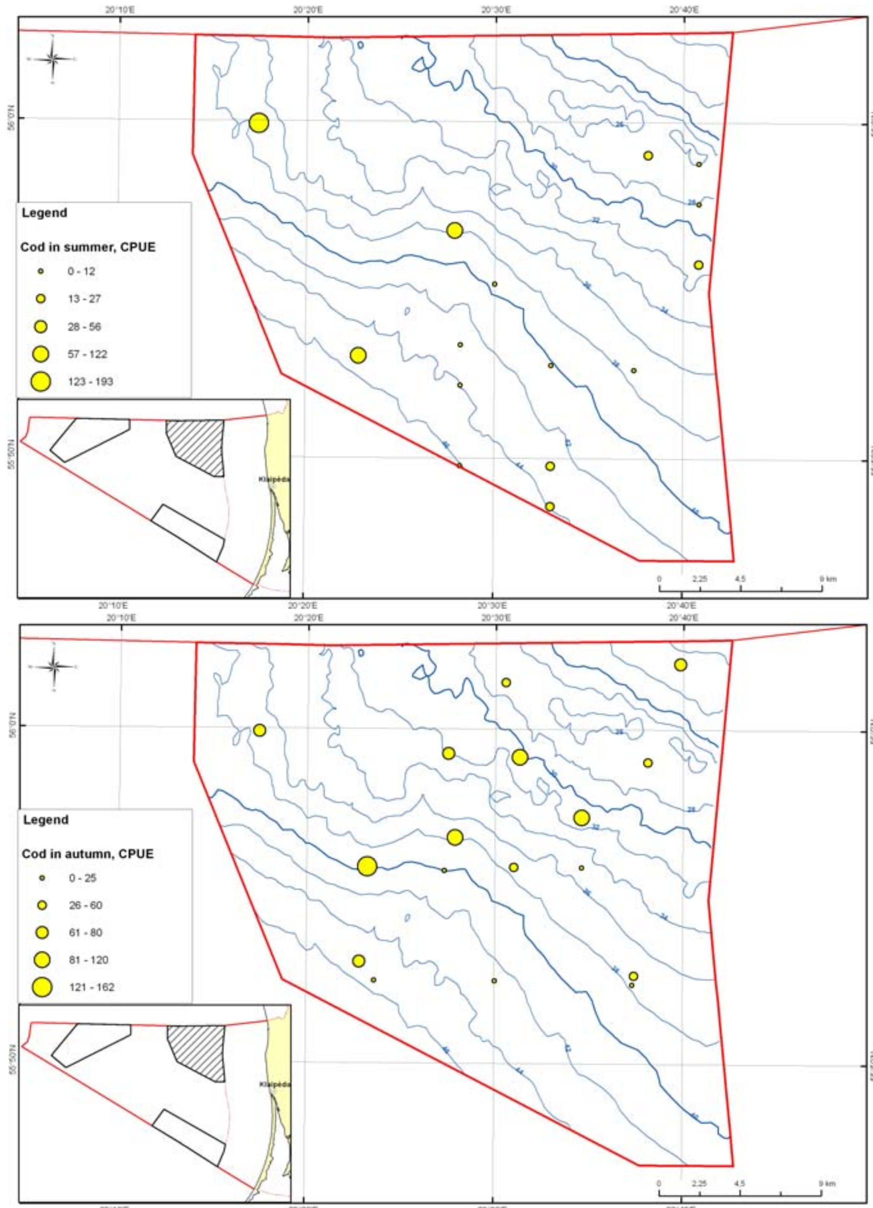
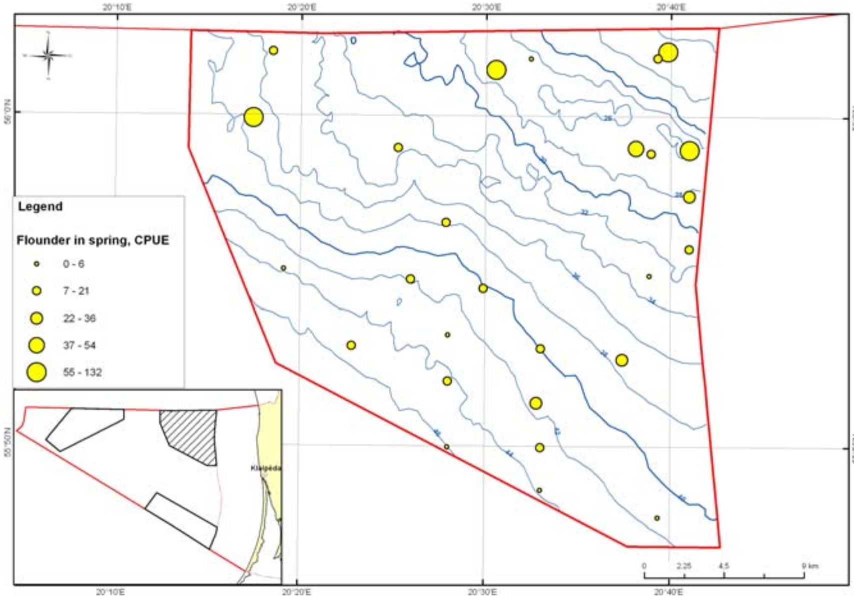
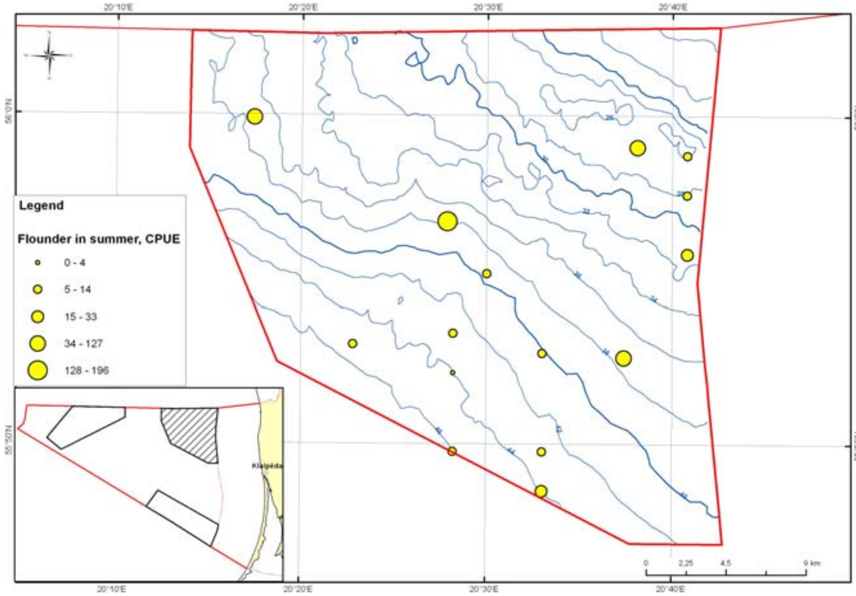



Figure 5.13. Distribution of Cod in gillnet surveys at Klaipeda-Ventspils plateau during different seasons in 2011-2013.





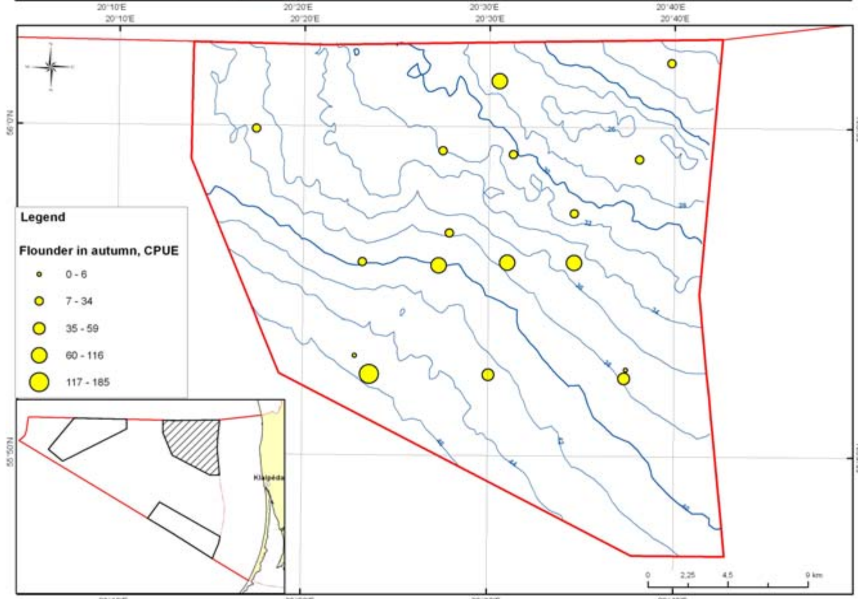




Figure 5.14. Distribution of Flounder in gillnet surveys at Klaipeda-Ventspils plateau during different seasons in 2011-2013.

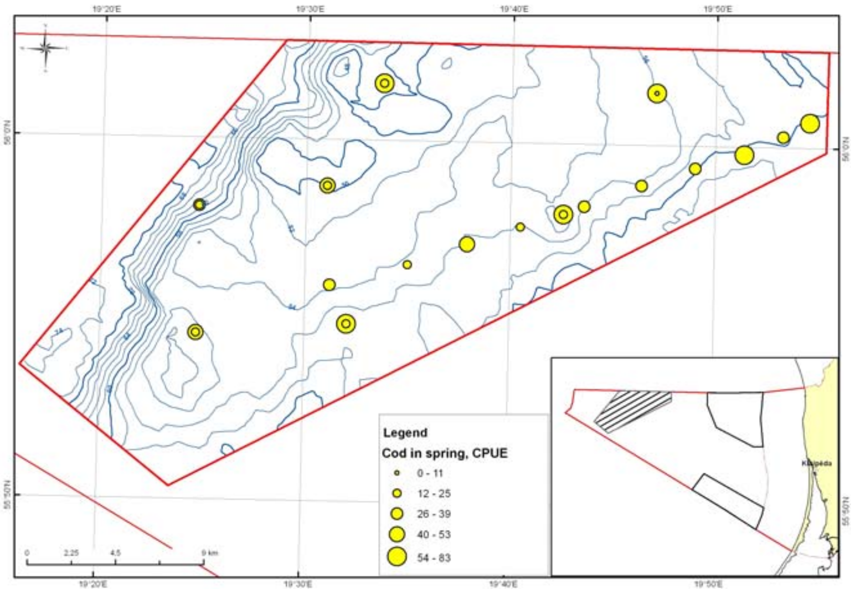
### 5.3.3 Klaipeda bank

The results of gillnet survey at Klaipeda bank suggest that Cod was most abundant fish species (Table 5.6). Cod is most abundant during autumn time in this area (Fig. 5.15) and this is in accordance with the results of the redundancy analysis of fish spatial distribution which demonstrates positive correlation between Cod abundance and Season (Autumn). The whole area is covered by sediments of small granulometric size– various sands with relatively small insertions of gravel and pebble. Despite this type of bottoms, Cod abundance is still quite high in the area; it might be determined by other unknown factors.

Flounder is not abundant in the Western part of the Klaipeda bank; it is related to deepness of this part of the project area (Fig. 5.16). Flounder is not abundant during summer as season negatively correlates with Flounder abundance. Low numbers of Flounder during autumn might be result of continuous summer effect.

Table 5.6. Relative abundance (CPUE) of Cod, Flounder and other fish species (Herring, Shorthorn sculpin, Plaice) in gillnet surveys at Klaipeda bank during 2011-2013.

| | Cod CPUE | Flounder CPUE | Other sp CPUE |
|---|---|---|---|
| Spring | 37 | 32.8 | 1.4 |
| Summer | 33.6 | 4.3 | 0.5 |
| Autumn | 53.1 | 0.5 | 2.2 |



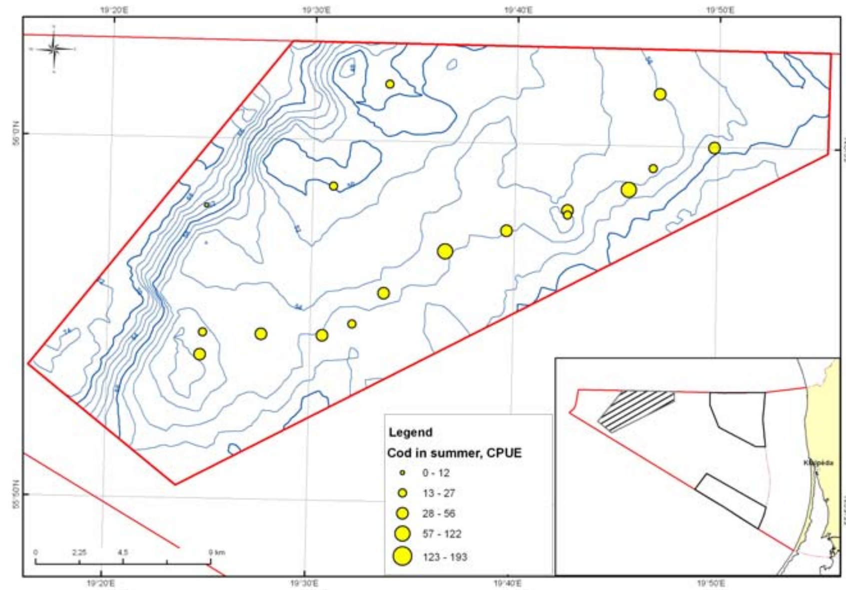
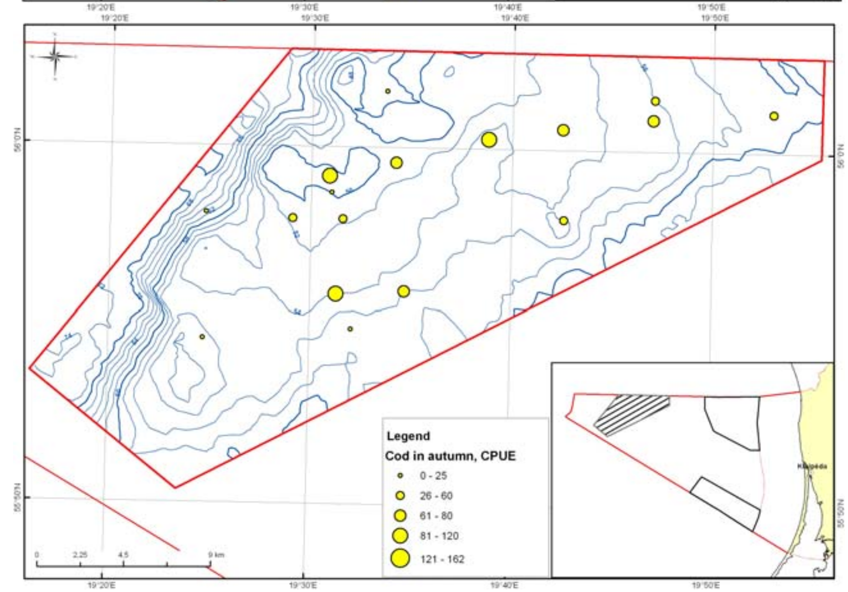
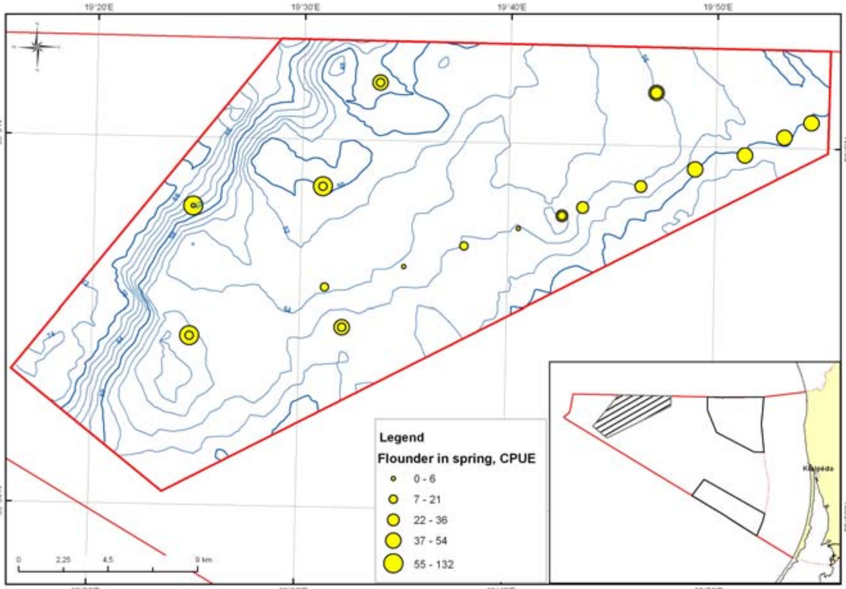




Figure 5.15. Distribution of Cod in gillnet surveys at Klaipeda bank during different seasons in 2011-2013.





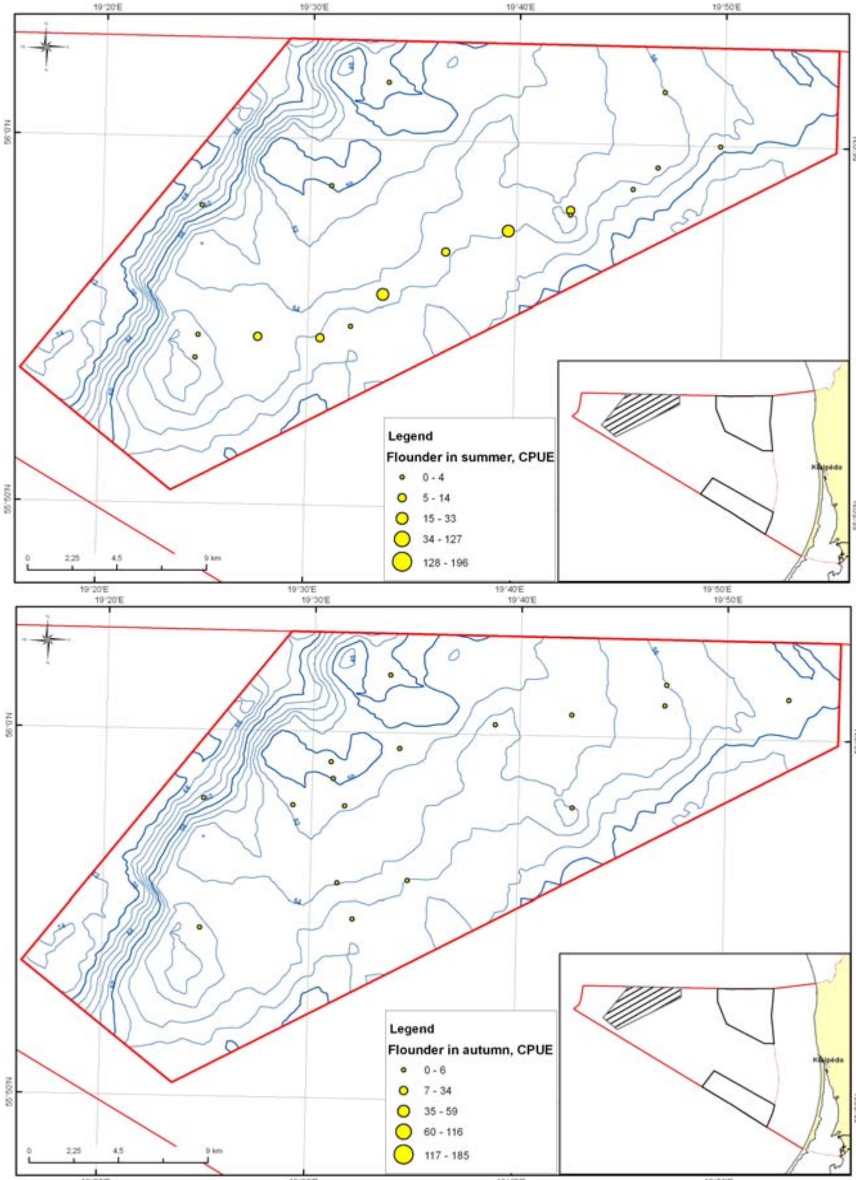




Figure 5.16. Distribution of Flounder in gillnet surveys at Klaipeda bank during different seasons in 2011-2013.

## 5.4 Acoustic sampling results

In total about 1510 nautical miles for night acoustic tracks and 53 pelagic trawling hauls within project survey areas were performed in years 2011-2013. However, no target species have been caught, despite trawling hauls were done in the area of sites where Twaite shad was caught according to historical surveys. Considering adequacy of present survey's structure (night survey strategy, seasonal coverage) and results of survey using bottom gillnets it can be concluded that species targeted by the project in surveyed areas were not common during 2011-2013.

The trawl catches were dominated by other two clupeid species: Baltic herring and Sprat, which together constituted up to 95% of the catch on average (Table 5.7). In addition to these two clupeids, relatively high rate of occurrence in pelagic habitat was observed for Atlantic cod (occurrence rate 62%; average relative abundance 8%), which often follows sprat and herring as the main prey species (Neuenfeldt, Beyer, 2003).

Table 5.7. Fish species composition, occurrence rate and average relative abundance in trawl surveys at project areas in 2011-2013.

| Klaipeda-Ventspils plateau | Sambian plateau | Klaipeda bank | Occurrence rate, % | Average relative share in trawl by weight, % |
|---|---|---|---|---|
| Baltic herring | Baltic herring | Baltic herring | 94 | 54 |
| European sprat | European sprat | European sprat | 89 | 41 |
| Atlantic cod | Atlantic cod | Atlantic cod | 62 | 8 |
| Flounder | Flounder | Flounder | 38 | 3 |
| European plaice | - | - | 6 | <1 |
| Lumpfish | Lumpfish | Lumpfish | 13 | <1 |
| Sand goby | Sand goby | - | 6 | <1 |
| European smelt | European smelt | - | 9 | <1 |
| 3-spinned stickleback | - | 3-sp stickleback | 9 | <1 |
| River lamprey | - | - | 2 | <1 |

In general, the highest number of species in the trawling surveys was registered in Klaipeda-Ventspils plateau. Composition of fish species in trawl catches, however, have only supportive information, while most of caught species were occasional and their relative abundance in trawl catches was usually very low (Table 5.7). Relatively high occurrence rate in trawl surveys was recorded for Flounder despite this species is even not considered as a pelagic fish. Occurrence of Flounder in water column at 20-40 m above bottom is not usual phenomenon and as a typical bottom fish (without swim-bladder) is not surveyed hydroacoustically (Didrikas et al., 2011) as gas inclusion in the swim-bladder makes fish body a strong acoustic target and is accounted to reflect of 90-95% acoustical energy (Foote, 1980).

As the hydroacoustic/trawling survey specifically had targeted the pelagic fish, detailed analysis of abundance and distribution has been done on typical pelagic fish.

The densities (numbers in millions per square nautical mile) of Baltic herring and Sprat within project areas are shown in Fig. 5.17. The highest abundance of clupeids in 2011 and 2012 was observed in the Sambian plateau, while in 2013 the highest relative density was in the Klaipeda-Ventspils plateau. Sprat dominated by the total abundance among clupeids in trawl catches (Fig. 18). It should be noted that if total clupeids abundance was low, the share of Herring in the catch was more expressed.

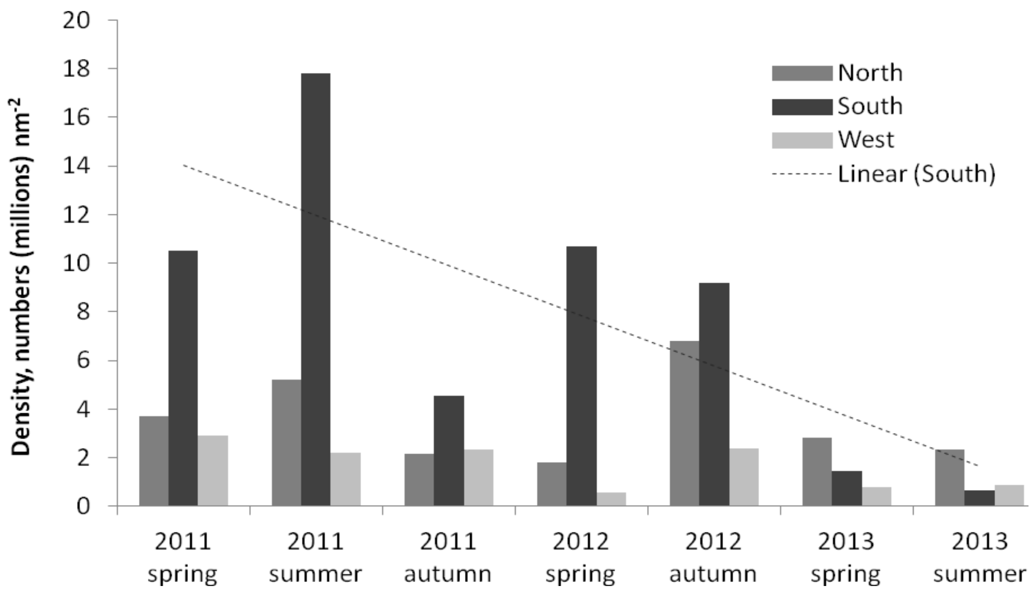



Figure 5.17. Distribution of pelagic clupeids (herring and sprat) density between project areas and survey seasons. For the Southern area the declining trendline of density is $R^2$=0.540, P<0.05.

There was no statistically significant difference between fish density in different seasons (spring, summer, autumn; Mann-Whitney test, P>0.05). Some conspicuous decline trend in clupeids abundance could be seen in Sambian plateau area over the project duration (Fig. 5.18), while in the rest areas the stock status remains at the constant level. As the main part of clupeids mixed stock is constituted by sprat, these fluctuations mainly reflect abundance of sprat stock. Since the 1990s, trends in the Baltic sprat have been driven mainly by reduced predation by cod and high recruitment. Recently, a strong increase of cod stock has occurred in the southern Baltic (especially in Subdivision 25 and, to a minor extent, in Subdivision 26; FAO FIRMS, 2013). This probably will have a strong effect on sprat in particular area (Subdivision 25), but limited effect on the whole Baltic sprat population. High abundance of cod in Sambian plateau could have also local effect on sprat abundance in this area.

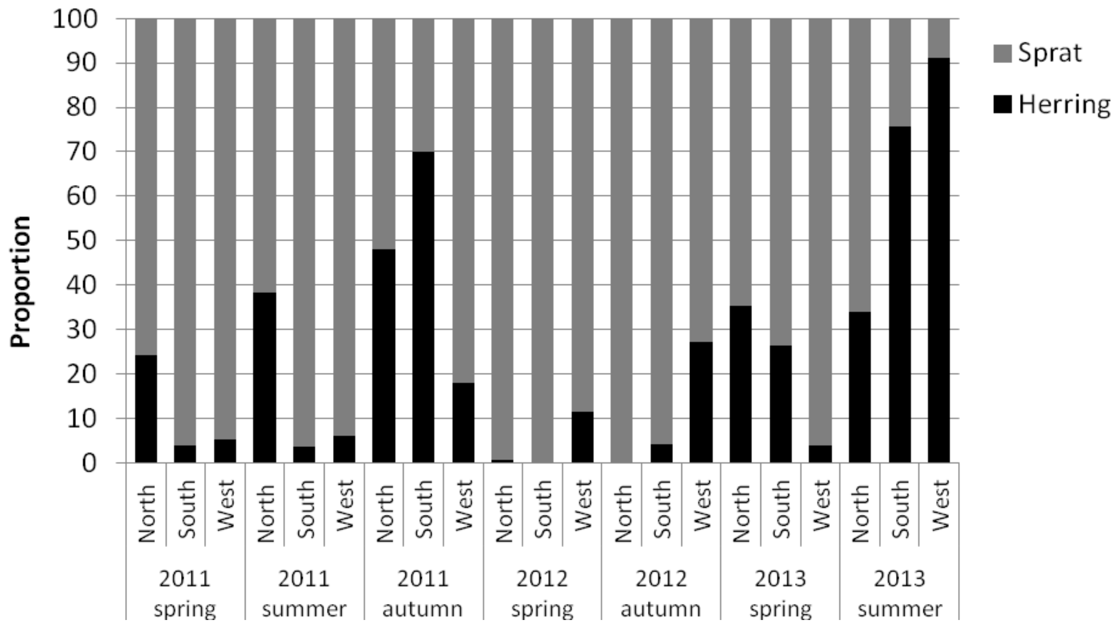



Figure 5.18. Clupeid (Sprat and Herring) proportion in the trawl catches.

As there is no seasonal component in clupeid stock dynamic within project areas, the results of different season surveys were pooled and compared between the project areas. The clupeid stock distribution between survey areas was significantly different (one-way ANOVA, log-transformed data, P<0.05), as the Sambian Plateau had higher density of pelagic fish comparing with the Klaipeda Bank and did not differ from the Klaipeda – Ventspils Plateau (post-hoc test, P<0.05) (Fig. 5.19).

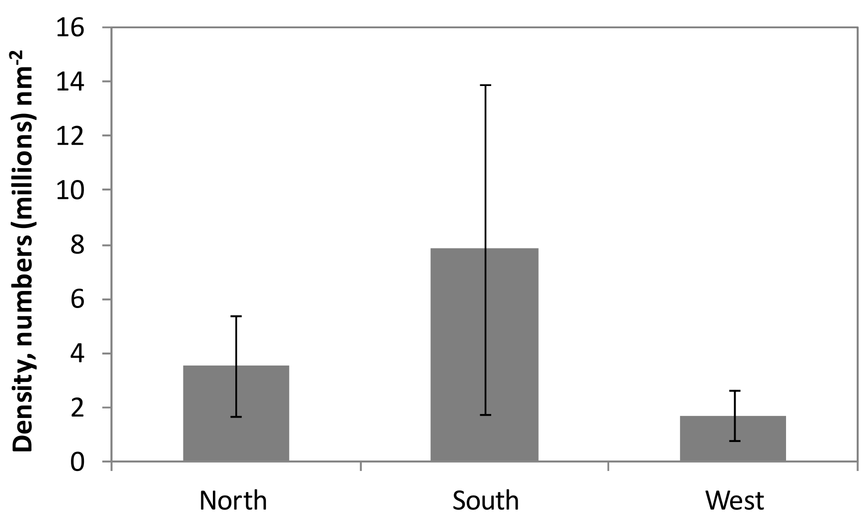



Figure 5.19. Differences in average densities of pelagic clupeids (Herring and Sprat) between project areas.

If data are calculated as an absolute fish abundance in numbers (millions) and biomass in tons per project area, the differences between the three survey areas in abundance of clupeids are even more conspicuous, the Southern area being the most productive (Table 5.8 and Fig. 5.19).

Table 5.8. Abundance and biomass of Sprat and Herring stocks in project areas in 2011-2013.

| | | Sprat | | | Herring | | |
|---|---|---|---|---|---|---|---|
| | | Klaipeda – Ventspils Plateau | Sambian Plateau | Klaipeda Bank | Klaipeda – Ventspils Plateau | Sambian Plateau | Klaipeda Bank |
| Abundance in numbers (millions) | 2011 spring | 516 | 1254 | 412 | 166 | 49 | 22 |
| | 2011 summer | 725 | 2125 | 316 | 233 | 83 | 17 |
| | 2011 autumn | 3053 | 2307 | 109 | 11 | 199 | 101 |
| | 2012 spring | 193 | 1468 | 71 | 1 | 0 | 1 |
| | 2012 autumn | 1976 | 2459 | 193 | 5 | 110 | 72 |
| | 2013 spring | 518 | 930 | 341 | 284 | 333 | 14 |
| | 2013 summer | 725 | 2125 | 316 | 233 | 83 | 17 |
| | Average ± SD | 1101±1030 | 1810±587 | 251±128 | 133±124 | 122±111 | 35±37 |
| Biomass, in tonne | 2011 spring | 2316 | 5164 | 3873 | 6822 | 2681 | 948 |
| | 2011 summer | 3256 | 8748 | 2973 | 9589 | 4542 | 727 |
| | 2011 autumn | 5205 | 7596 | 1087 | 109 | 8867 | 4557 |
| | 2012 spring | 636 | 12550 | 421 | 74 | 0 | 25 |
| | 2012 autumn | 5535 | 9536 | 1563 | 197 | 5955 | 3758 |
| | 2013 spring | 2042 | 5873 | 3225 | 12117 | 16921 | 646 |
| | 2013 summer | 3256 | 8748 | 2973 | 9589 | 4542 | 727 |
| | Average ± SD | 3.18±1.74 | 8.32±2.46 | 2.30±1.28 | 5.50±5.25 | 6.22±5.45 | 1.63±1.77 |

Two project areas (Sambian Plateau and Klaipeda – Ventspils Plateau) at the Lithuanian EEZ are characterized as productive areas for economically important clupeid fishes, especially sprat (ICES, 2012; 2013). In 2011-2012 the estimated clupeid stock in eastern EEZ (ICES SD 26, rectangles 40H0 and 41H0) are in good condition and this is in accordance with our project results. As an example, in 41H0 rectangle (overlaps with the Klaipeda – Ventspils Plateau) the abundance of herring in 2011-2012 varied in 1276 – 753 million, and sprat reached 3313-4712 million per rectangle (ICES, 2012; 2013). If back-calculate from the total abundance in rectangle to the density per square nautical mile, values fall between 1,34-0,79 for herring and 3,48-4,94 million nm$^{-2}$ for sprat The densities for sprat in Sambian Plateau and Klaipeda – Ventspils Plateau were somewhat higher. This emphasizes the relative importance of Eastern project areas for the Lithuanian pelagic fish stocks. The productivity of project areas is reasonable in the ICES rectangle 26 or even whole South-Eastern Baltic Sea. On the other hand, ICES data and our results are not directly comparable, as hydroacoustic assessment of pelagic fish stocks is usually implemented at the day time, while a great part of the fish are close to the bottom during daytime and therefore not detectable by echosounder. This leads to an underestimation of pelagic fish (ICES, 2008).

The analysis of age and length distribution showed distinctive patterns for sprat and herring populations within surveyed areas. Sprat populations at Sambian Plateau and Klaipeda-Ventspils Plateau are dominated by juveniles (0-1 year old individuals), and this highlights the importance of these areas in the eastern EEZ as nursery habitats for sprat. Klaipeda Bank have distinct age distribution pattern for sprat as older individuals are more common (Fig. 5.20).

For herring population there is no clear differences between survey areas in patterns of age structure; older (4-5 years) individuals are dominating the population. Surveyed two project areas in the east of EEZ may potentially have high recruitment densities of herring, but juvenile stages were relatively not abundant in all seasons in all areas.

Considering importance of surveyed areas as nursery zones for pelagic fish, some temporary fishing restrictions for the area could be applied based on regular stock assessment monitoring, when high recruitment densities are established, to avoid high by-catch of juveniles. On the other hand, natural physical obstacles such as relatively shallow depth and high bottom roughness preserve some parts of these plateaus from intensive fishing, at least with bottom trawls. This circumstance maintains high sprat recruitment potential for these areas.

Despite clupeids are the key species in the Baltic ecosystem shaping its structure and functioning, are economically important for fisheries, it has no any special protection except the ICES management plans for stock exploitation. As this species is common and abundant in the Lithuanian EEZ and whole Baltic Sea it needs no special protection so far.

Establishment of MPA's in the Sambian Plateau and Klaipeda-Ventspils Plateau to protect benthic habitats and communities may potentially have a positive effect on pelagic fish stocks and their recruitment (Grober-Dunsmore et al., 2008). Although benthic communities are often viewed as functionally distinct from the dynamics of surface waters and associated pelagic populations, these two realms may be linked ecologically in ways that profoundly influence dynamics of local ecosystem. These linkages, and their implications for resource management, must be considered when designing fishing restrictions and others protection measures in MPAs (Grober-Dunsmore et al., 2008).

Recently surveyed Sambian Plateau and Klaipeda-Ventspils Plateau in its eastern edges have conditions not suitable for bottom trawling and in some cases even for pelagic trawling. Therefore these areas, considering high abundances of sprat juveniles may naturally act as a "spill-over" areas.

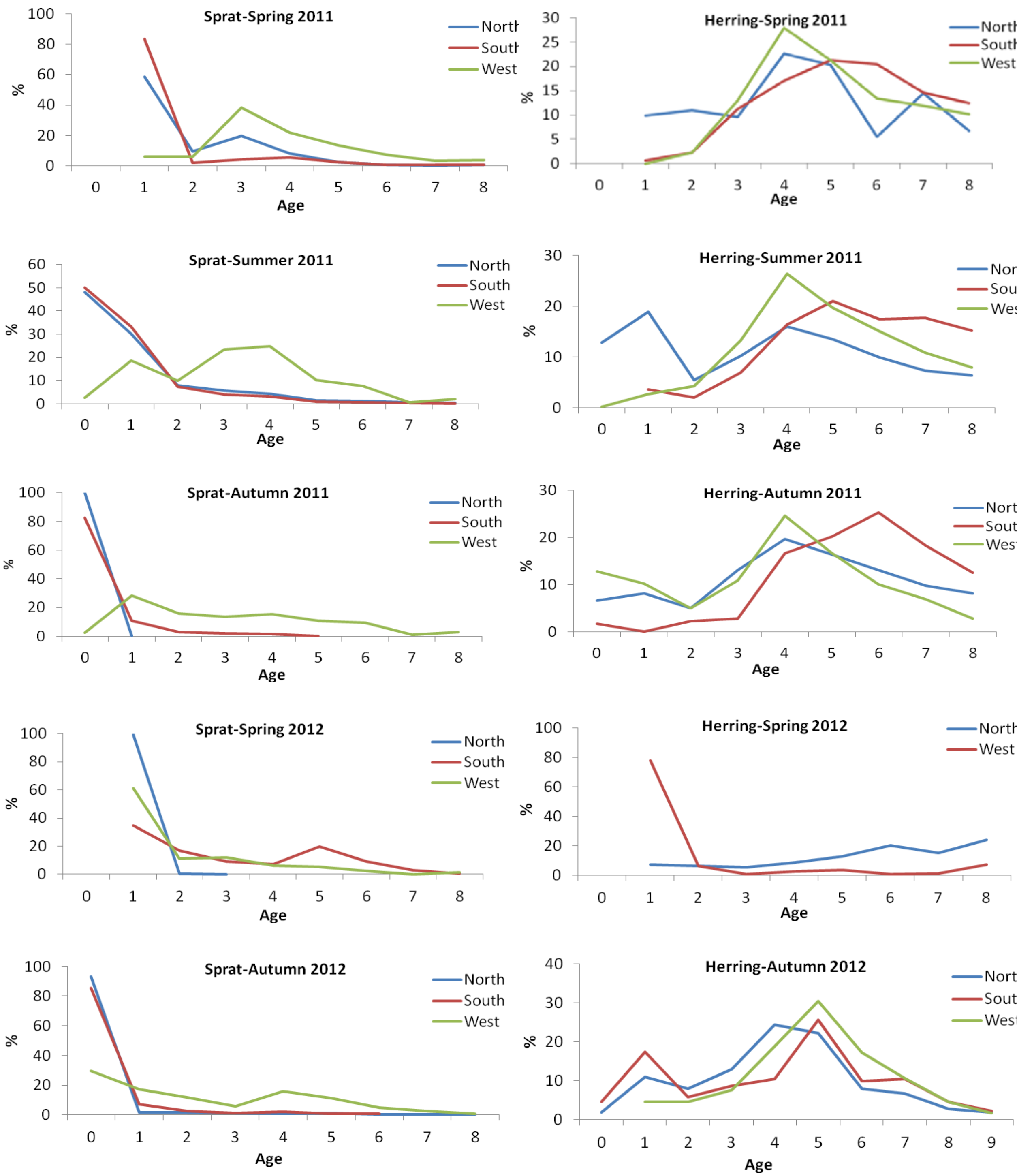



Figure 5.20. Age structure of Sprat and Herring populations in 2011-2012.

Spatial distribution of pelagic fish (in general Sprat, Herring and Cod) at the Lithuanian EEZ scale have distinct patterns. The eastern part of Lithuanian EEZ including Klaipeda-Ventspils Plateau and Sambian Plateau have the highest potential for abundant pelagic fish stock and recruitment.

Spatial distribution at the mesoscale, within particular project survey area is given in the next chapters.

### 5.4.1 Sambian plateau

The distribution of mixed clupeid stock within Sambian plateau in different surveys is given as prediction maps of distribution, produced by kriging method interpolating acoustic data (Fig. 5.21). The map for summer 2011 was not accomplished, as the hydroacoustic tracks of this particular survey were not properly covering the survey area, though data are still suitable for estimation of density and abundance. The density distribution between different survey events is, however, not comparable due to high variation in total fish abundance, as for example in autumn 2011 and subsequent spring 2012 the densities differ by more than 100-fold. Therefore, the colors of density value in the maps are applicable to particular map only for comparative analysis of spatial distribution within area.

Clupeids in all survey events were mainly occupying north-eastern edge of the area, where shallow part of the plateau declines into deep edge of Gdansk basin, creating substantial bottom slope. The shallow parts of this area were relatively less inhabited during all survey events, except for spring 2011 when this particular part of the area was not covered by hydroacoustic records.

As the data are based on the night-survey when fish are distributed above seabed, the analysis of quantitative distribution versus environmental and seasonal factors were not accounted for the bottom and habitat type, except the bottom roughness.

The highest densities of pelagic clupeids were found at depths below 50-60 m and the distribution patterns somewhat reflecting the configuration of bottom slope.

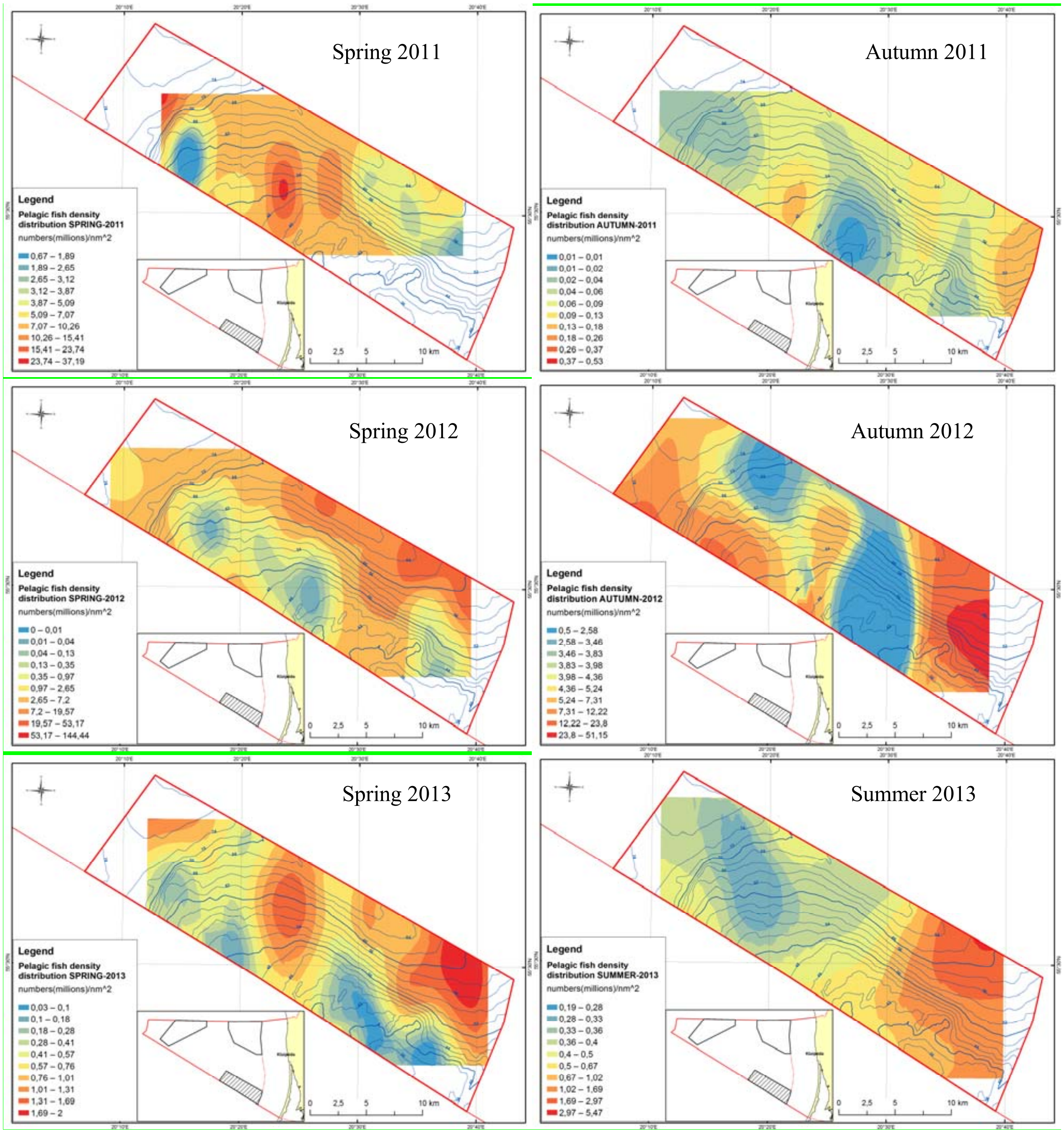



Figure 5.21. Maps of predicted density distribution of pelagic fish at the Sambian Plateau. Density distribution is based on hydroacoustic data interpolated by kriging method. Important: for every map the values of density colors are individual for the map and not comparable between maps.

### 5.4.2 Klaipeda-Ventspils plateau

Pelagic distribution of clupeids within the Klaipeda-Ventspils plateau has the most pronounced and consistent pattern seasonal distribution. The fish were most abundant below the depths of 35-40 m at the south-western edge of the project territory. The northern and north-eastern parts of the territory, above the depths of 30 m were “empty” through the seasonal surveys, except for the summer of 2013, when somewhat opposite to the overall distribution was observed (Fig. 5.22). In summer 2013, the clupeids were most abundant above 30 m isobaths at the shallowest parts of the territory.

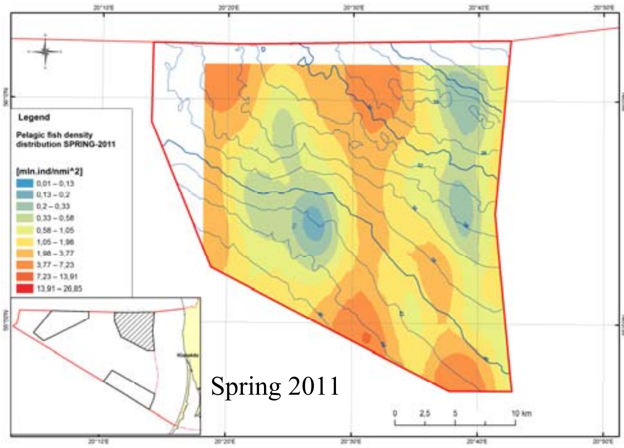
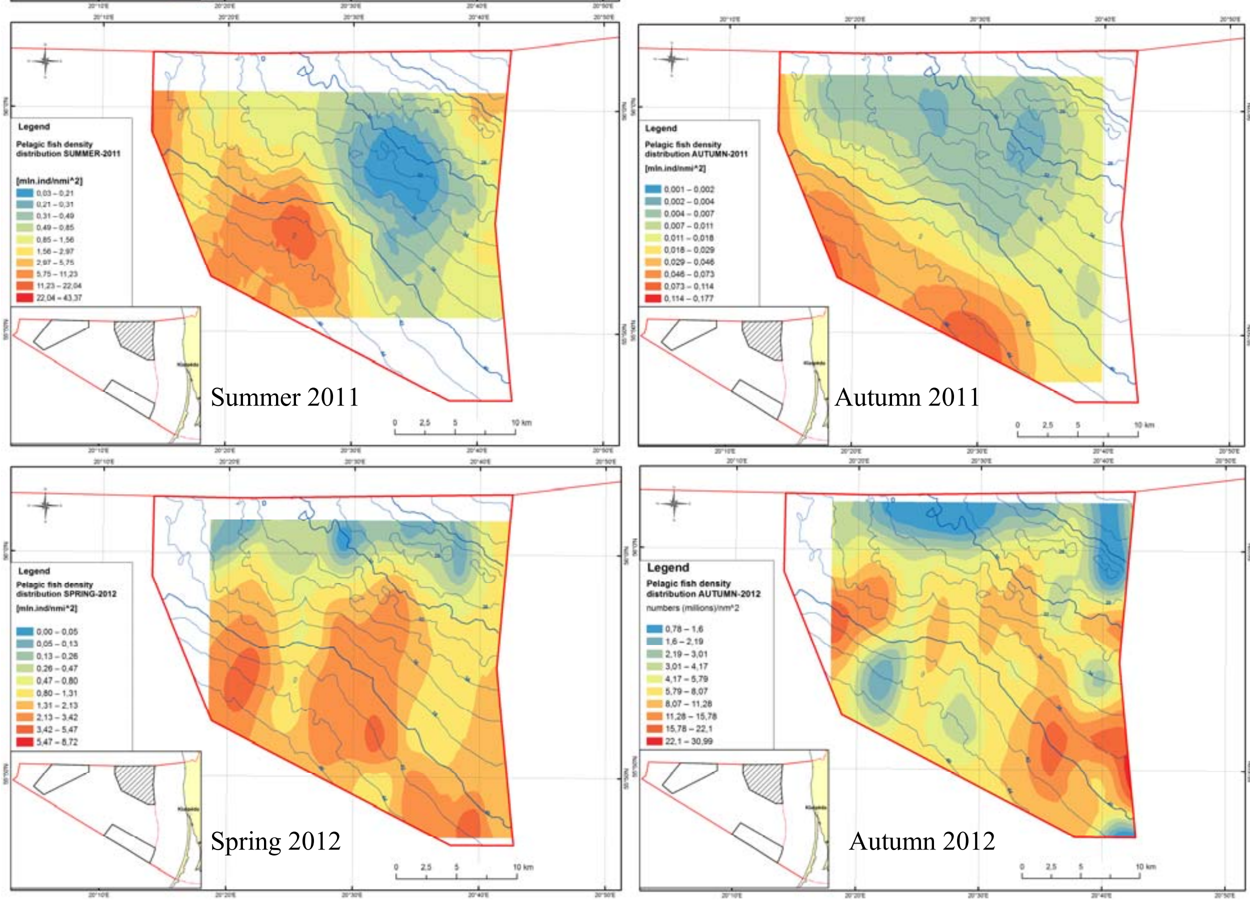
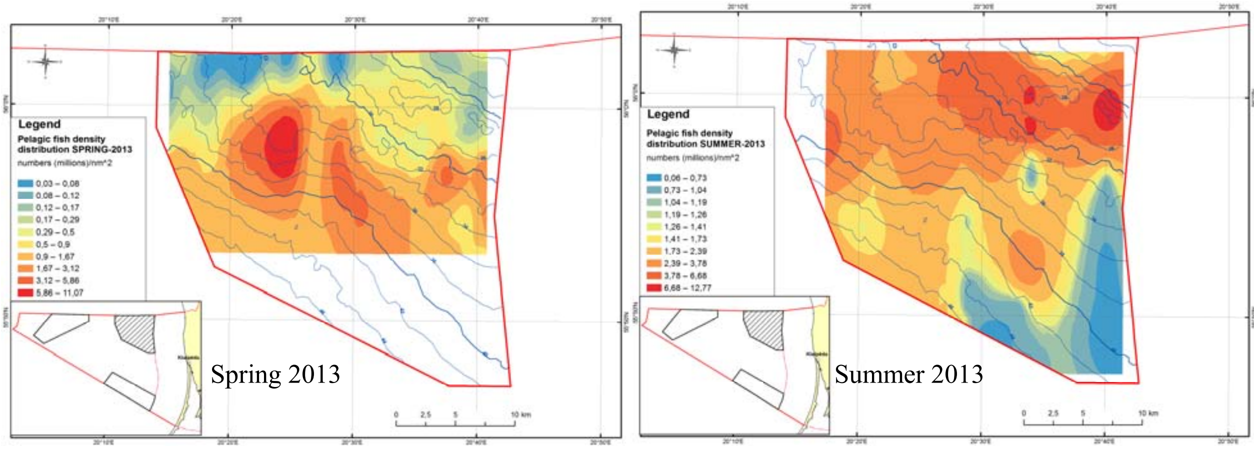



Figure 5.22. Maps of predicted density distribution of pelagic fish at the Klaipeda-Ventspils plateau. Density distribution is based on hydroacoustic data interpolated by kriging method. Important: for every map the values of density colors are individual and not comparable between maps.






### 5.4.3 Klaipeda bank

The pattern of pelagic mixed clupeid stock distribution within the Klaipeda bank was very patchy and inconsistent. The most important part within this survey area is the shallowest top of the bank at 50 m depth. In spring 2013, summer 2011 and 2013, and autumn 2012 there was registered relatively highest density of clupeids (Fig. 5.23). The deepest parts of this project area are inhabited in spring (2011 and 2012), when water column is more or less mixed. Despite sprat tolerate low oxygen condition quite well (Köster et al., 2003), possibly because of temporary or permanent hypoxia in deeper parts, later in the summer and autumn clupeids prefer shallower parts of the area.

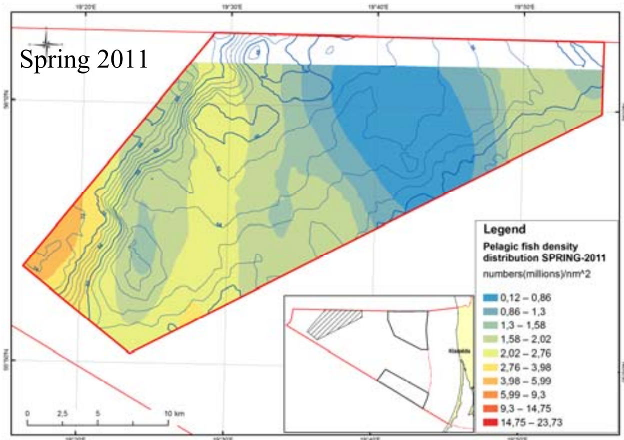
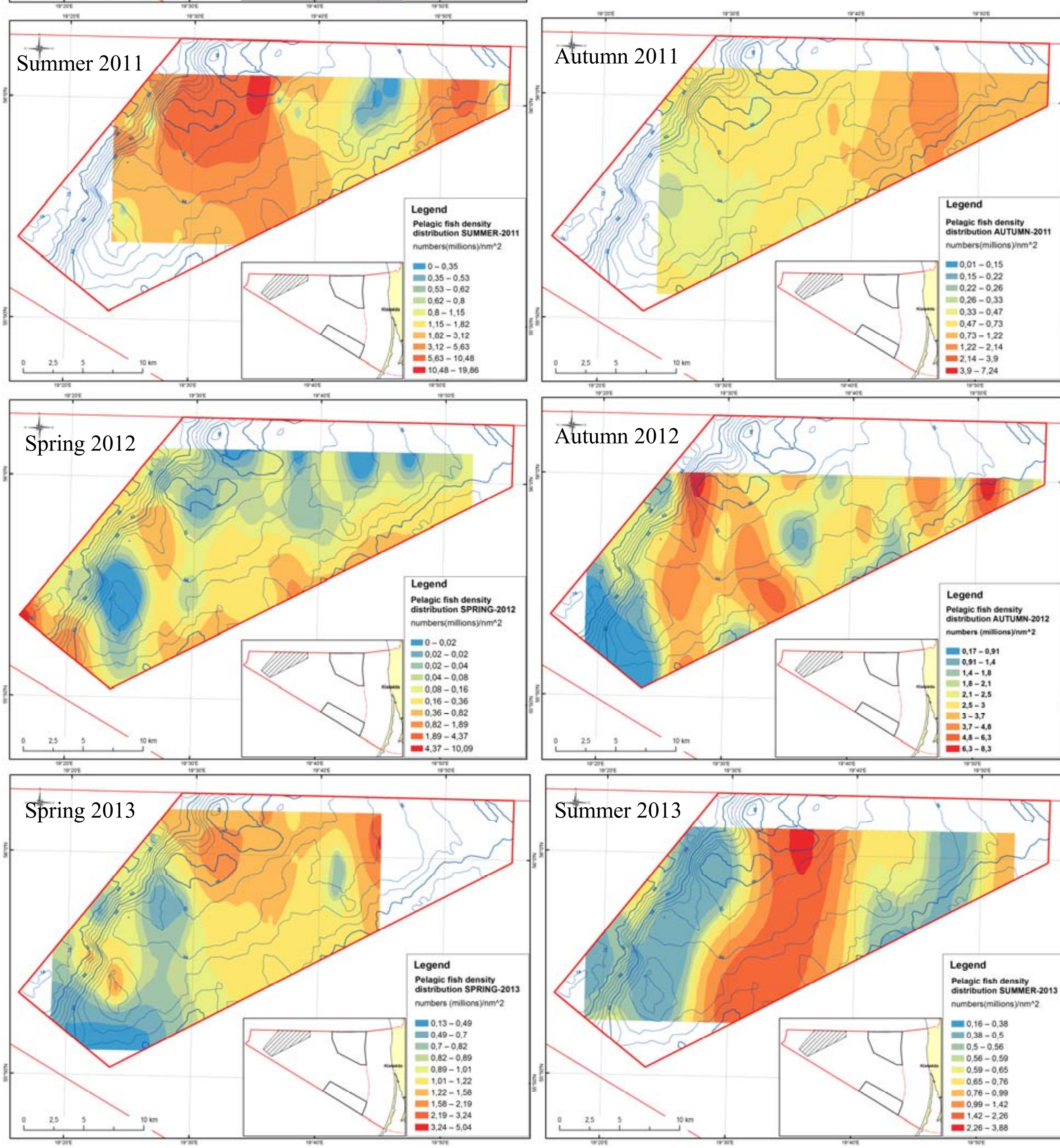



Figure 5.23. Maps of predicted density distribution of pelagic fish at the Klaipeda Bank. Prediction of density distribution is based on hydroacoustic data interpolated by kriging method. Important: for every map the values of density colors are individual and not comparable between maps.



# 6. BIRD INVENTORY

## 6.1 Material and methods

### 6.1.1 Ship surveys

**Survey procedure.** Standard methodology of ship-based waterbird surveys was used during the waterbird inventory (Webb & Durinck, 1992). The survey was conducted from a vessel moving at a speed of 7–9 knots along a predefined survey route consisting of a number of line transects arranged in a zig-zag formation. The route of transects was usually selected along a gradient that was likely to have influence on the distribution and abundance of waterbirds. In case of surveys in the Lithuanian EEZ project areas, survey transects were oriented along a depth gradient. In most cases, the same survey transects were used during different surveys in each project area. However, survey transects were sometimes altered in order to accommodate for weather conditions or short daylight period in mid-winter, when the "standard" survey route could not be covered during the daylight period (ca. 7 hours of daylight in late December – early January). A 300 m wide transect, either to the left or to the right of the ship (depending on weather conditions, sun glare, etc.), was observed during the surveys. This survey transect was subdivided into four transect bands: 0–50 m, 50–100 m, 100–200 m and 200–300 m (Fig. 6.1). All birds, observed sitting on water in transect were recorded and assigned to one of the four transect bands. Birds were also assigned to 2 min. sampling intervals, which at a speed of 8 knots corresponded to *ca*. 500 m long sampling units. Thus, birds were sampled in 300 m wide and *ca*. 500 m long sampling units. During the data handling, the length of the sampling units was corrected according to the actual distance travelled in 2 min., as recorded by the GPS receiver during the survey. Flying birds were registered during "snapshots" at 2 min. intervals. Only birds flying within transect were recorded at the moment of a "snapshot". Flying birds were not assigned to a concrete transect band. While birds outside transect were also recorded during surveys as additional information, they are not discussed in this report and all the numbers and densities reported here are of birds recorded within survey transects only. It has to be noted that Red-throated Divers (*Gavia stellata*) and Black-throated Divers (*Gavia arctica*) were not identified to species during the ship-based surveys. These birds tend to be very shy and fly or dive away at a great distance from the ship, and are difficult to tell apart accurately from a distance. Therefore, these two species were always recorded just as Divers (*Gavia* sp.).

Observations were made by at least two observers from an “observation box”, installed on a stable platform *ca*. 4 m above the sea surface (making the observation elevation at least 5 m above the sea surface). Observation and any additional information (precipitation, ice, waves, wind, etc.) were recorded into a special paper form. Gymboss interval timer was used for time keeping. Garmin GPSMAP 62S GPS receiver was used to constantly record the survey track at 1 min. intervals. Waterbird surveys were carried out exclusively in favourable weather conditions – wind below 10 m/s (sea state up to 3 on Beaufort scale), and preferably below 7 m/s (sea state up to 2 on Beaufort scale).

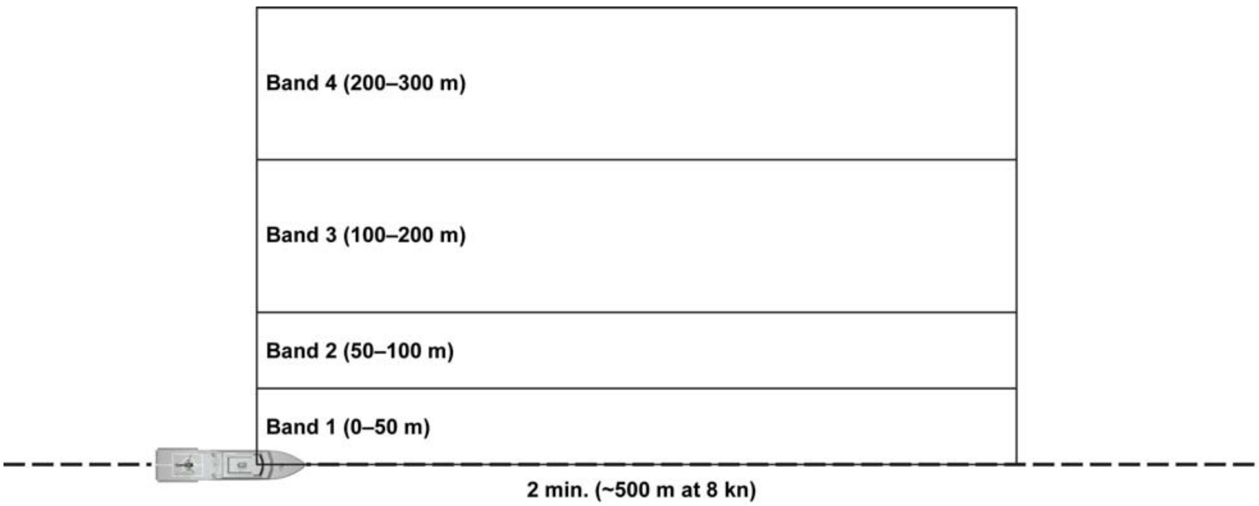



Figure 6.1. Survey transect and transect bands, used during the ship-based waterbird surveys.

**Survey effort**. Overall, 22 ship surveys were carried out in all three project territories during the period March 2012 – December 2013 (Table 6.1). Only on one occasion a survey had to be cancelled after leaving the port due to a sudden deterioration of weather conditions en route to the project territory. On the other hand, on no occasions weather conditions allowed to survey all three project sites during one expedition, and only in several cases it was possible to survey two project areas during a single expedition. Therefore, in most cases only a single site was covered during one expedition.

Additional waterbird surveys were planned during the wintering season in October – December 2013 in the Klaipeda-Ventspils project site, after large aggregations, meeting SPA designation criteria, were identified in the Klaipėda-Ventspils plateau project area. However, stormy weather conditions during this period, allowed to carry out only one successful waterbird survey in the Klaipėda-Ventspils plateau project area in December 2013. In total, 2900 nautical miles or 5400 km were covered during the waterbird inventory expeditions, of which 1400 nautical miles, or 2600 km were survey transects.

Table 6.1. The number of successful ship-based waterbird surveys in different project areas by quarters.

| Project site | 2012 Q1 | 2012 Q2 | 2012 Q3 | 2012 Q4 | 2013 Q1 | 2013 Q2 | 2013 Q3 | 2013 Q4 |
|---|---|---|---|---|---|---|---|---|
| Klaipėda-Ventspils plateau | 1 | 1 | 1 | 3 | 2 | 1 | – | 1 |
| Klaipėda bank | 1 | – | – | – | 1 | 1 | – | – |
| Sambian plateau | 1 | 1 | 1 | 2 | 3 | 1 | – | – |

**Data handling and analysis.** Survey data from observation forms was transcribed into Excel files, whereas GPS tracks were downloaded from the GPS receiver and imported into ArcGIS ArcMap software as points. Bird data were then georeferenced by an observation timestamp in the GIS environment.

Scarce and widely scattered species were mapped as raw observations (numbers of birds observed in a transect in a sampling unit), whereas data on abundant species, likely to meet the criteria for SPA designation, were further prepared for modelling.

First of all, numbers of birds observed sitting on water in transect were corrected for omissions by using Distance modelling (fitting detection probability function to the observation data). Effective strip width (ESW) was estimated for each species in question separately (namely, for Velvet Scoters and Long-tailed Ducks). The estimated correction coefficient was applied to the observations of birds sitting on water. The corrected numbers were added to the numbers of flying birds observed in the same sampling units (the latter were not subjected to corrections). Further, the final, corrected, observed bird numbers were converted to bird densities (birds/km²) by dividing them by the area of a sampling unit, which, in turn, depended on the ship speed, i.e. the distance travelled by the ship in 2 min. This distance was obtained from the recoded GPS tracks. The observed bird densities from different surveys were averaged into a 1×1 km grid, which was further used for estimation of bird density distribution in the entire project areas. Generalized additive models (GAM) were used for identification of relationships between the bird distribution (densities) and environmental variables. Environmental variables, considered as possible and ecologically relevant predictors of bird distributions, included water depth, bottom slope, bottom habitats (as categorical variable), distance to coast, distance to shipping lanes, filterfeeder index (developed and provided by the DHI, Denmark) as well as latitude and longitude. Akaike information criterion (AIC) was used for the selection of the most parsimonious model, which, in turn, was used for fitting the model onto the environmental data of the entire project area. Model estimation and fitting was carried out with the *mgcv* package of R statistical software (R Core Team 2012). The predicted bird densities were mapped in the same 1×1 km grid.

### 6.1.2 Satellite tracking

**Bird capture.** All bird captures and implanting of satellite transmitters within the project were carried out under the appropriate permits, issued by the Environmental Protection Agency (permit No. 7 dated 9 February 2012 and permit No 1 dated 7 January 2013).

Birds were captured using a nigh-lighting technique by approaching them (preferably downwind) with a boat, temporarily startling with a flashlight and catching them with a 70×70 cm landing net on a 4 m long telescopic handle. In addition, night vision equipment was used to locate birds at sea. Bird captures were performed only in relatively calm weather conditions during new moon in coastal waters up to 4–5 km from the coast. Captured birds were kept in animal transportation crates with bedding material or net liners to keep them dry and clean.

**Satellite transmitters and fitting.** Implantable satellite transmitters PTT-100 by Microwave Telemetry, Inc. were used during the Study. Two types of transmitters of different weights (26 and 38 g) and, respectively, expected battery life (500 and 750 transmission hours) were used (Fig. 6.2). Initially, smaller transmitters were expected to be fitted to Long-tailed Ducks, which are considerably smaller than the Velvet Scoter, for which the larger transmitters were expected to be fitted. However, since capturing Long-tailed Ducks proved to be problematic due to the dramatic decrease in their numbers on Lithuanian wintering grounds, and only one Long-Tailed Duck was fitted with a transmitter, both types of transmitters were eventually used for both Velvet Scoters and Red-throated Divers.

The transmitters were surgically implanted at a veterinary clinic by a specially trained veterinarian. Transmitters were implanted into the bird's abdominal cavity to right abdominal air sack, following general anaesthesia using isoflurane gas. Transmitter's 20 cm long antenna exited the skin laterally to the sacral vertebrae (Fig. 6.3). Implantation of transmitters in Red throated divers was different from Velvet scoters and Long tailed ducks. As theirs abdominal space is narrower, location of transmitter implantation had to be defined more precisely then in ducks and transmitter fixed just after ishium.

After the surgery birds were injected with fluids, washed and dried. Care of birds during post-surgical time was improved, when piscivorous birds were fed with small size fish and homogenized mollusk and fish was used for diving ducks. Until release the birds were several times forced to feed with appropriate diet for the species. Also there was developed different care techniques for Divers and ducks. Divers were kept in cardboard boxes with towel paper. This let them to be more calm and less stressful, when they had no chance to see the surrounding. They where "swimming" on paper in box, this limited movements and self damage of birds. Ducks were kept in pet carriers.

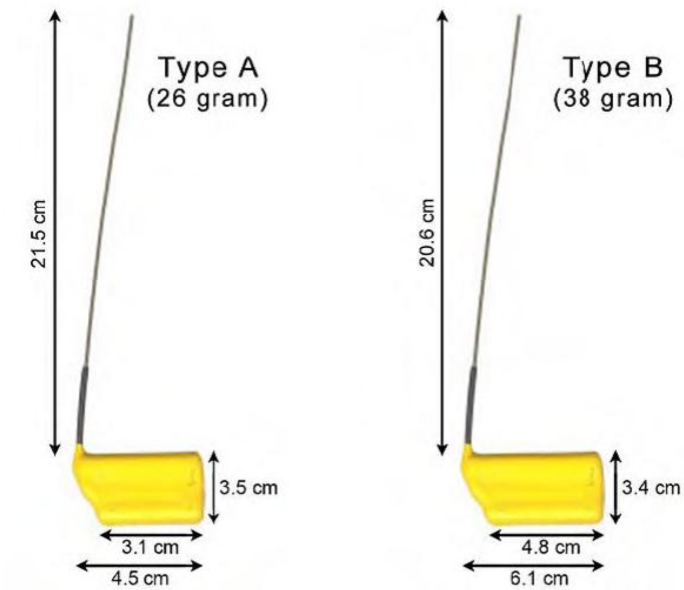



Figure 6.2. Implantable satellite transmitters PTT-100 used during the study.

Birds were kept for 4–8 hours before release (for the first hour after surgery – at a room temperature for recovery, for the remaining time – at a temperature +1 – -4 °C. Birds were always released from the coast close to the site of capture after the sunset, in order to reduce the risk of predation or harassment by large gulls.

Figure 6.3. Velvet Scoter (male), fitted with satellite transmitter.

**Data filtering.** Locations of tagged birds are identified by a network of ARGOS satellites, which utilise Doppler effect for locating the source of data, transmitted by the implanted satellite transmitters. Data from the ARGOS system is downloaded via an online interface. Satellite telemetry data require filtering to reduce noise produced by location fixes with low or unknown accuracy. We applied Freitas filter to eliminate unlikely locations on the basis of location quality class, calculated bird moving speed, distance between successive locations, and turning angles (Freitas *et al*., 2008). When applying Freitas algorithm, we set a maximum moving speed of eiders at 20 m/s and kept other parameters on default settings. Package *'argosfilter'* (Freitas *et al*., 2008) in R statistical environment (R CoreTeam, 2012) was used to apply the filtering algorithm. Filtering successfully eliminated the majority of unlikely locations outside of animal presence area and removed 'spikes' along bird tracks. The filtered dataset was further inspected visually and several obvious outlier positions were flagged and eliminated from the dataset.

**Home range calculation.** Local movements of satellite-tagged Velvet Scoters were assessed by calculating wintering home ranges of studied species and evaluating site fidelity. We present areas of 95% kernel home ranges and 50% kernel home ranges for each individual tracked throughout the wintering seasons. Due to their high mobility, home range analysis was unreasonable for tracked Red-throated Divers.

All bird positions, which passed the filtering, were used for calculating home ranges. Tens to hundreds of valid telemetry locations were available for each individual, therefore we applied iterative sub-sampling procedure to control number of bird locations used in the analyses. To ensure equal representation of each individual when delineating wintering home ranges, we randomly drew two locations per week for each individual during the wintering season (November through March). The same procedure of random location selection was applied 100 times for each individual and subsequently 100 home range areas were calculated. Each time when home range was calculated, it was intersected with water polygon, so parts of the home range area falling on land were eliminated. Finally, all home range sizes were averaged to obtain the most plausible estimate for each bird. The iterative sub-sampling procedure was applied aiming to reduce bias in otherwise arbitrary selection of several satellite telemetry locations for analyses. One hundred sampling iterations were deemed as a sufficient number based on inspection of plots of mean values and variability relative to the number of iterations used: home range areas and standard deviations stabilised at 50–70 iterations or less per individual bird.

**Assessment of bird presence in different jurisdiction areas.** Throughout the annual cycle Red-throated Divers and Velvet Scoters occur in marine waters of several countries, which share responsibility for protection and management of these birds. Using telemetry data we evaluated occurrence of tracked birds in exclusive economic zones (EEZs) of different countries. We used the approach developed by Harrison (2012). Every filtered telemetry location was linked to a particular EEZ matching its geographic location. We fitted generalized additive mixed models (GAMMs) to predict probability of birds using EEZs of different countries.

**Habitat modelling.** Finally, telemetry data were used to assess habitat use and predict habitat probabilities of tracked Velvet Scoters. Since telemetry data represent presence-only data, we used Maximum Entropy Modelling (Maxent) for fitting habitat models (Elith *et al*., 2011). Maxent is recognized as consistently being one of the best modelling algorithms for fitting presence-only data (Manly *et al*., 2002). The same as for home range estimation, we used iterative subsampling of telemetry locations for the model fitting: two weekly locations per individual bird were randomly picked for the wintering period. The procedure was repeated 10 times and 10 models were fitted on each subsample. The final result was obtained by averaging results of the 10 models. Habitat modelling was not possible to achieve for reid-throated divers due to broad dispersion of tagged individuals.

## 6.2 Results from ship surveys

### 6.2.1 Sambian plateau

All target species were observed at the Sambian Plateau during the ship-based waterbird surveys, however, only Razorbills and Long-tailed Ducks were more numerous, whereas only a single individual of Black Guillemot was observed throughout the project surveys.

**Divers.** Although, compared to the other two project areas, divers were the most abundant in this project area, they were still very scarce. Only up to 49 birds were recorded in transect during a single survey (March 2013). Their distribution was rather sporadic across the entire project site, but higher number were observed in the shallower eastern part of the project site (Annex T2B1). Due to bird scarcity, no modelling of Diver distribution was attempted in this project site.

**Velvet Scoter.** While this species is a very abundant winterer along the Curonian Spit coast in inshore waters, very few individuals were observed in the offshore waters in the Sambian plateau project area. Velvet Scoters were recorded only during 4 out of 9 surveys in this area. Not surprisingly, no birds were recorded during summer and early autumn surveys. However, no Velvet Scoters were also recorded during some of the wintering period surveys (e.g. March 2013). The sporadic observations of Velvet Scoters were somewhat more common in the eastern part of the project area at intermediate depths with a steeper bottom slope (Annex T2B2). Due to bird scarcity, no modelling of Velvet Scoter distribution was attempted in this project site.

**Long-tailed Duck.** Long-tailed Ducks were common, but not very abundant in this project site. Up to 200 birds were recorded in transect during a single survey. Although recorded across the entire Sambian plateau project area, this species was most abundant in its shallower eastern and south-eastern part (Annex T2B3), where they aggregated during most of the surveys when these birds were recorded. Modelling of Long-Tailed Duck distribution revealed, that, on average, up to 1350 birds were wintering in the Sambian plateau project area during the wintering seasons of 2011/2012 and 2012/2013, with the mean bird densities up to 42.3 birds/km² (Annex T2B4). This number is far below the threshold abundance value for SPA designation, therefore this site was not considered as a potential SPA for the Long-Tailed Duck.

**Razorbill.** Razorbill was the most abundant waterbird species in the Sambian plateau project area, with recorded numbers and observed distribution varying greatly between different surveys (Annex T2B5). Attempt at modelling the distribution of this species in the Sambian plateau project area was not successful – environmental variables failed to explain any considerable variation in the distribution of Razorbills. Since these birds are ichthyophagous, their distribution is most likely related to some dynamic parameters like the distribution of prey fish species or water currents, data on which were not available for modelling.

**Guillemot.** Another ichthyophagous waterbird species, which was observed at very low numbers sporadically across the entire project site (Annex T2B6). Interestingly, Guillemots were observed in the Sambian plateau project area during all surveys, except in March 2012, but the numbers were very low and never exceeded 30 birds during a single survey.

**Black Guillemot.** Only a single Black Guillemot was observed during all the nine surveys (in March 2013) in the Sambian plateau project site.

### 6.2.2 Klaipeda-Ventspils plateau

Just as in Sambian plateau, all project target species of waterbirds were recorded during the 10 ship-based surveys in Klaipėda-Ventspils plateau. However, the abundance of Velvet Scoters and Long-tailed Ducks far exceeded that observed in the Sambian plateau. On the other hand, Razorbills were less numerous, while Divers, Guillemots and especially Black Guillemots were recorded only occasionally. No target species were recorded during the summer survey in August 2012.

**Divers.** Single individuals of divers were recorded in various places of the Klaipėda-Ventspils plateau project site (Annex T1B7).

**Velvet Scoter.** Velvet Scoter was the most abundant waterbird species in the Klaipėda-Ventspils project area. Consistently high numbers of this species were observed here during all surveys in wintering period (November – March). It was most abundant in the north-eastern part of the project area with depths of up to 35 m. Interestingly, rather consistent, albeit much less numerous aggregations were also observed during several surveys in much deeper areas in the southern part of the site (Annex T1B8). Modelling of Velvet Scoter distribution, based on surveys performed in wintering seasons of 2011/2012 and 2012/2013, revealed mean densities of up to 1040 birds/km² in the north-eastern part of the project site. The total mean number of Velvet Scoters, estimated in the entire project area, based on modelling, was 28500 birds. This greatly exceeded the threshold number of birds for the designation of SPA, therefore this site was considered for SPA designation for the protection of wintering Velvet Scoters (see Chapter 5).

In order to collect additional data for the possible SPA designation process, additional ship-based survey was carried in December 2013. During this survey, exceptionally large numbers of Velvet Scoters were recorded in the north-eastern and northern part of the project area (Annex T1B9). In total, more than 2600 birds were recorded in transect (the maximum number of birds recorded during the previous surveys was 970). The data from this survey were not included into modelling of Velvet Scoter distribution for the SPA designation, because SPA boundaries had already been proposed by December 2013, but it greatly supported the value of the proposed SPA for the conservation of Velvet Scoters.

**Long-tailed Duck.** Long-tailed Ducks were also rather abundant in this project area, particularly in it shallowest northern – north-eastern part. Up to 700 birds were observed in transect during the surveys in wintering season of 2012/2013. Modelling of Long-tailed Duck distribution, based on surveys performed in wintering seasons of 2011/2012 and 2012/2013, revealed mean densities of up to 435 birds/km² in the north-eastern and eastern part of the project area (Annex T1B10). The total mean number of Long-tailed Ducks, estimated in the entire project area, based on modelling, was 7550 birds. Although this was considerably below the threshold value for the designation of SPAs, the distribution of Long-tailed Ducks was also taken into consideration when proposing the SPA boundaries in this area (see Chapter 5).

**Razorbill.** Razorbills were common, but not abundant during most of the waterbird surveys. They were not recorded in the project site only during August and October 2012 surveys. This species was widely scattered across the entire project area, with no obvious spatial pattern (Annex T1B11).

**Guillemot.** Mostly single individuals of Guillemots were observed sporadically during most of the surveys across the entire project area, with more frequent encounters in its deeper areas in the southern part (Annex T1B12).

**Black Guillemot.** Only 4 Black Guillemots were observed in the Klaipėda-Ventspils project area during the survey in February 2013.

### 6.2.3 Klaipeda bank

Klaipėda bank proved to contain the lowest waterbird numbers and diversity out of all the three project sites. Only three waterbird surveys were carried out in this area, since surveys carried out during the apparently peak presence of waterbirds in other project sites (March 2012, January 2013) revealed almost no birds. Additional survey in May 2013 also resulted in almost no birds recorded. Therefore the initially planned survey effort was reduced. This site also proved to be most difficult to survey due to its greatest distance from the Klaipėda port, which meant that a very large good weather window was required to successfully survey this area.

**Divers.** Only several Divers were recorded during two surveys in this project area (Annex T3B13).

**Velvet Scoter.** Three birds were recorded during the survey in May 2013.

**Long-tailed Duck.** Two and seven birds were recorded in March 2012 and January 2013, respectively, in eastern part of this project area (Annex T3B14).

**Razorbill.** The most abundant waterbird species in this project area, with almost 100 birds recorded in transect in January 2013 and 50 birds – in March 2012. Birds were more common in central and eastern part of the project area (Annex T3B15).

**Guillemot.** Only 10 Guillemots in total were observed during two surveys (January 2013 and May 2013) in this project area (Annex T3B16).

**Black Guillemot.** No Black Guillemots were recorded in Klaipėda bank project area.

## 6.3 Satellite tracking results

**Collected data.** In total, 11 Velvet Scoters, 9 Red-throated Divers and 1 Long-tailed Duck were fitted with satellite transmitters. Of these, some birds stopped producing location fixes shortly after release or did not produce any location fixes at all either due to transmitter malfunction or bird death. Successful tracking was carried out on 8 Velvet Scoters, 6 Red-throated Divers and 1 Long-tailed Duck. These birds produced a total of 16000 location fixes, of which 14600 were retained for further analysis after data filtering.

**Velvet Scoter winter home ranges.** Wintering Velvet Scoters dispersed rather broadly along the coast of the eastern Baltic, still the majority of tagged birds spent a substantial amount of time in Lithuanian waters. Birds distinguished by small core home ranges represented by 50% kernel distribution, which averaged at 72 km² (23–132 km², Fig. 6.4). However, bird mobility and tendency to use several sites during the winter season determined large overall winter home ranges defined by 95% kernel distribution: average 655 km² (298–1231 km², Fig. 6.4).

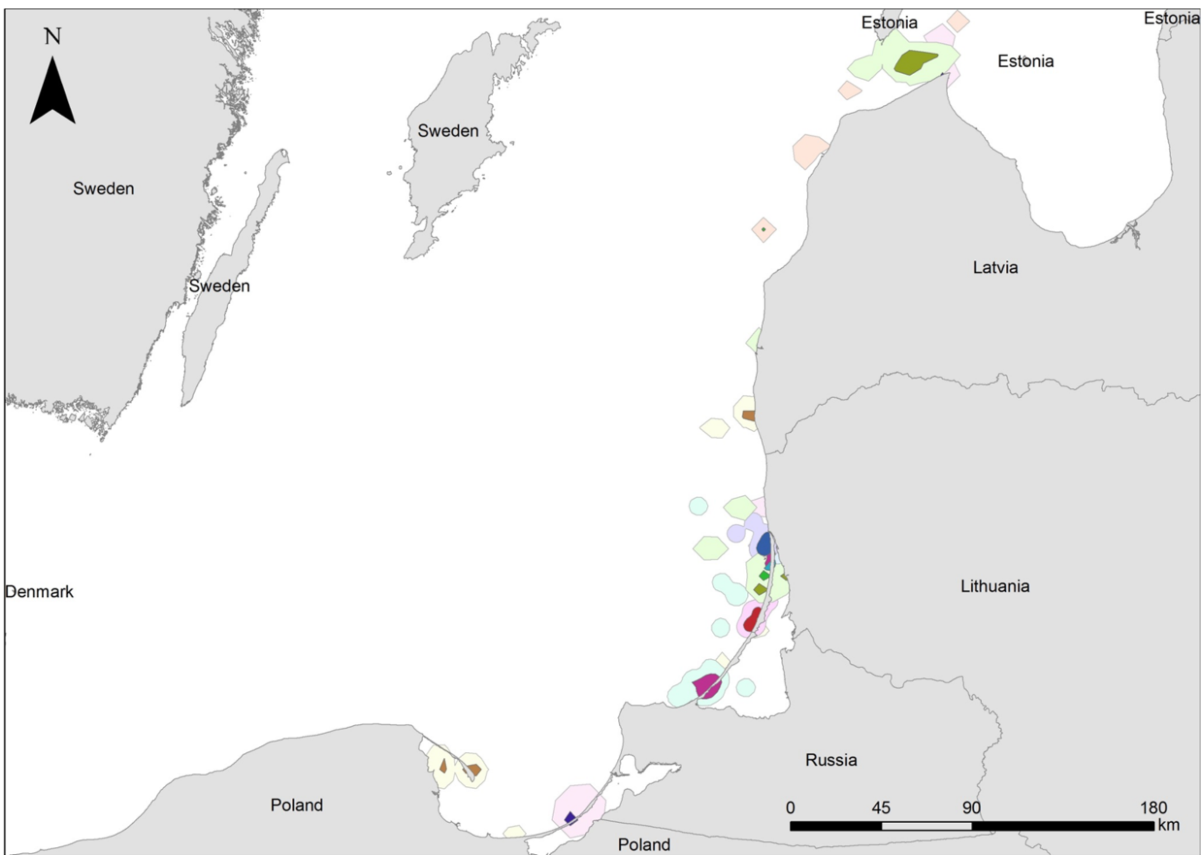



Figure 6.4. Winter home ranges of 8 Velvet Scoters tracked using satellite telemetry. Home ranges are represented as 50% and 95% kernels (darker and lighter colours respectively). Different colours represent different individuals.

Assessment of bird presence in different jurisdiction areas. Assessment of probabilities of Velvet Scoter occurrence in EEZs of different countries suggested that there was about 50% probability that a bird equipped with satellite transmitters in Lithuania will remain within the EEZ of this country, and lower probabilities that birds will use waters of neighbouring countries (Fig. 6.5). Further, this analysis clearly indicated that in spring birds mostly use Latvian and Estonian EEZs, spend breeding season in Russian EEZ and eventually return to Estonia, Latvia and Lithuania during the next season (Fig. 6.5).

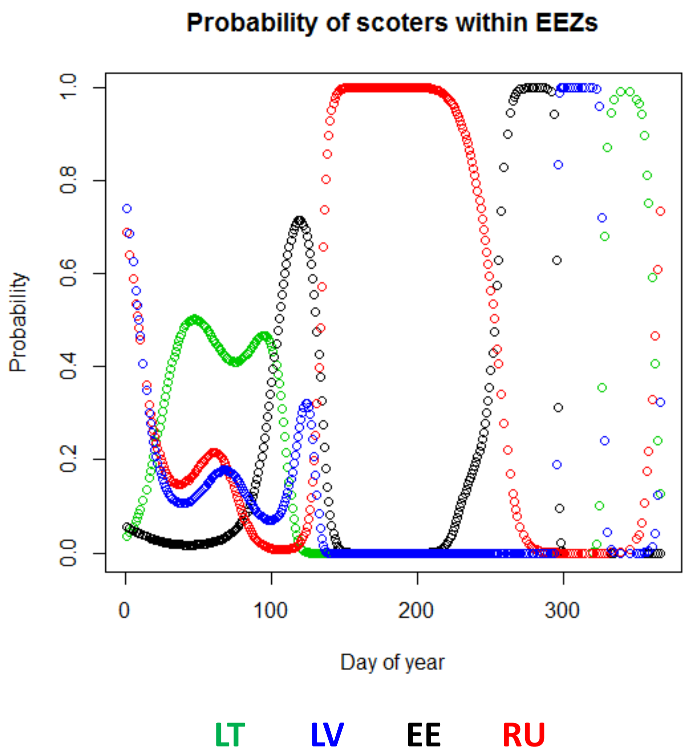



Figure 6.5. Probability of tracked Velvet Scoter occurrence in exclusive economic zones of different countries throughout the annual cycle.

Similarly, telemetry locations showed that tracked divers were most likely to use Lithuanian EEZ during winter period only, and also that they were highly mobile birds and used EEZs of many other countries (Fig. 6.6). As with many other analyses, fitting models on diver data was problematic due to broad dispersion of tracked individuals, which affected the sample size: six successfully tracked individuals during winter season cumulatively occurred in EEZs of 12 countries.

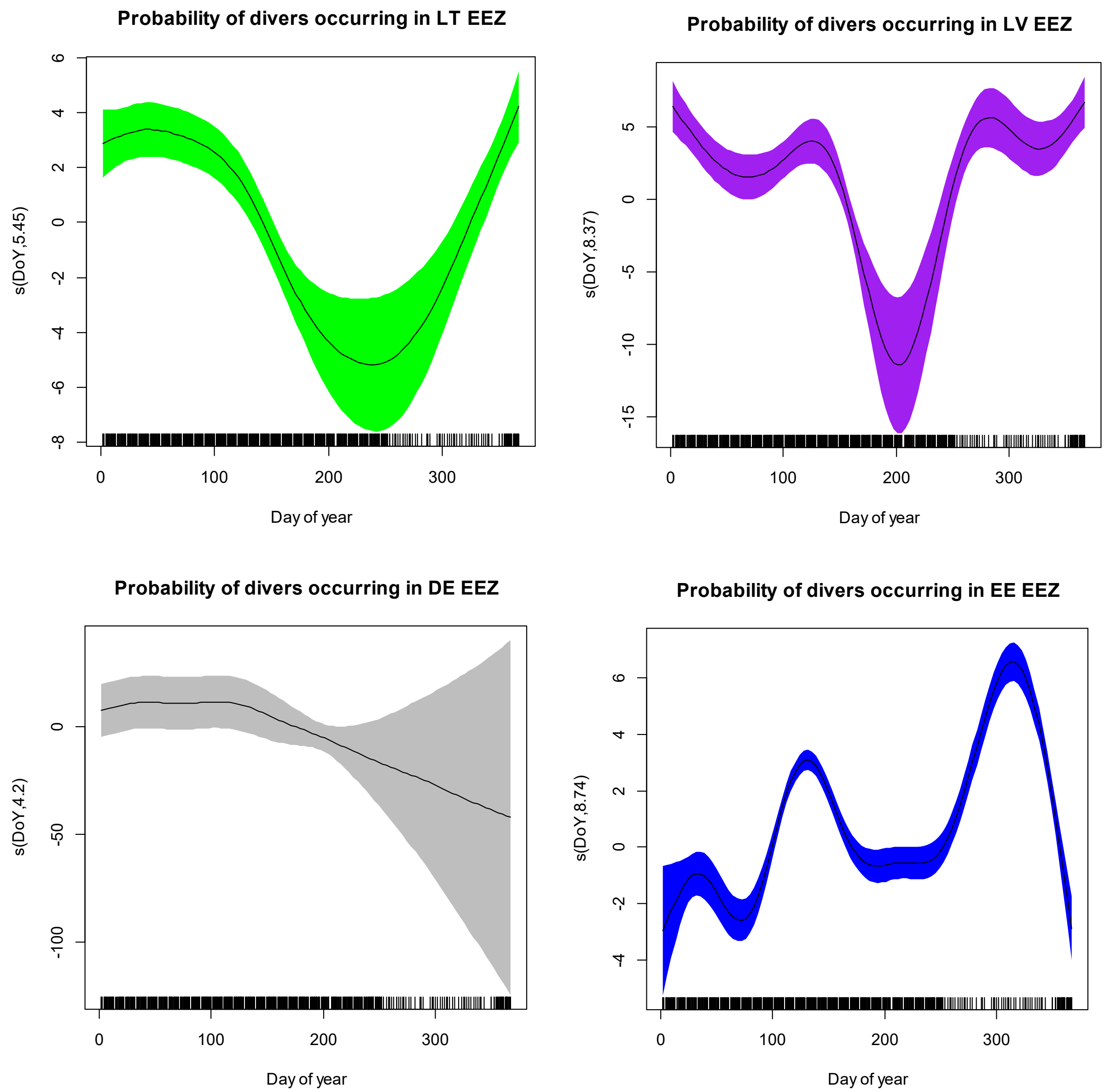



Figure 6.6. Probability of tracked Red-throated Diver occurrence in exclusive economic zones of different countries throughout the annual cycle.

### Velvet Scoter distribution modelling based on satellite telemetry data

The best model fit of Maxent models was achieved using predictor variables characterizing depth, distance to shipping lanes, filter feeder index and bottom slope (Fig. 6.7). Jack knife test indicated that bathymetry and filter feeder index had the highest contribution to the model fit and distance to the shipping lanes was least important of the predictor variables (Fig. 6.8). Overall, the fitted model had very good fit with AUC values exceeding 0.9 (Fig. 6.8). Finally, the predicted distribution maps had good correspondence with the input data (Fig. 6.9).

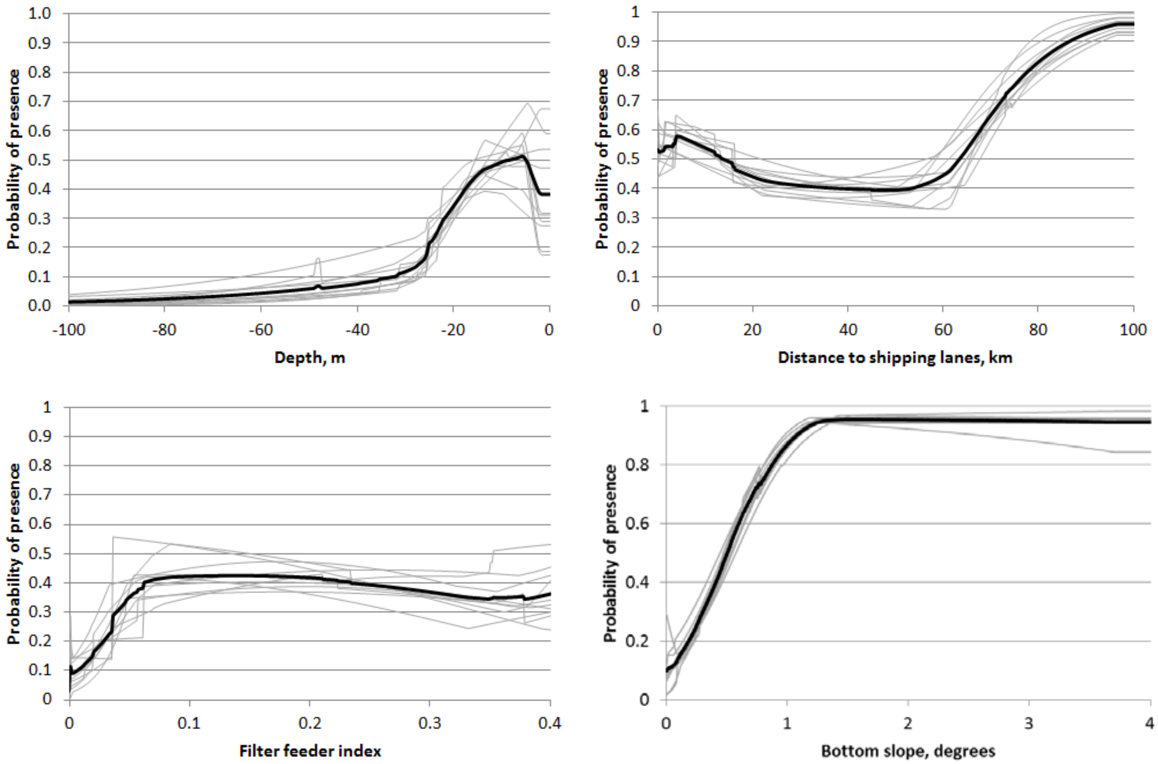



Figure 6.7. Response curves of environmental variables showing how each of them affects model predictions of Velvet Scoter distribution. Grey lines show response curves of 10 different models based on random subsampling of bird telemetry locations and black thicker lines represent the average of these 10 models.

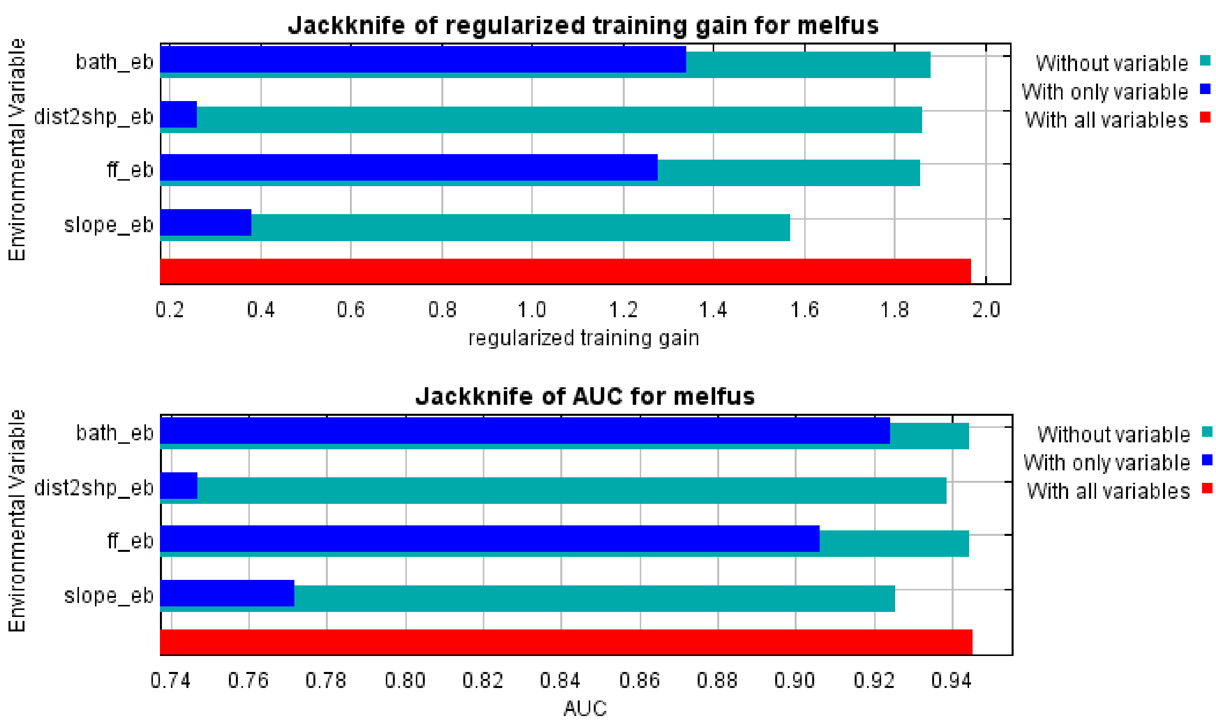



Figure 6.8. Plots representing jack-knife tests of variable importance in Velvet Scoter distribution models.

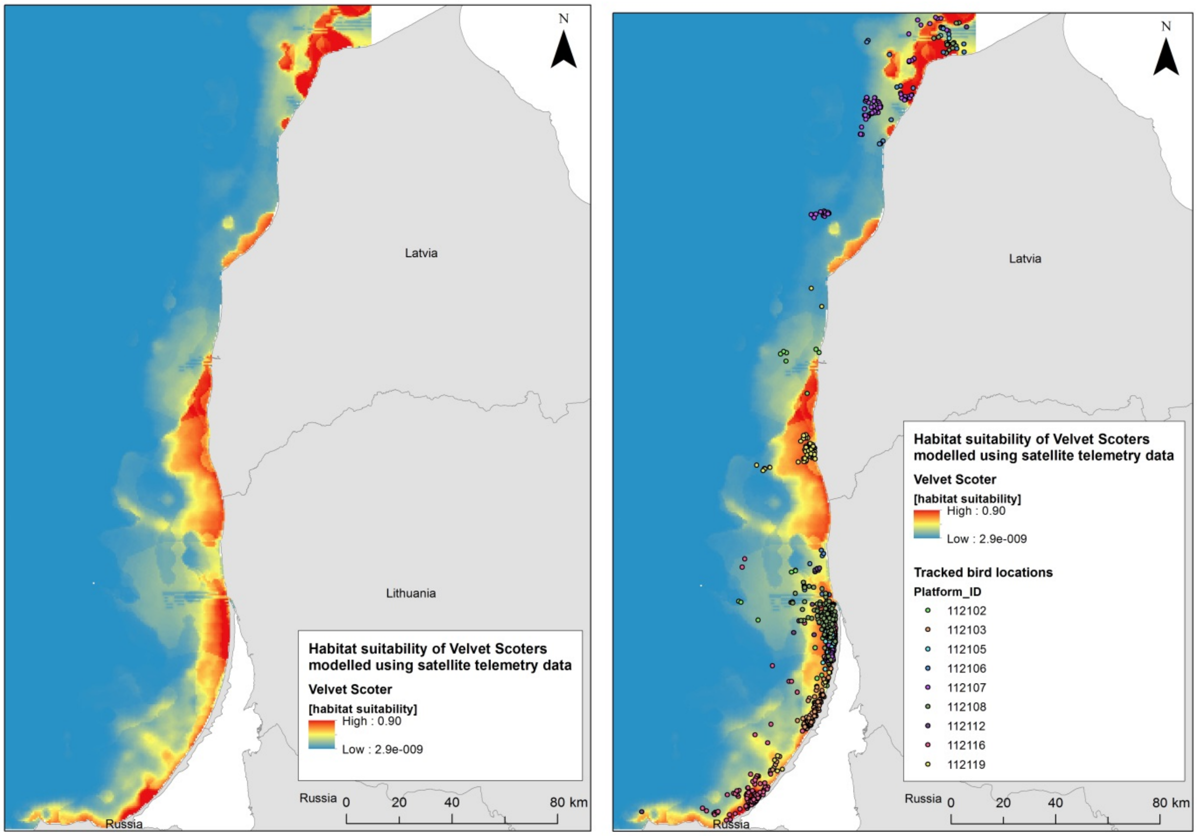



Figure 6.9. Velvet Scoter habitat suitability maps predicted using Maxent modelling of satellite telemetry data. The maps represent averaged results of 10 models fitted on random subsampled bird telemetry locations.

# 7. EVALUATION OF SITES

## 7.1 Data integration

The project areas comprise complex environments, where seabed geomorphology and water column characteristics are supporting diversity and abundance of benthic life, high aggregations of pelagic fishes and marine birds. In order to obtain broader view on distribution of marine life in the project areas, overlay of boundaries derived from individual data layers of key components of marine life (benthic habitats, pelagic fishes, flounder and cod, marine birds) was performed for each area separately (Table 7.1). Klaipeda Bank area was excluded from this overview at the very initial stage due to absence of features qualifying for protection of marine life: reefs and/or sandbanks, Habitat Directive Annex I and V fish and marine bird species.

Table 7.1. Summary of data layers and delineation criteria used for data integration and site evaluation.

| Component | Delineation criteria for setting spatial boundaries | Legal status of criteria in marine conservation |
|---|---|---|
| Reefs | Distribution boundaries (reef presence) | HD Annex II |
| Aggregations of Velvet Scoters | Distribution boundaries of density above threshold set by Marine Conservation Criterion | BD Annex I |
| Aggregations of Long-tailed Ducks | Distribution boundaries of density above threshold set by Marine Conservation Criterion | BD Annex I |
| Aggregations of Velvet Scoters | Distribution boundaries of density above threshold set by Marine Conservation Criteria | HD Annex I |
| Aggregations of Long-Tailed ducks | Distribution boundaries of density above threshold set by Marine Conservation Criteria | HD Annex I |
| High concentration of pelagic fishes in spring | Distribution boundary of density ind ($10^6$) $nm^{-2}$ above spring average value in the project area | Supporting criteria (quantitative) |
| High Cod density in spring, | Density (CPUE) above spring average value in the project area | Supporting criteria |
| High Flounder density in spring | Density (CPUE) above spring average value in the project area | Supporting criteria |

During the data integration process main results of field inventories were used. Distribution boundaries of reefs were considered in case of benthic habitats, whereas aggregations of Velvet Scoters and Long-tailed ducks exceeding density threshold values of the Marine Conservation

Criteria were taken into account in reviewing important bird areas. Additionally, supporting data layer on acoustic density of pelagic fishes in spring was considered by setting empirical criteria for delineation of the boundary based on density exceeding three years spring average value of pelagic fishes. Point data on density of flounder and cod collected by seasonal gillnet surveys was used as supplementary source of information for qualitative justification of important areas.

Data integration is based on assessment of distribution and density based characteristics of main biological features (pelagic fishes, Long-Tailed Ducks, Velvet Scoters, Cod and Flounder) in a context of reefs, which is defined as a key habitat type in project areas. Although importance of reefs differed between the areas, the main patterns largely remained the same. Both distribution and density based characteristics of the Long-Tailed Ducks, Cod and Flounder showed high association with the reefs. Modeled average density of Long-Tailed Ducks was 2-5 times higher in the reef areas compared to the adjacent territories (Table 7.2). This was particularly pronounced if distribution of densities above Marine Conservation Criteria is analysed i.e. the shallow parts of the reefs in depths of 24-30 m are entirely used by the species in the Klaipeda-Ventspils Plateau (Fig. 7.1), while in deeper Sambian Plateau association of Long-Tailed Ducks is less pronounced and restricted to the most shallow areas of 35-38 m depth (Fig. 7.2).

Table 7.2 Characterization of reefs distributed in the Klaipeda-Ventspils and Sambian Plateaus based on quantitative biological features.

| Criteria | Estimate |
|---|---|
| **Klaipeda-Ventspils Plateau** | |
| Average density of Long-Tailed Ducks in the reef area (vs. non-reef areas), birds $km^{-2}$ | 43 (9) |
| Reef area occupied by Long-Tailed Ducks (vs. non-reef areas), % | 80 (52) |
| Reef area (vs. non-reef areas) occupied by Long-Tailed Ducks density higher than marine conservation criterion (>19.73), % | 30 (7) |
| Average spring density of pelagic fishes in the reef area (vs. non-reef) mln ind. $nm^{-2}$ | 1,6 (2,0) |
| Reef area occupied by pelagic fishes in spring with density higher than average (vs. non-reef) % | 39 (47) |
| Average spring density of Cod in the reef area (vs. non-reef area), CPUE | 27 (13) |
| Average spring density of Flounder in the reef area (vs. non-reef area), CPUE | 55.4 (20.6) |
| **Sambian Plateau** | |
| Average density of Long-Tailed Ducks in the reef area (vs. non-reef areas), birds $km^{-2}$ | 5.0 (2.5) |
| Average spring density of pelagic fishes in the reef area (vs. non-reef) mln ind. $nm^{-2}$ | 2 (12) |
| Average spring density of Cod in the reef area (vs. non-reef area), CPUE | 47.8 (25) |
| Average spring density of Flounder in the reef area (vs. non-reef area), CPUE | 14 (16) |

Similar pattern was also observed for European Flounder with high association level to the shallow reef areas in the Klaipeda - Ventspils Plateau during spring. On the other hand, this pattern was obvious only if shallow areas with depths less than 30 m are observed, therefore average density of Flounder in the Sambian Plateau did not differ between reef and non-reef areas (Table 7.2). Independently from depth, average spring density of Cod was consistently 2-3 times higher on reefs compared to surrounding territories; but data are less accurate due to point based results from gillnet surveys.

Velvet Scoters and pelagic fishes have negative association pattern in respect to reefs when both, quantity and distribution characteristics are estimated for the project sites. Pelagic fishes were concentrated along the slopes with higher preferences to the greater depths. Although the total area with higher than average pelagic fish density is comparable in the reef and non-reef sites of the Klaipeda-Ventspils Plateau (Table 7.2), distribution at deeper parts along the slope is less fragmented. In contrast, Velvet Scoters being negatively associated with the cobble and boulder reefs are also restricted to the shallow places. These preferences define the species distribution along the soft bottom slopes adjacent to the both sides of reef (Fig. 7.1). Although the distribution zone below 40 m accounts for approx. 30-35% of the total occupied area, shallow parts obviously overlap with sandy bottoms dominated by *Macoma balthica* and spionid polychaetes (Fig. 7.2) and therefore remain as having high explanatory value.

Summarizing data integration results, it is obvious there is limited overlap in distribution of main biological features targeted by the project: pelagic fishes, Long-Tailed Ducks, Velvet Scoters, Cod and Flounder. The association between these components is negligible in the most distant Klaipeda Bank, where most important target species and habitats were not recorded. At two eastern sites, and particularly in the Klaipeda-Ventspils Plateau shallow parts of reefs highly integrate distribution and densities of Long-Tailed Ducks, Cod and Flounder. In this area distribution boundaries of Velvet Scoters are adjacent to the most important reef sites, used by Long-Tailed Ducks, therefore north-eastern part of the Klaipeda-Ventspils Plateau can be considered as the most complex site with strongest links between biological components and distribution of bottom habitats.

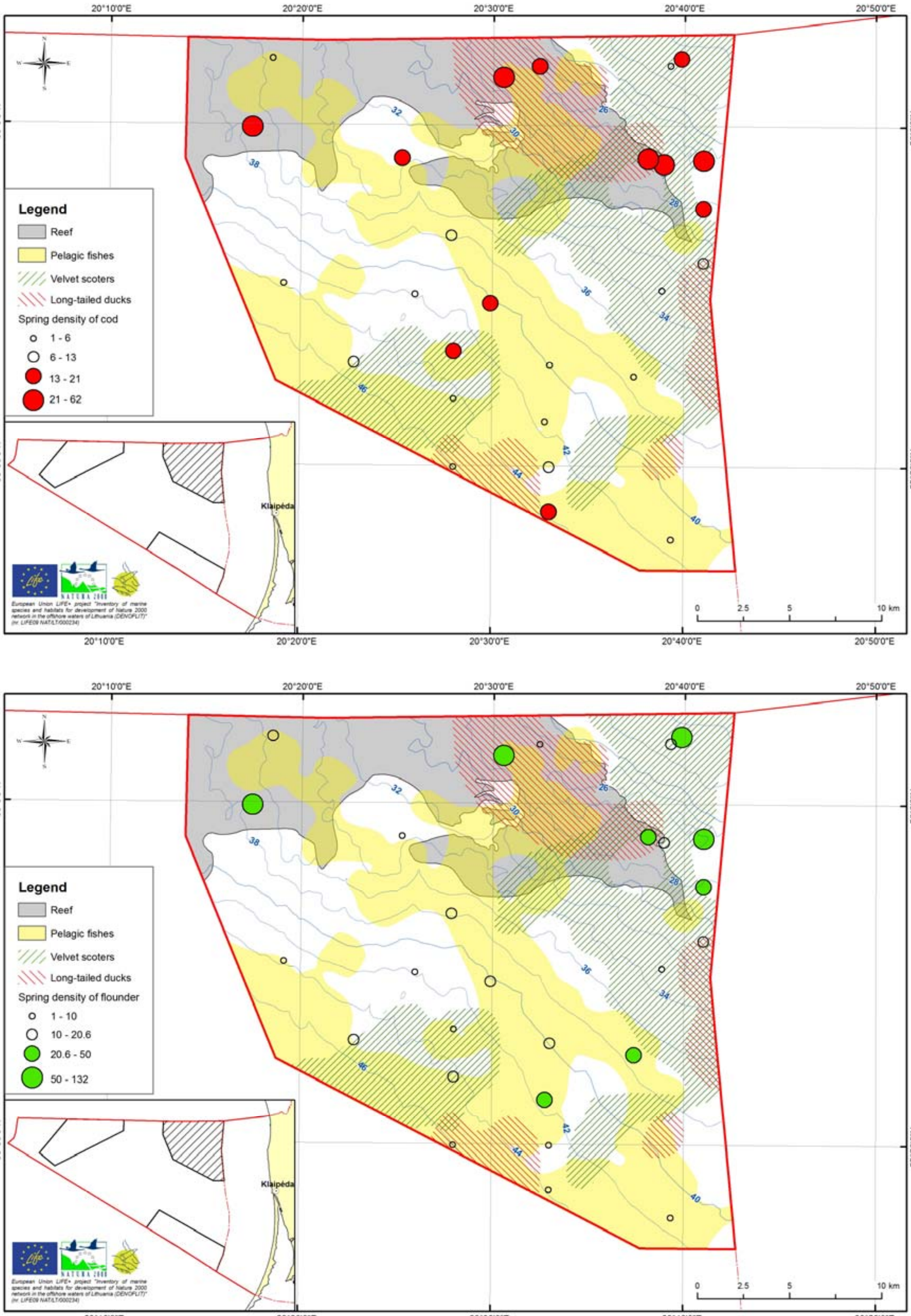



Figure 7.1. Distributions of Velvet Scoters (modeled density above Marine Conservation Criterion), Long-tailed Ducks modeled density above Marine Conservation Criterion), pelagic fishes (mln ind. nm$^{-2}$), cod (CPUE) and flounder (CPUE) in the Klaipeda-Ventspils Plateau.

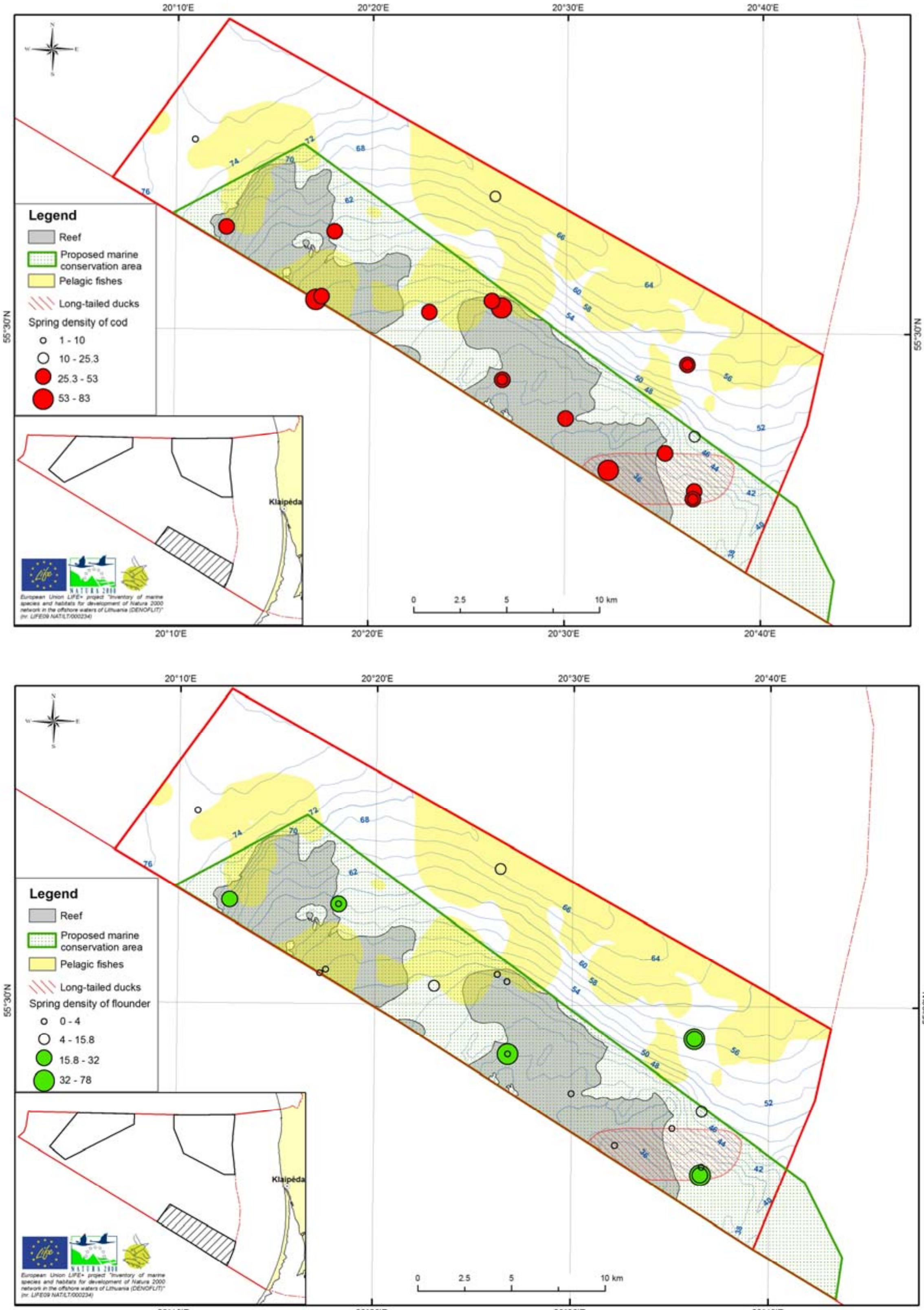



Figure 7.2. Distributions of Long-Tailed Ducks modeled density above Marine Conservation Criterion), pelagic fishes (mln. ind. $nm^{-2}$), cod (CPUE) and flounder (CPUE) in the Sambian Plateau.

## 7.2 Assessment and comparative analysis of project sites

Three project sites are located in the opposite corners of the Lithuanian EEZ, however similarities and differences among them are mainly determined by depth and distance from the coast. In this respect two eastern sites, Klaipeda-Ventspils Plateau and Sambian Plateau are much more similar compared to the distant Klaipeda Bank, which in turn is less geomorphologically distinct and serves the nearest eastern shallow site next to the slopes of the Gotland Deep. In contrast, two areas adjacent to the territorial waters have clearly pronounced elongated shallow parts at least partly surrounded by soft bottom slopes. Klaipeda-Ventspils Plateau has lower depth gradient and slopes of lower steepness, its uppermost part is more shallow and less topographically fragmented (Table 7.3). On the other hand, its moraine bottoms including boulder and cobble reefs extend over larger territories (incl. slopes) and are much less fragmented compared to the Sambian Plateau. These environmental differences have numerous reflections in biology of these areas. Both are similar in distribution patterns of demersal and pelagic fishes. Slopes are characterized as productive areas for economically important clupeid fishes, especially sprat. Sprat constituted 75% of mixed clupeid stock on average with high dominance of juveniles (0 and 1 year), therefore both areas can be important for sprat (and potentially for herring) as nursery sites.

In contrast to pelagic fishes, distribution of cod and flounder tend to be associated with shallow parts. Shallower reef areas of Klaipeda-Ventspils Plateau attract approx. 6 times higher densities of Flounder compared to the Sambian Plateau, where no differences between reef and non-reef areas are found (Table 7.3). Historical data analysis also demonstrate higher occurrence of Twaite shad in the deeper parts of the slopes along this Plateau. Although occurrence of this species was very low during project period, both Twaite shad individuals caught during gillnet surveys in 2011-2013 were recorded in the Klaipeda-Ventspils Plateau. On the other hand reefs in the Sambian Plateau favour higher spring densities of cod, which are approx. twice higher than in the Klaipeda-Ventspils Plateau.

In respect to marine birds, the project area in the Klaipeda-Ventspils Plateau is supporting much higher numbers of Long-Tailed Ducks compared to Sambian Plateau, while only few individuals of Velvet Scoters have been observed in the later area (Table 7.3). In both areas, however, Long-Tailed Ducks obviously preferred uppermost parts of reefs, where average densities were 2-5 times higher than in non-reef areas.

Table 7.3. Overview of comparative characteristics for two project areas with features qualifying for designation of Natura 2000 sites.

| Criteria group | Criteria | Klaipeda-Ventspils Plateau | Sambian Plateau |
|---|---|---|---|
| Environmental features of the reef | Depth interval (m) | 24 - 40 m | 33-73 m |
| | Mean depth (m) | 32 | 49 |
| | Mean slope (degrees) | 0.108±0.08 | 0.162±0.114 |
| | Reef size ($km^2$) | 164.94 | 98.04 |
| | Relative area of the reef (%) occupied with hard substrate (acoustic signal) | 96.7 | 71.7 |
| Functional features of the reef | Total number of Long-tailed Ducks in the reef area (birds)<br><br>Average density of Long-tailed Ducks in the reef area, birds $km^{-2}$ | 7110<br><br>43 | 508<br><br>5 |
| | Total number of Velvet Scoters in the reef area (birds)<br><br>Average density of Velvet Scoters in the reef area, birds $km^{-2}$ | 3579<br><br>22 | - |
| | Total reef area occupied by Long-tailed Ducks, $km^2$<br><br>Total reef area occupied by Long-tailed Ducks with densities exceeding the marine conservation criterion (>19.73birds $km^{-2}$) | 131<br><br>49 | 91<br><br>5 |
| | Total reef area occupied by Velvet Scoters ($km^2$)<br><br>Total reef area occupied by Velvet Scoters with densities exceeding the marine conservation criterion (>5.53), $km^2$ | 107<br><br>59 | -<br><br>- |
| | Average spring density of pelagic fishes in non- reef area (mln ind. $nm^{-2}$) | 2,0 | 12.0 |
| | Average spring density of cod in the reef area, CPUE | 27 | 47.8 |
| | Average spring density of flounder in the reef area, CPUE | 55.4 | 14 |

## 7.3 Recommendations for designation of protected sites and management measures

**Klaipeda Bank.** This project site does not contain qualifying features in any group of environmental features (habitats) and marine organisms (birds, fishes) targeted by the project. Although it may serve important refuge area for mobile organisms from neighbouring Gotland Deep slopes during hypoxic or anoxic periods, environmental conditions in this area does not support existence of important benthic habitats or permanent aggregations of marine birds with pelagic feeding mode. Klaipeda Bank is also less important for clupeid stock compared to the less distant areas from the coast.

**Klaipeda-Ventspils Plateau.** This project site is the only area which meets both habitat and marine bird criteria for NATURA 2000 sites. Reef habitat is stretching over approximately a quarter of the area in the north at depths down to 40 m, although half of it is distributed in depths of less than 30 m. Coverage of hard substrate also appears to be the highest in the uppermost part of the reefs showing presence of relatively valuable sites for development of rich and complex epifaunal communities in the shallow parts of the reef. Visual inspection of the reef in these shallow areas provided evidences on presence of pristine dense and diverse mussel colonies, compared to currently deteriorated population in the shallow coastal areas. Klaipeda-Ventspils plateau is the only area where Twait Shad has been recorded during the field inventories, while the shallow part of the area is showing complex diversity of environmental features and good coincidence in distribution of Long-Tailed Ducks and higher densities of flounder with the reef. Additionally, the highest densities of Velvet Scoters recorded along the north-eastern and south-eastern sandy slopes bordering the shallow reef area demonstrate importance of ecotones and reef edges bordering rich soft bottom communities.

The observed large aggregations and high densities of wintering Velvet Scoters during the ship-based waterbird surveys in wintering seasons of 2011/2012 and 2012/2013 warranted for further investigation of Velvet Scoter aggregations in Klaipeda-Ventspils Plateau in terms of their compliance with the Marine Conservation Criterion for the SPA delineation and further designation. Application of the 5.53 birds/km² density threshold value to the Velvet Scoter density distribution map revealed a continuous high density (up to 1040 birds/km²) aggregation of birds in the north-eastern – eastern part of the project site, bordering the territorial waters of Lithuania in the east and Latvian EEZ in the north (Annex B17). A smaller almost separate aggregation with considerably lower Velvet Scoter densities (up to 250 birds/km²) was located in the southern part of the site, where depth exceeds 40 m. Furthermore, a dense aggregation of Long-tailed Ducks, with densities exceeding the threshold value of 19.73 birds/km², was located in the shallowest northern part of the Klaipeda-Ventspils Plateau, with depths up to 30 m (Annex B18). This area exclusively coincide with the distribution of the most shallow reefs (Fig. 7.3), and although the number of Long-tailed Ducks in this aggregation did not meet the abundance criterion, it was taken into account during the delineation of proposed SPA (Fig. 7.4). Just as the Velvet Scoter, the population of Long-tailed Duck has recently experienced a dramatic decline, observed across the entire Baltic Sea (Skov *et al*. 2011). Furthermore, it has nearly vanished from its formerly stable and abundant wintering grounds in the inshore along the Palanga coast of Lithuania, presumably as a result of food resource depletion by the invasive round goby (*Neogobius melanostomus*) (D. Daunys, A. Šiaulys, A. Šaškov, pers. observations). Therefore, protection of this alternative, previously unknown wintering ground of the Long-tailed Duck could be important for the maintenance of wintering ground network for this species on the Baltic Sea scale. Recommended area for designation includes 176 km$^2$ in the Lithuanian EEZ (27% of the project area), stretching in depths from 25 to 35 m. This area covers all the shallow reefs which overlap with sites occupied by Long-Tailed Ducks in densities higher than Marine Conservation Criterion (19.73 birds km$^{-2}$).

It was further recalled that during the LIFE-Nature project "Marine Protected Areas in the Eastern Baltic Sea" (project number LIFE 05NAT/LV/000100), implemented in 2005–2009, large aggregation of Velvet Scoters was observed during several ship-based surveys in the territorial waters of Lithuania, off the coast of Palanga. This aggregation did meet the bird density criterion for the designation of SPA, but did not meet the abundance criterion, therefore, SPA was not proposed there at the time. However, since this aggregation stretched to the border of territorial waters, it was stipulated, that it could have been a part of a larger aggregation extending into the EEZ waters of Lithuania. This supposition was confirmed during the current project, since the previously identified aggregation of Velvet Scoters matched almost exactly the aggregation of Velvet Scoters, identified during the waterbird inventory in 2012–2013 (Annex B20). Considering all of the above, delineation of boundaries of the proposed SPA took into account both the distribution of Velvet Scoter and Long-tailed Duck, recorded during the present study, as well as the distribution of Velvet Scoters, recorded in 2007–2008 (Fig. 7.4). Therefore total area suggested for designation accounts for 316 $km^2$, 140 $km^2$ of which is stretching in the territorial waters covering previously identified important areas for Velvet Scoter.

**Sambian Plateau.** This project site meets qualifying criteria for designation of protected area due to presence of reef habitat, which stretches over 98 $km^2$ in the south-west along the border with Russian Federation (Fig. 7.5). In contrast to the Klaipeda-Ventspils plateau, reefs are located in deeper waters (depths higher than 30 m), therefore links to distribution of bottom feeding marine birds (Velvet Scoters, Divers and Long-tailed Ducks) were weak both during surveys and in predictive models. Marine birds with pelagic feeding mode, such as Razorbills, were either abundant but with highly variable numbers and distribution, or regularly found in low numbers (Guillemot).

Distribution of adult and juvenile Cod is positively correlated with cobble and boulder reefs particularly in autumn. Due to these reasons suggested boundary of protected site is exclusively reflecting distribution of two reef fragments and steepest slope areas in the south-east down to halocline at 60 m, which is typically foreseen as the depth boundary in the south-eastern Baltic Sea where the most of distribution limits of the benthic macrofauna species occur. Suggested boundaries delineate the entire area of the reef with the eastern part covering the most shallow sandy areas of the plateau (depths less than 40 m). The suggested area extends beyond the project area into the territorial sea in order to merge this conservation zone with the Baltic Sea biosphere polygon, designated in the territorial sea by the order of Lithuanian Ministry of Environment (Nr. 53-2646) in May 2013. This the area will also include mega-ripples occasionally recorded during the project acoustic surveys at the border between project site and territorial sea. In total suggested conservation zone is extended over 211 $km^2$, with 17 $km^2$ distributed in the territorial waters.

**Summary.** Suggested areas for designation in the Sambian Plateau and Klaipeda-Ventspils Plateau cover 527 $km^2$, and increase marine conservation in Lithuanian waters of the Baltic sea from 636 $km^2$ to 1 163 $km^2$. Suggested territories would increase marine protected area in territorial waters by 25% (up to 793 $km^2$) reaching 35% protection of the territorial waters. Such level of protection is comparable to that of Latvian (33%), Danish (29%) and German (28%) waters. Additional marine territory of 370 $km^2$ suggested for designation in the EEZ will contribute to the first 8.7% of the Lithuanian offshore area set legally under protection regime. Both suggested territories are exceeding 10 thous. hectares and belong to category of large Baltic Sea protected areas (between 10 thous. and 100 thous. hectares) comprising about 95% of the total number of marine protected sites.

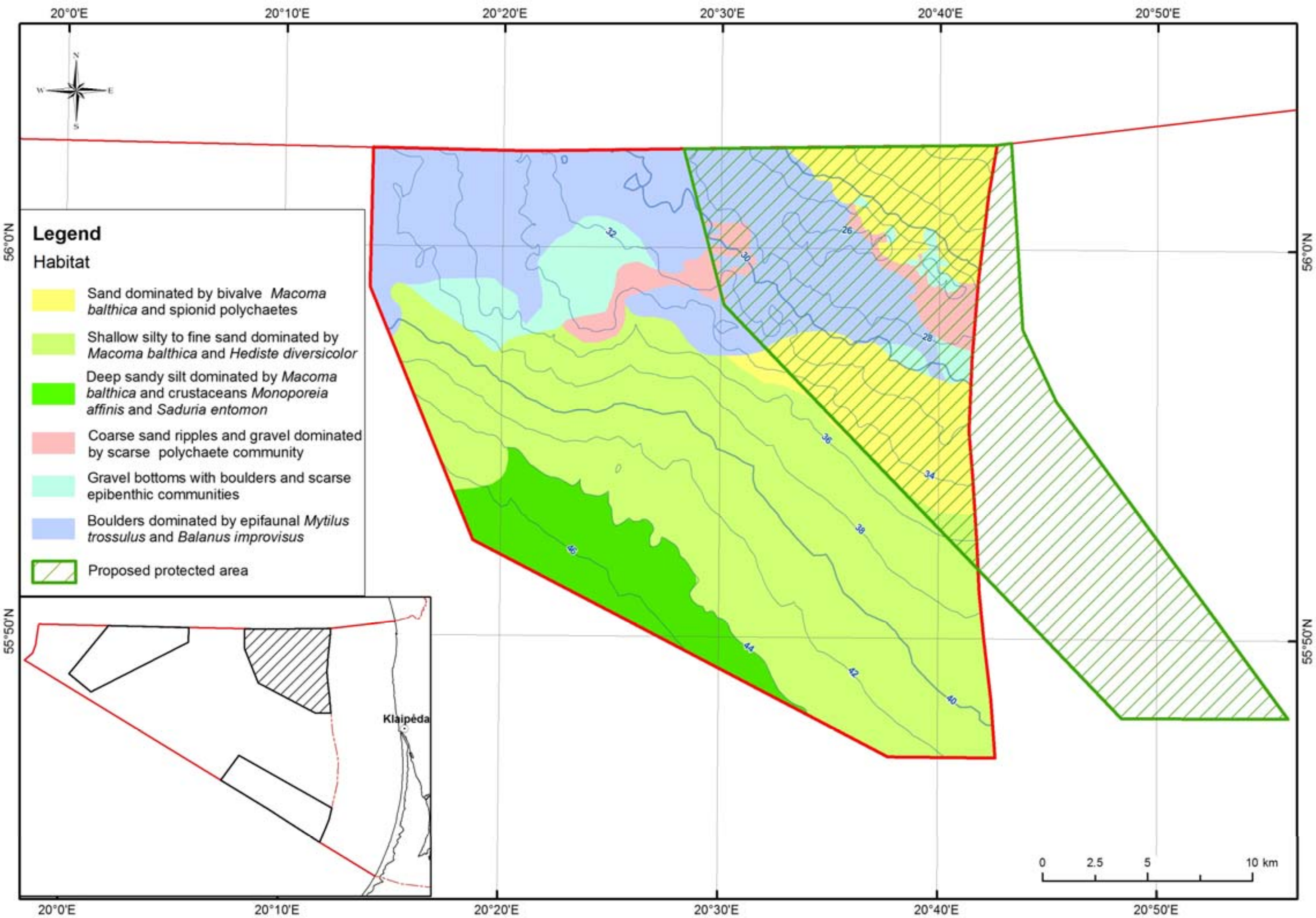



Figure 7.3. Proposed boundaries of Special Protection Area (SPA) in the project area Klaipeda-Ventspils Plateau, superimposed on distribution of benthic habitats (Boulders dominated by epifaunal *Mytilus trossulus* and *Balanus improvisus* qualify as reef habitat type according to the national interpretation of this habitat type).

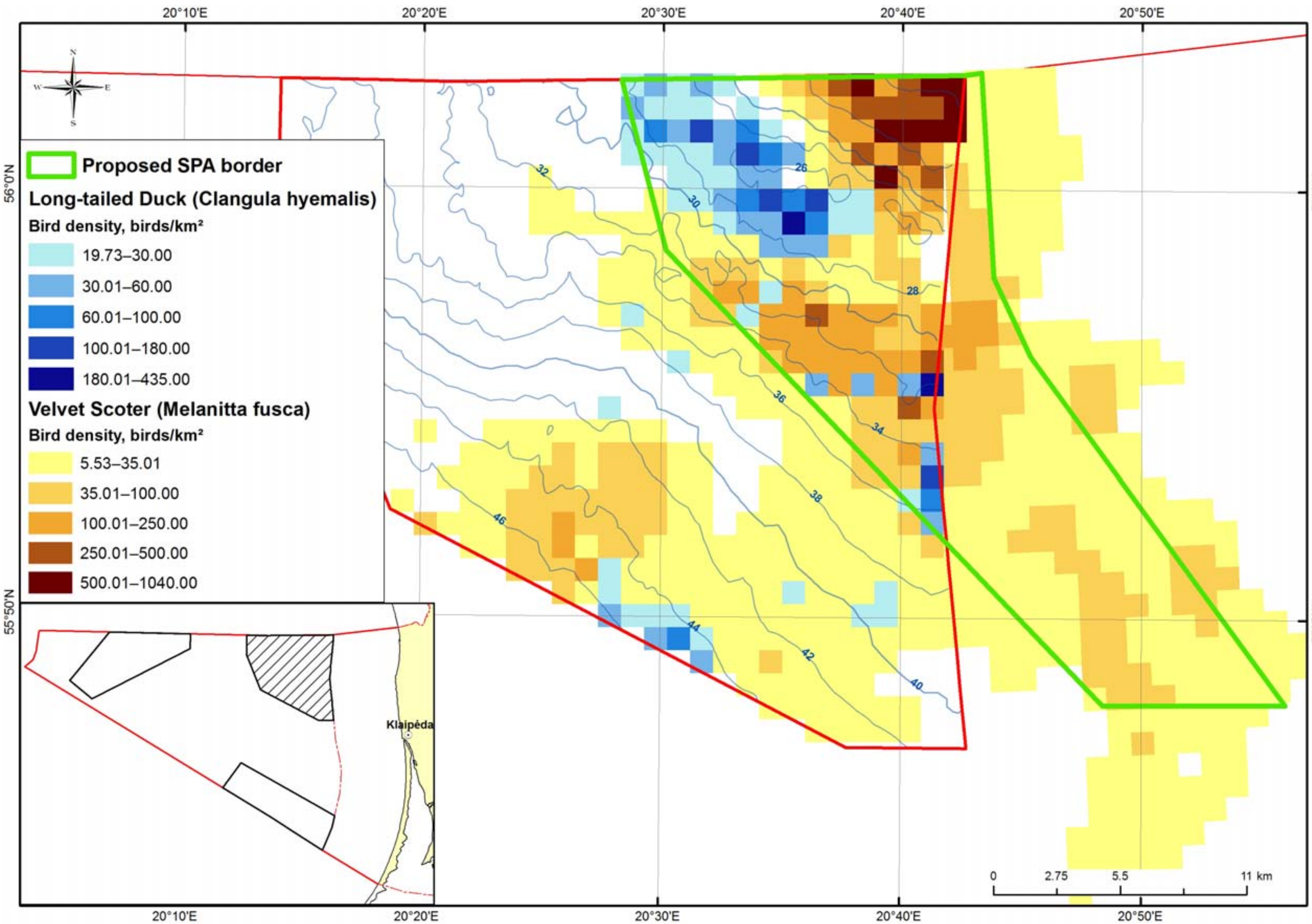



Figure 7.4. Proposed boundaries of Special Protection Area (SPA) in the project area Klaipeda -Ventspils Plateau, superimposed on Velvet Scoter (including 2007–2008 data, outside the project site boundaries) and Long-tailed Duck distribution, exceeding the threshold bird density values (5.53 birds/km² for Velvet Scoter and 19.73 birds/km² for Long-tailed Duck).

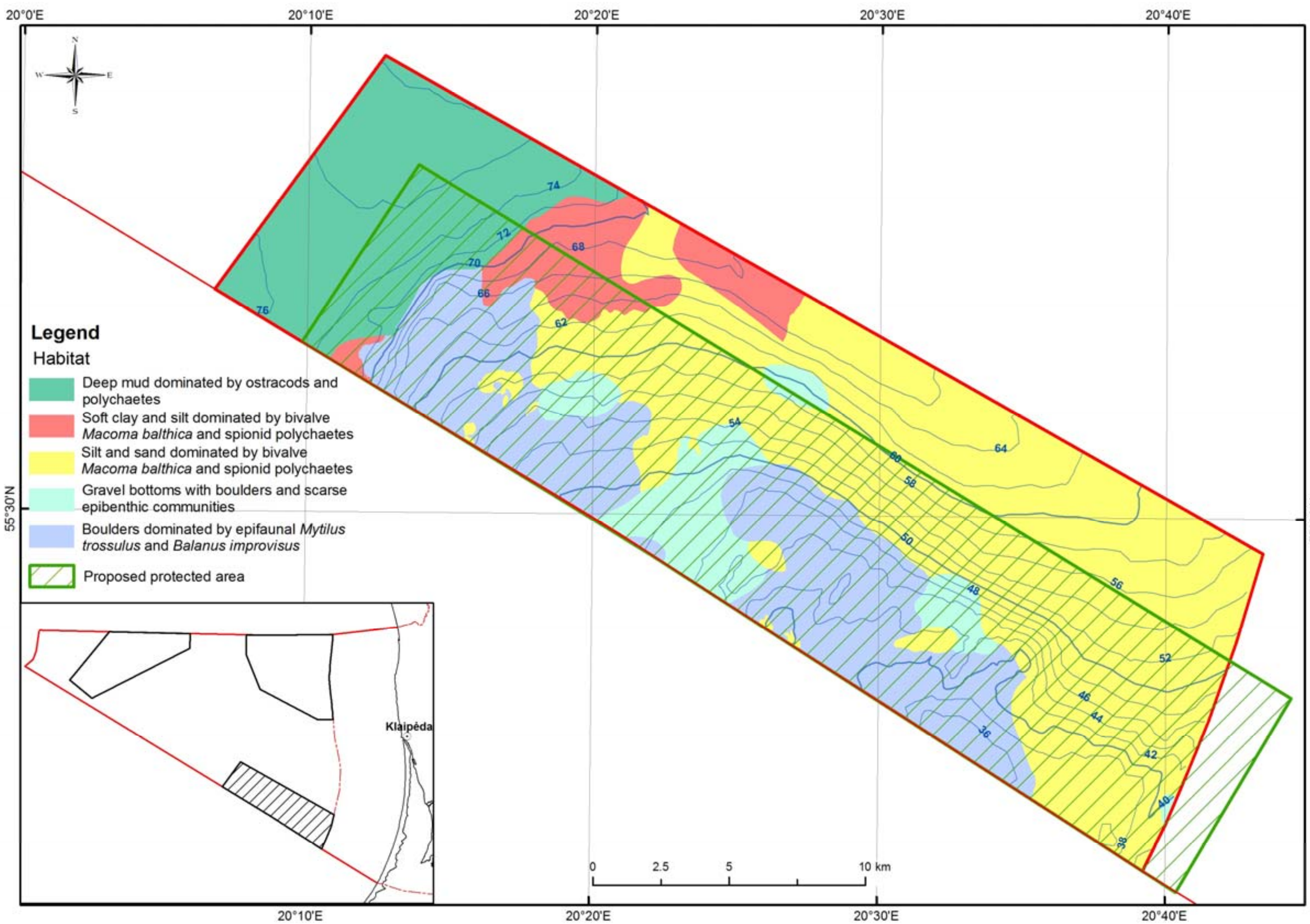



Figure 7.5. Proposed boundaries of Special Area of Conservation (SAC) in the project area Sambian Plateau, superimposed on distribution of benthic habitats (Boulders dominated by epifaunal *Mytilus trossulus* and *Balanus improvisus* qualify as reef habitat type according to the national interpretation of this habitat type).

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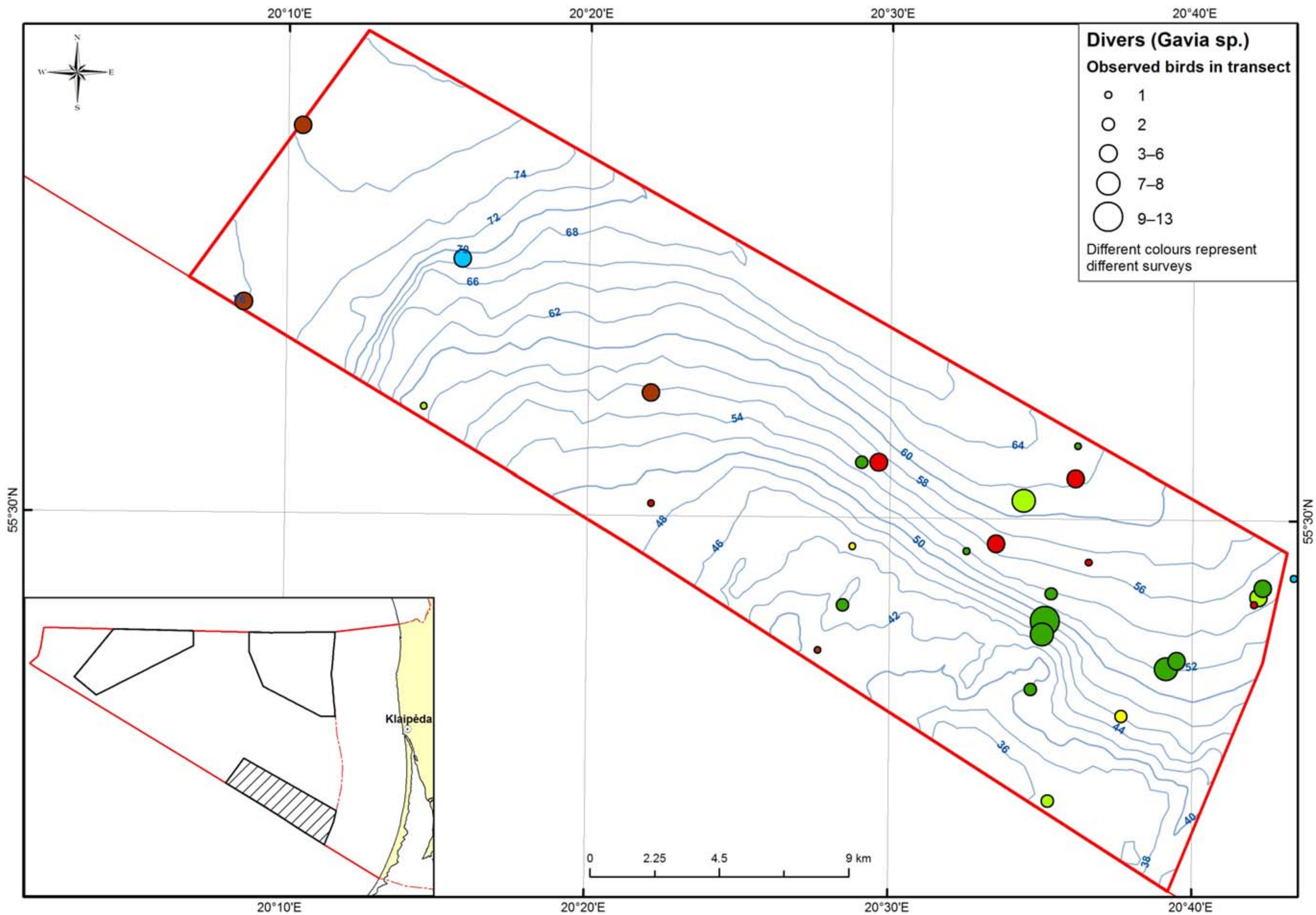
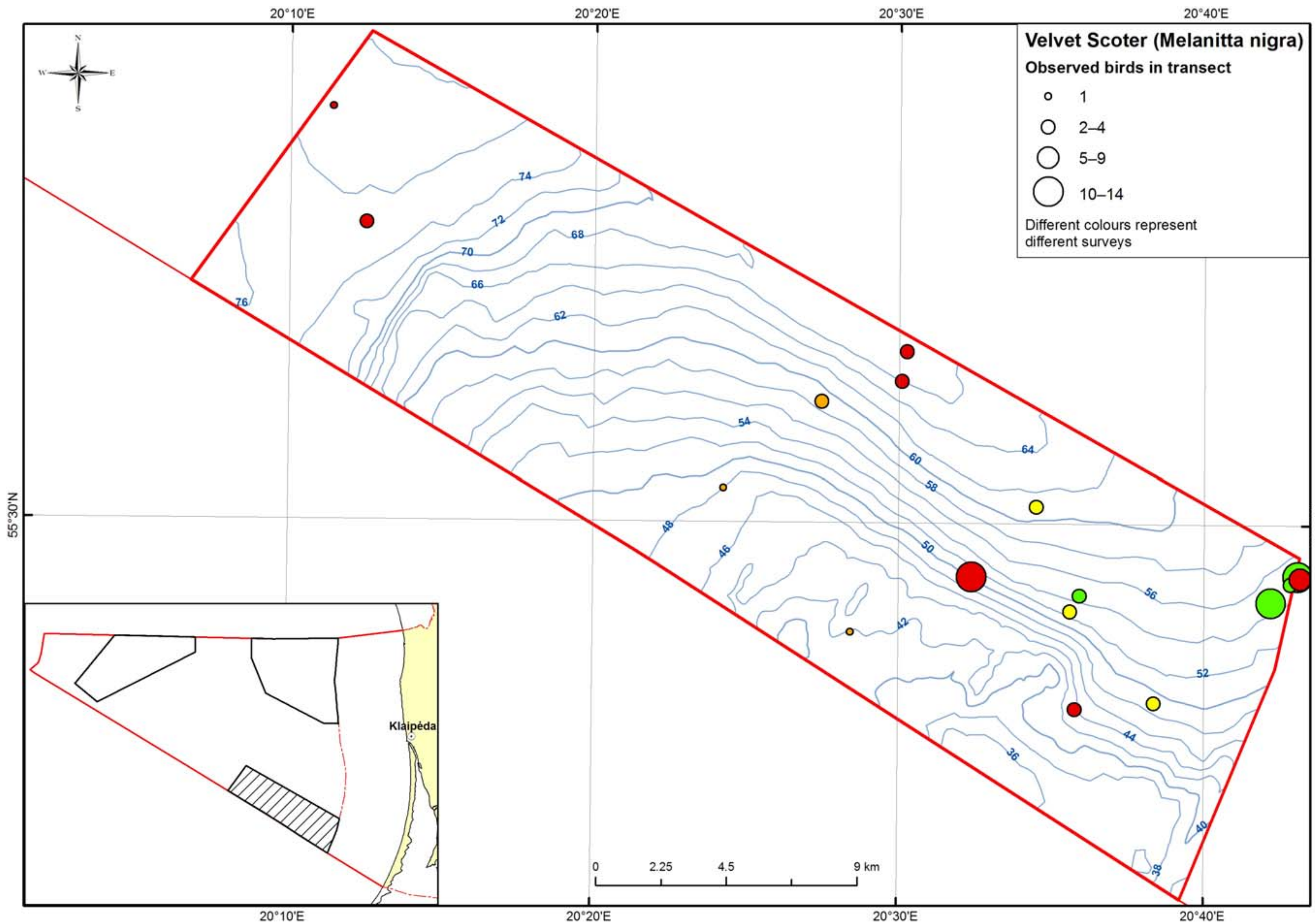
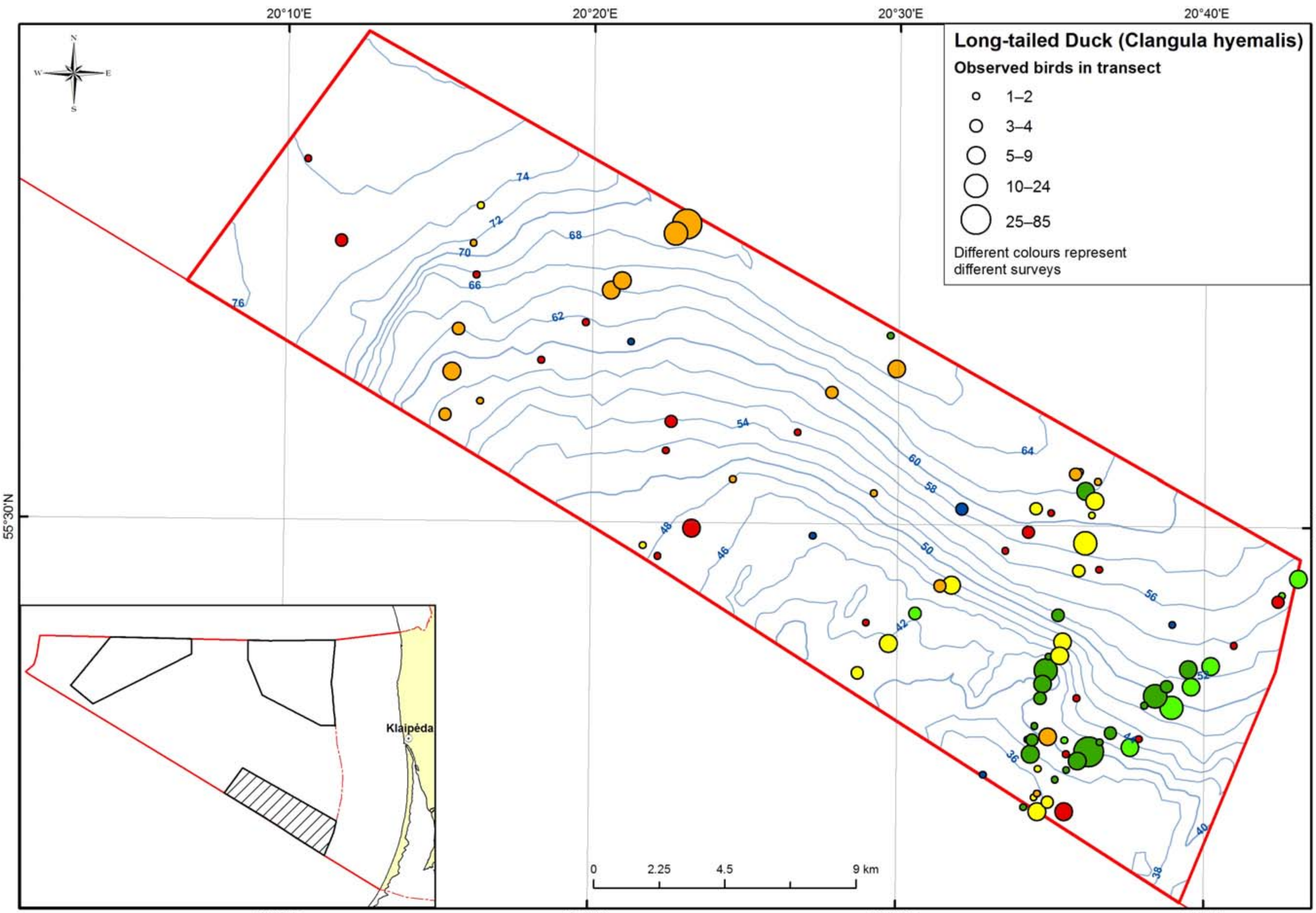
# ANNEXES



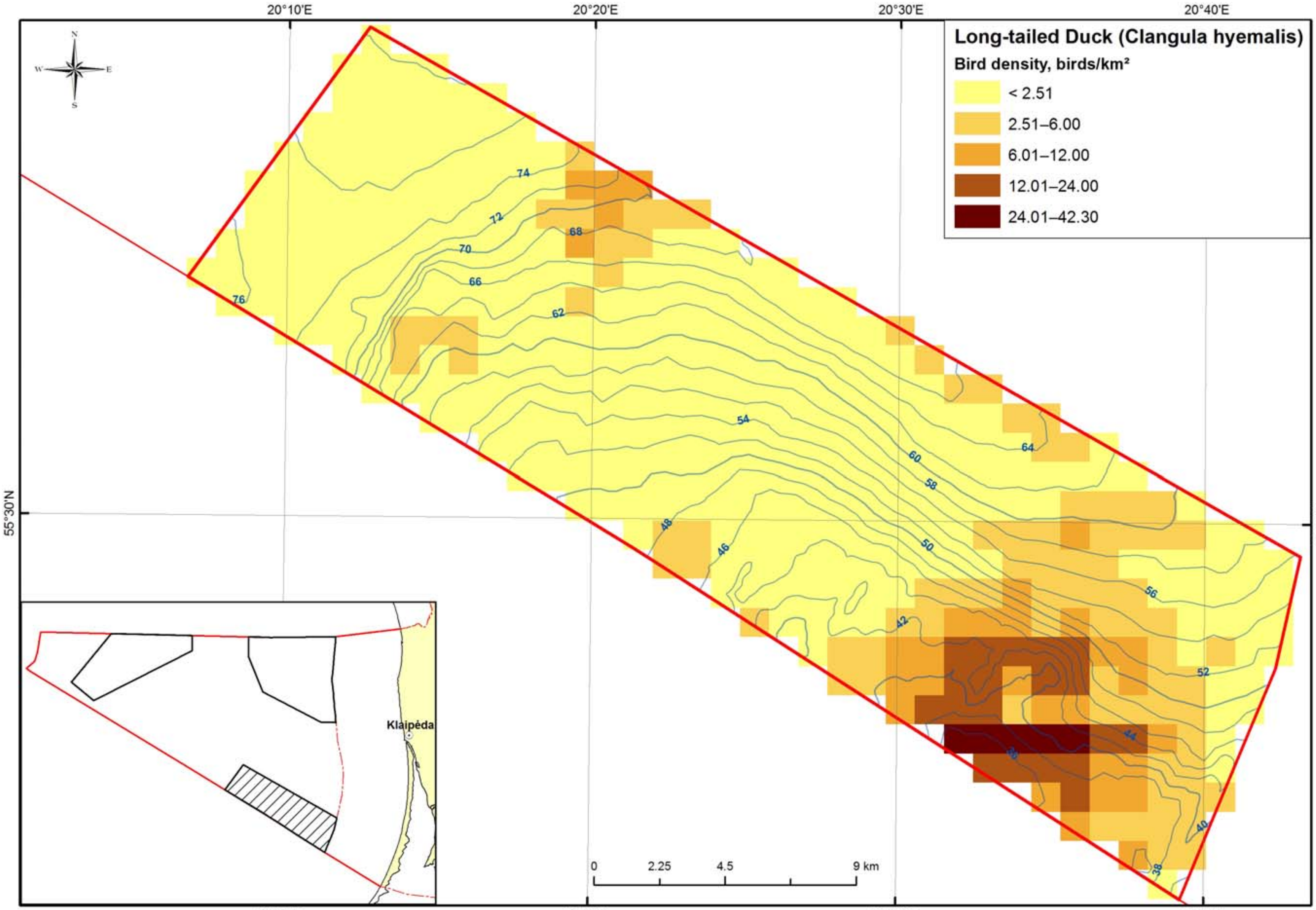

Annex T2B1. Divers (*Gavia* sp.) observed in transect during the ship-based waetrbird surveys in the Sambian plateau project area.



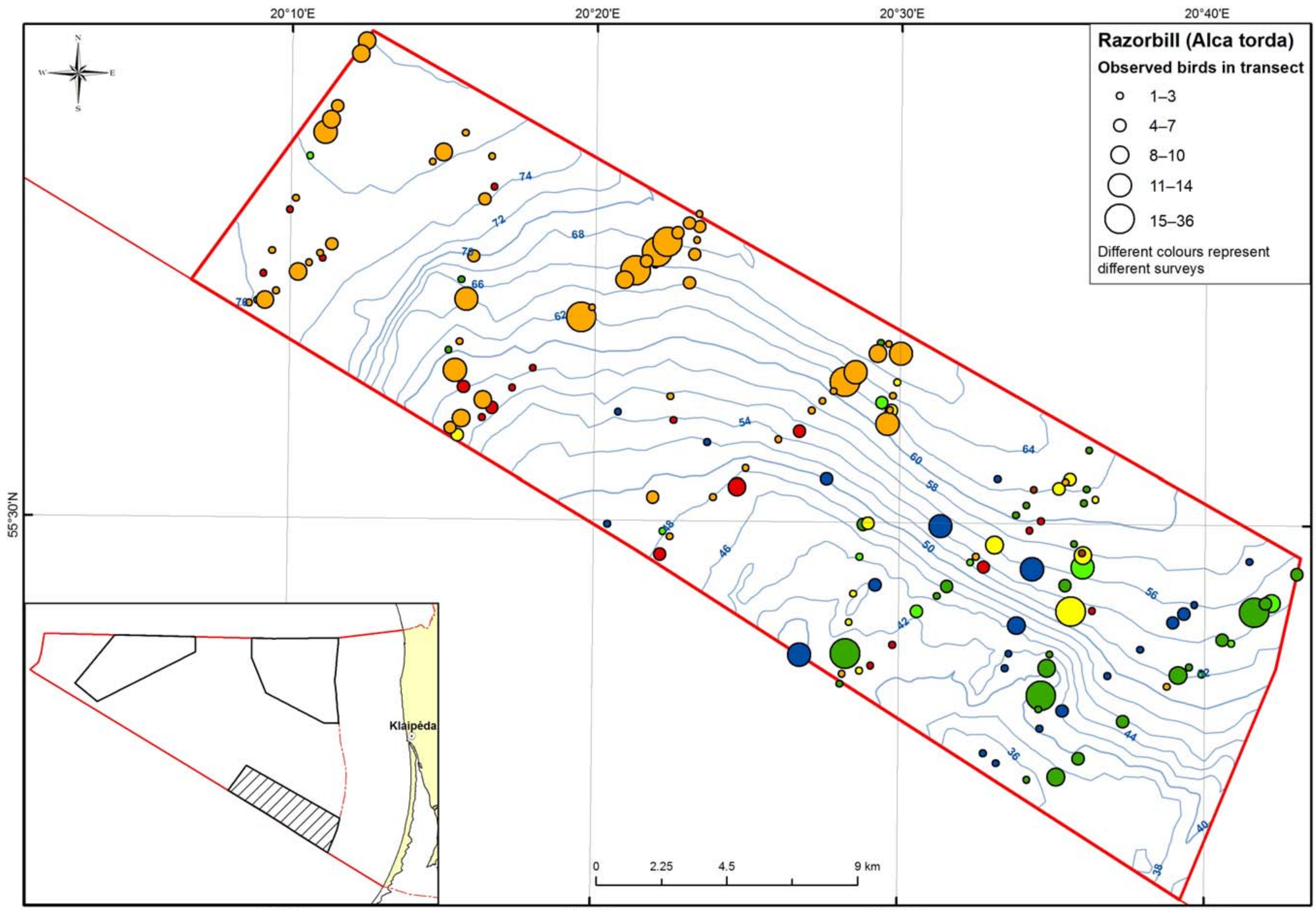

Annex T2B2. Velvet Scoters (*Melanitta fusca*) observed in transect during the ship-based waetrbird surveys in the Sambian plateau project area.



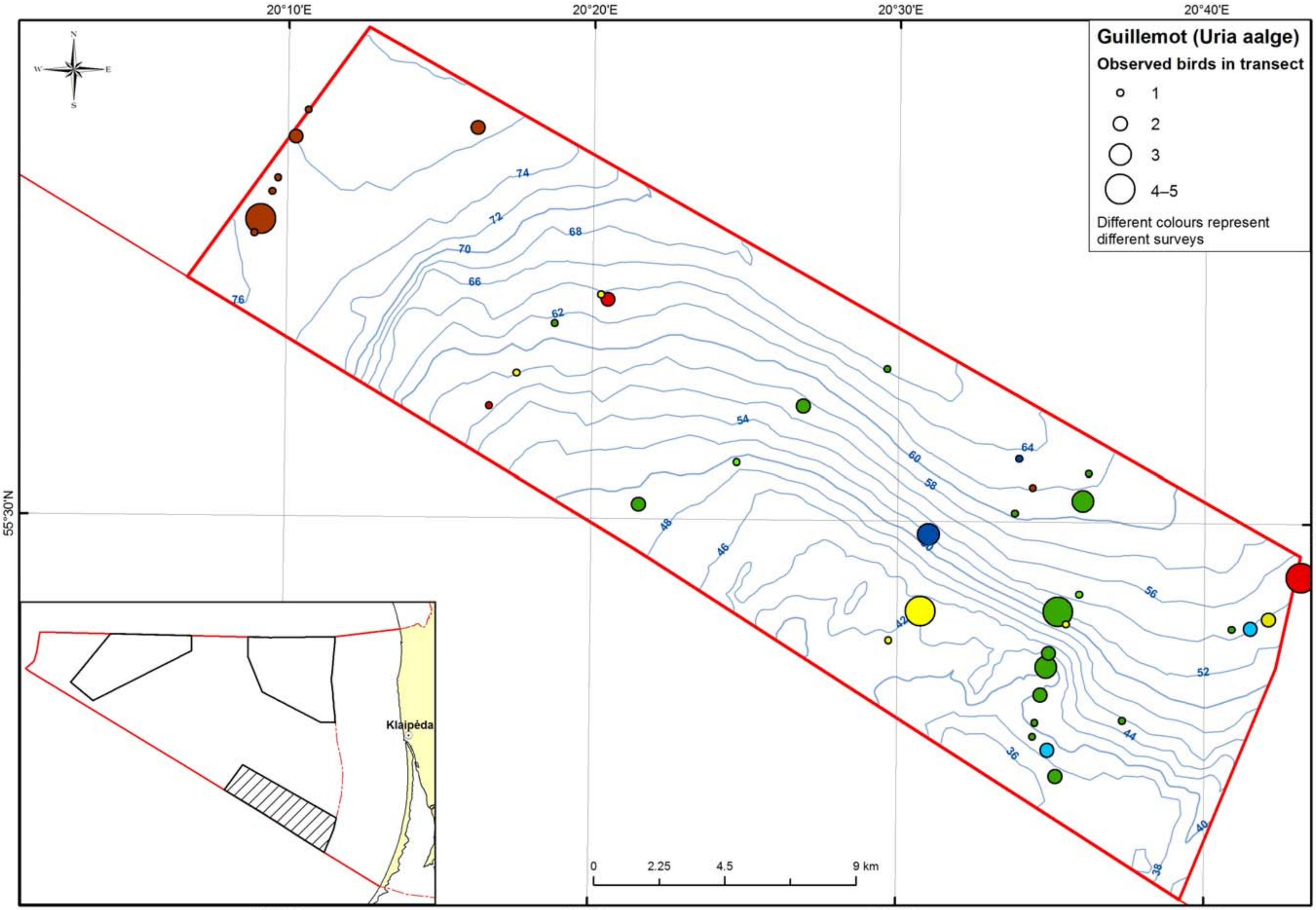

Annex T2B3. Long-tailed Ducks (*Clangula hyemalis*) observed in transect during the ship-based waetrbird surveys in the Sambian plateau project area.



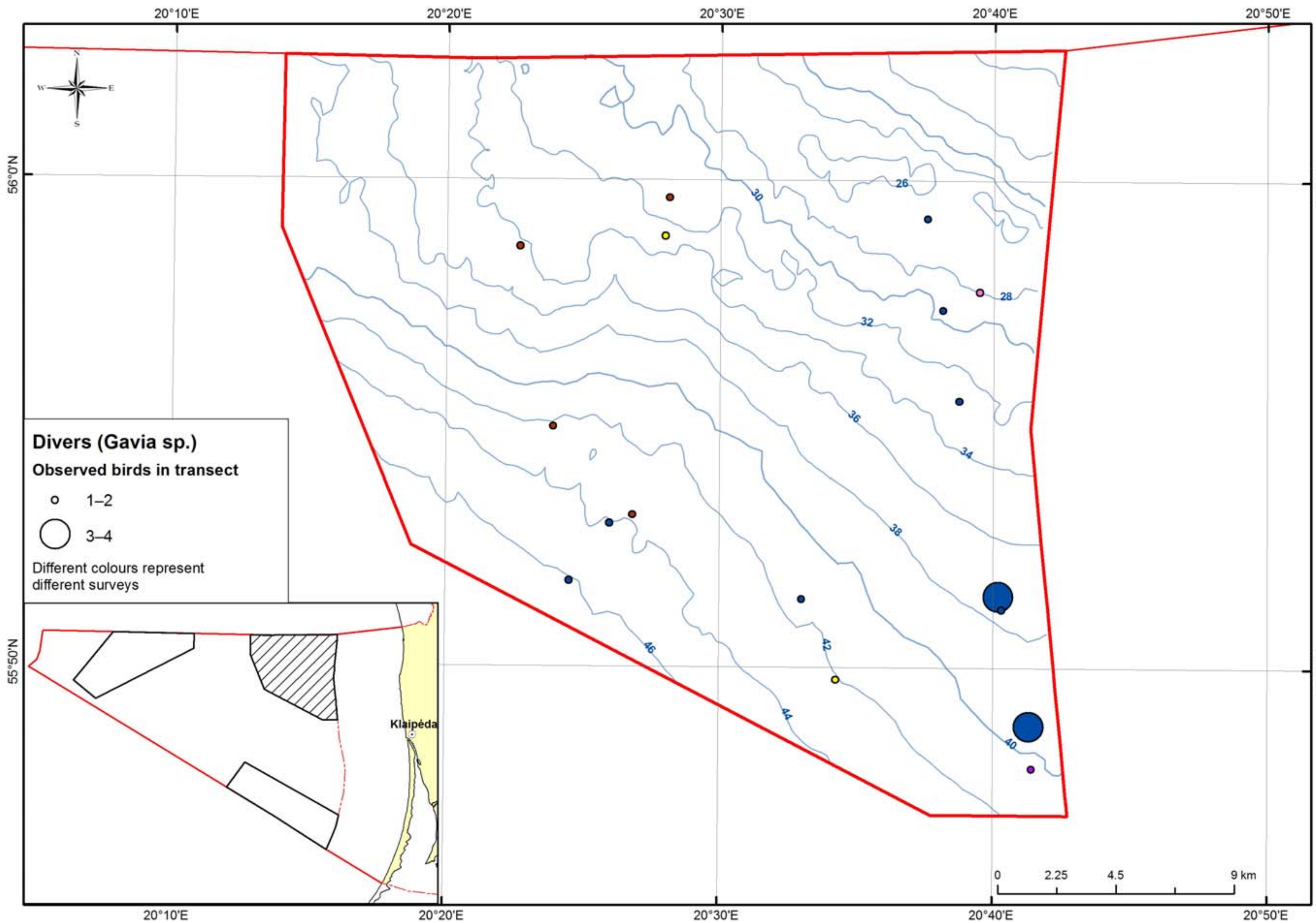

Annex T2B4. Modelled Long-tailed Duck (*Clangula hyemalis*) densities in the Sambian plateau project area during the wintering season.



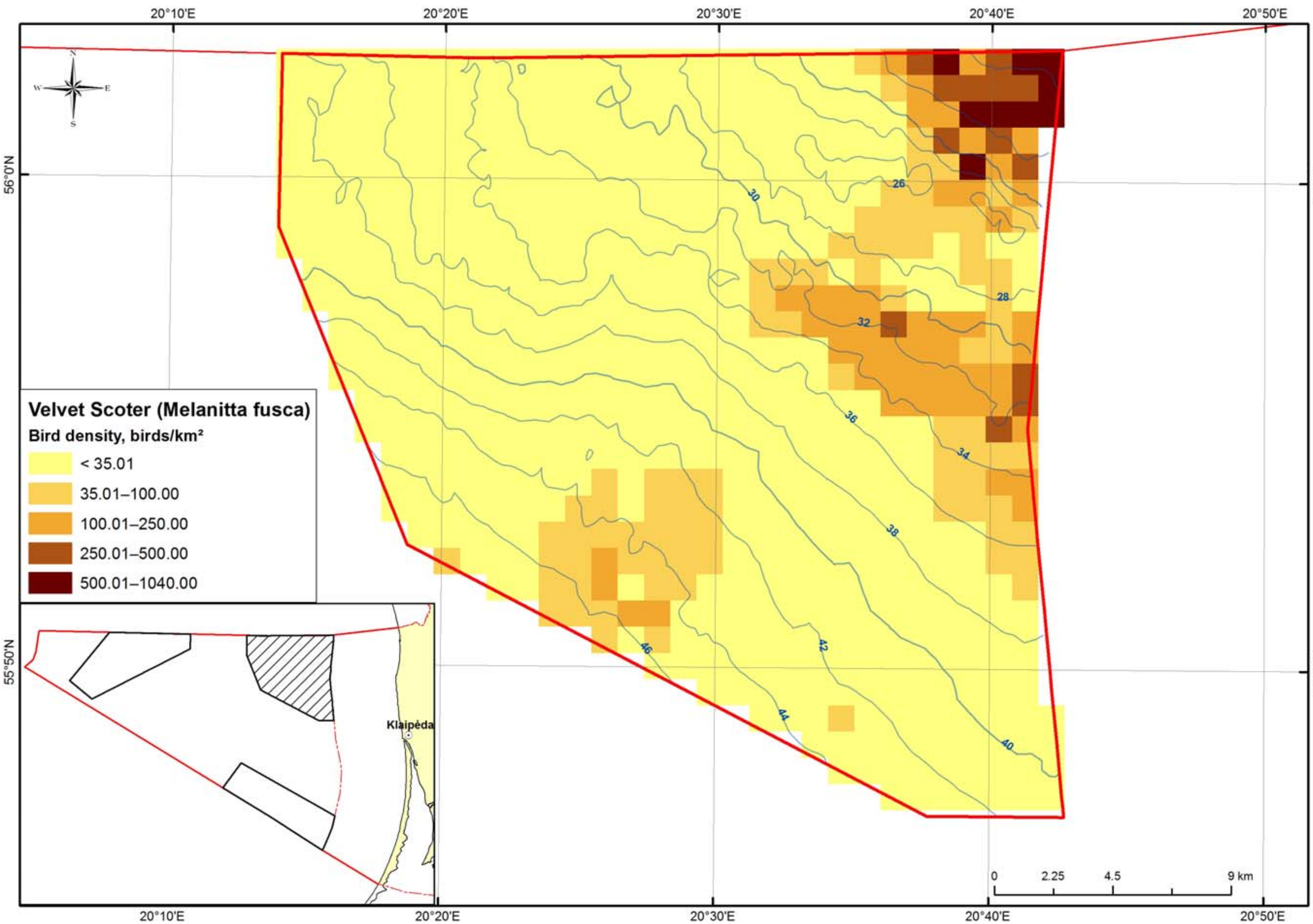

Annex T2B5. Razorbills (*Alca torda*) observed in transect during the ship-based waetrbird surveys in the Sambian plateau project area.



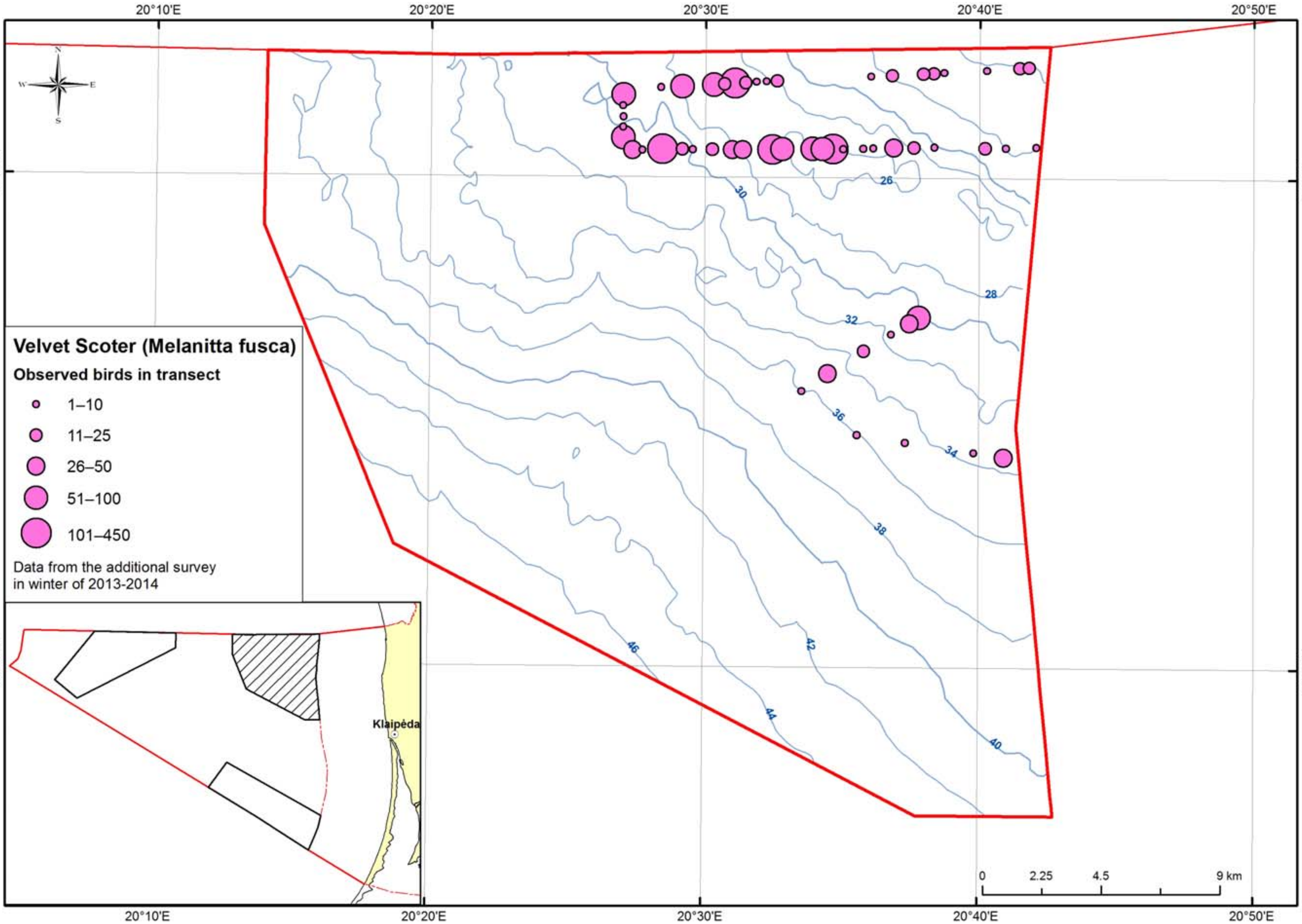
Annex T2B6. Guillemots (*Uria aalge*) observed in transect during the ship-based waetrbird surveys in the Sambian plateau project area.



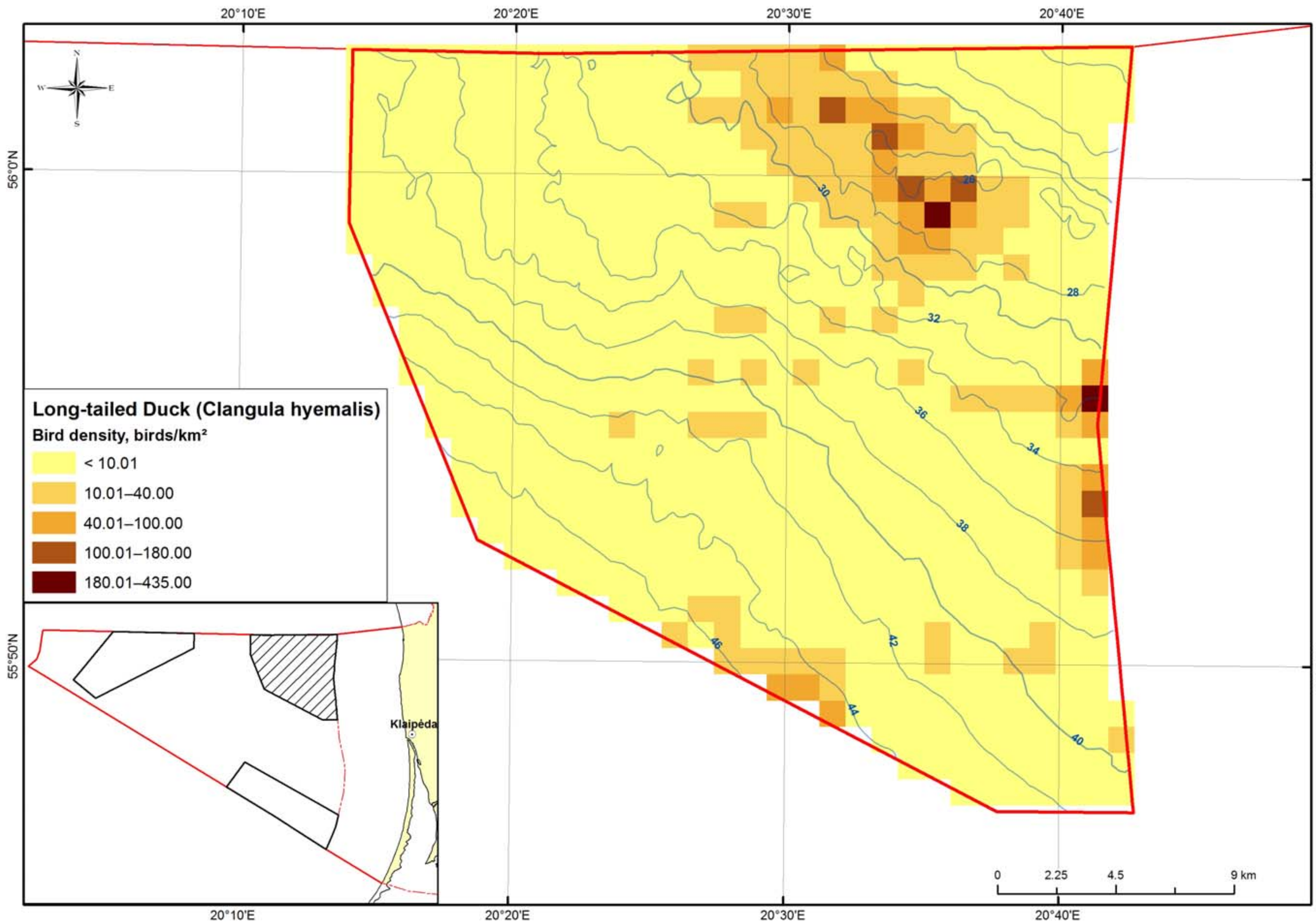
Annex T1B7. Divers (*Gavia* sp.) observed in transect during the ship-based waetrbird surveys in the Klaipėda-Ventspils plateau project area.



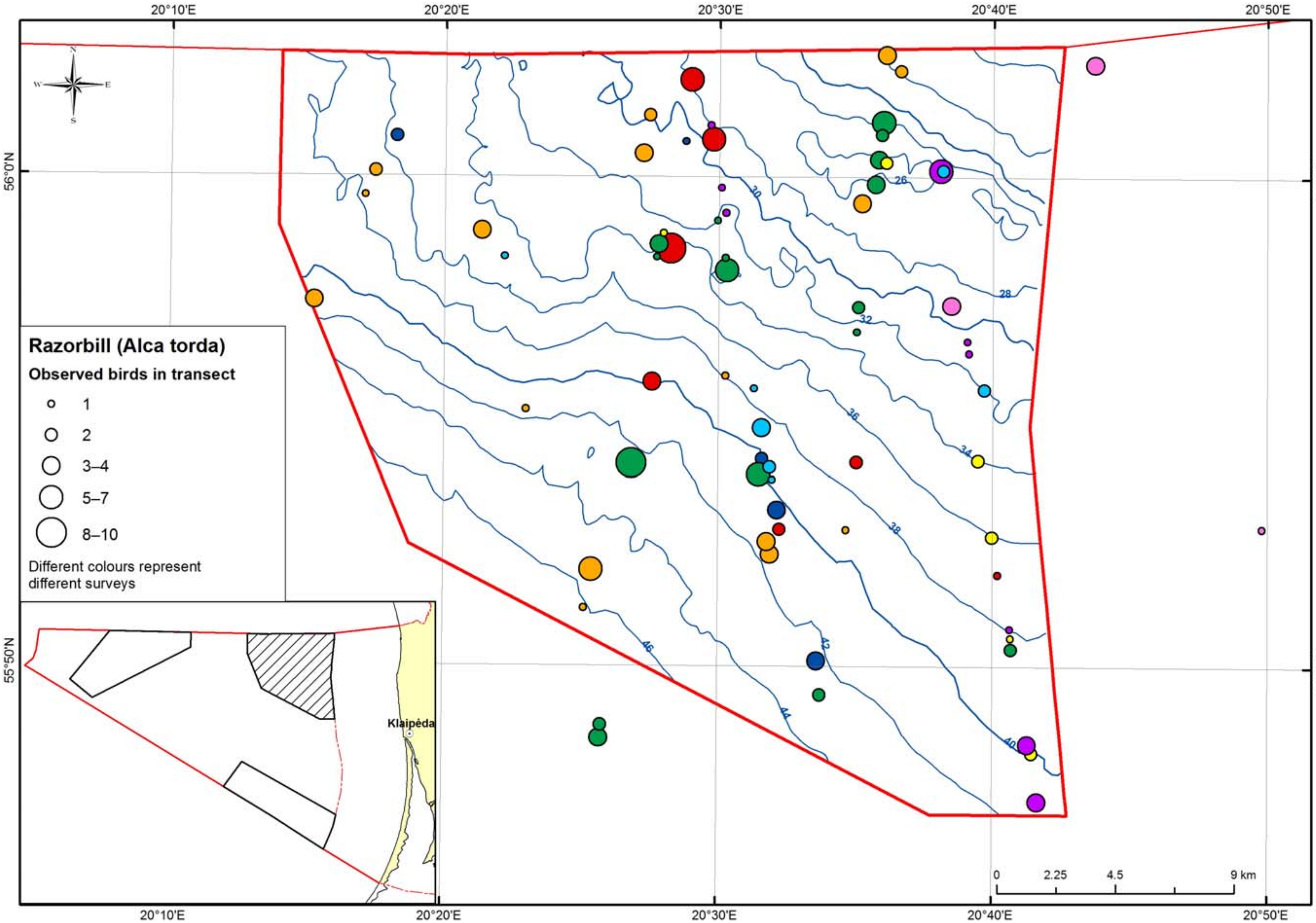
Annex T1B8. Modelled Velvet Scoter (*Melanitta fusca*) densities in the Klaipėda-Ventspils plateau project area during the wintering season.



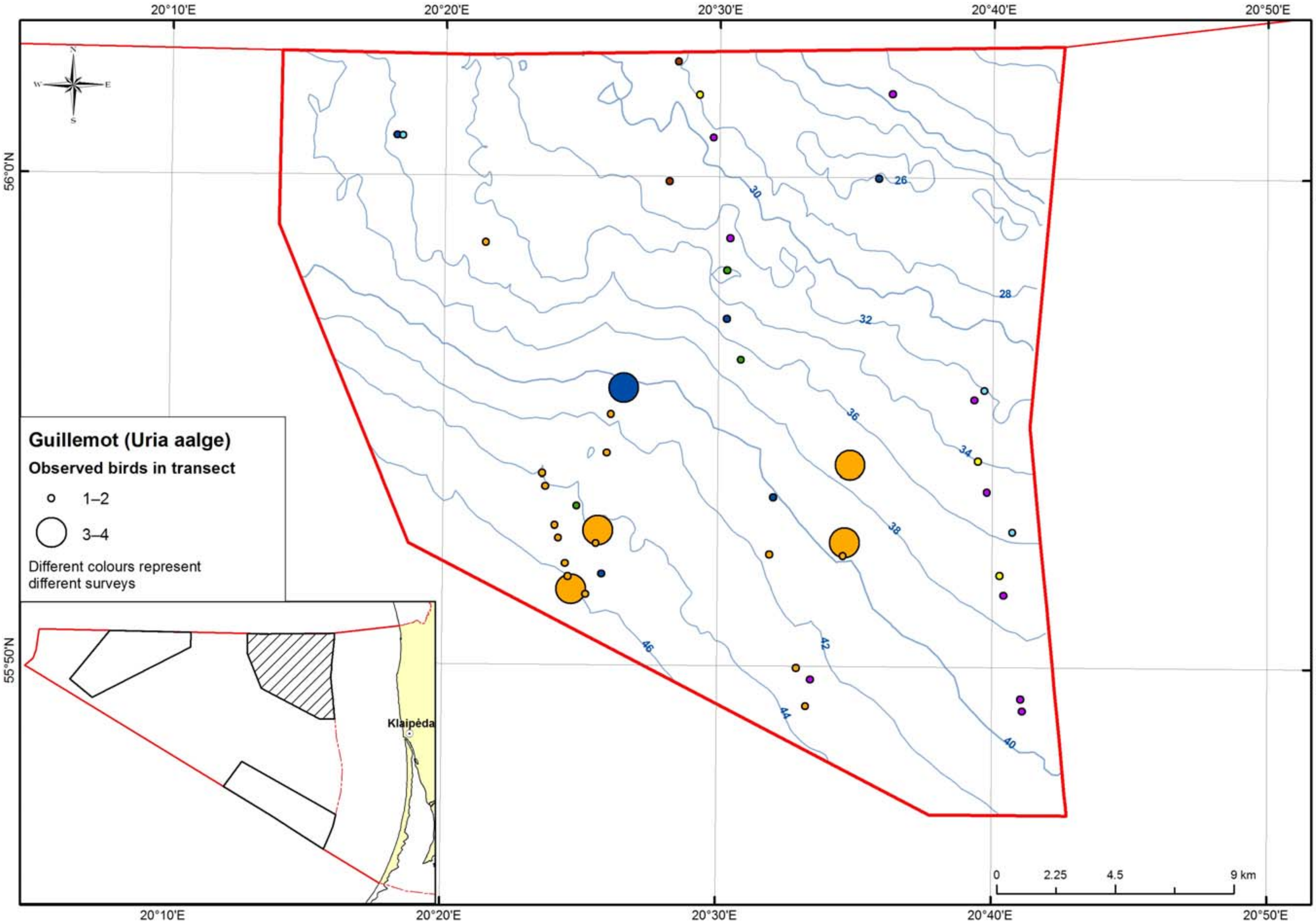
Annex T1B9. Velvet Scoters observed in transect during the additional survey in the Klaipėda-Ventspils plateau project area in December 2013.



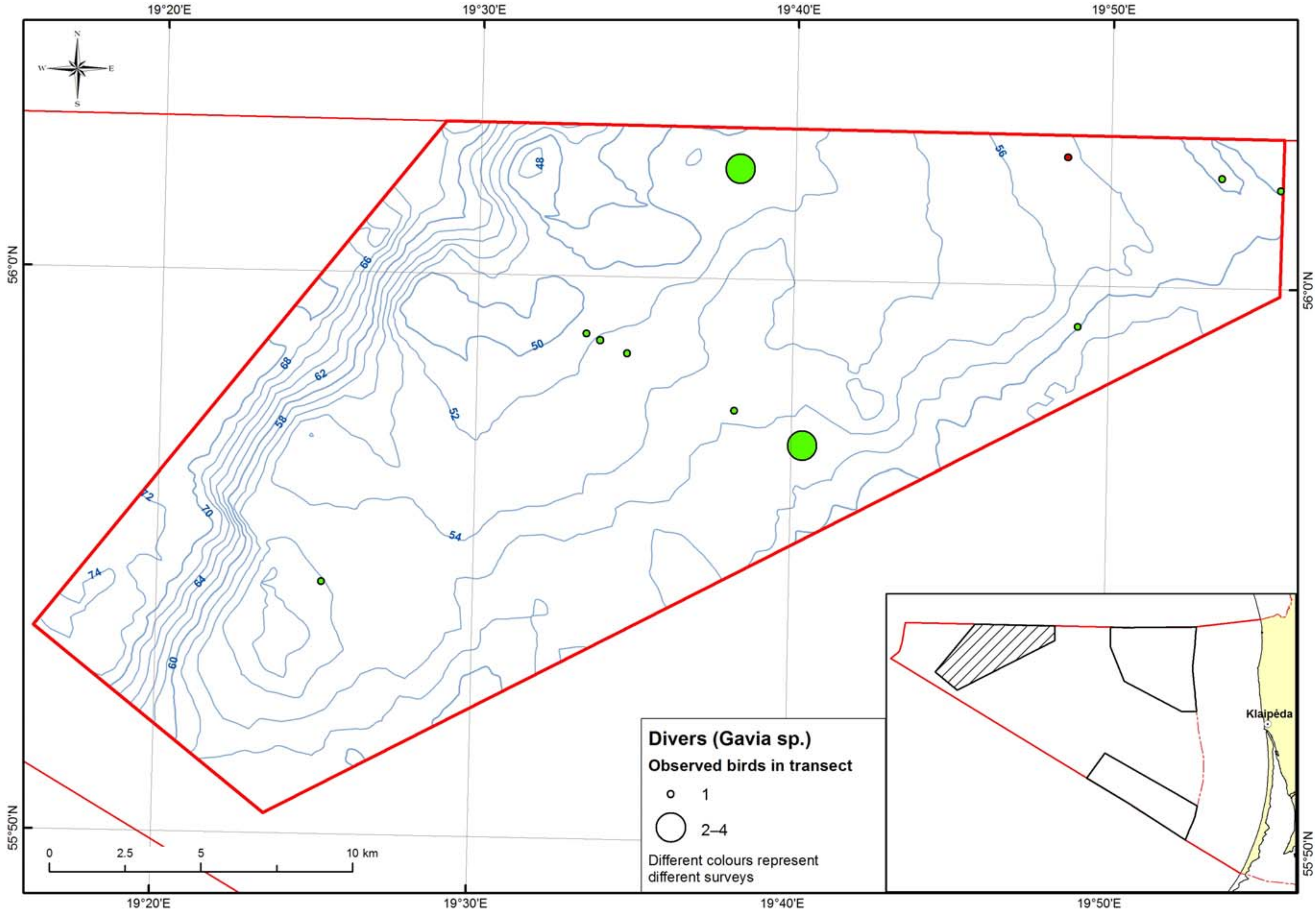

Annex T1B10. Modelled Long-tailed Duck (*Clangula hyemalis*) densities in the Klaipėda-Ventspils plateau project area during the wintering season.



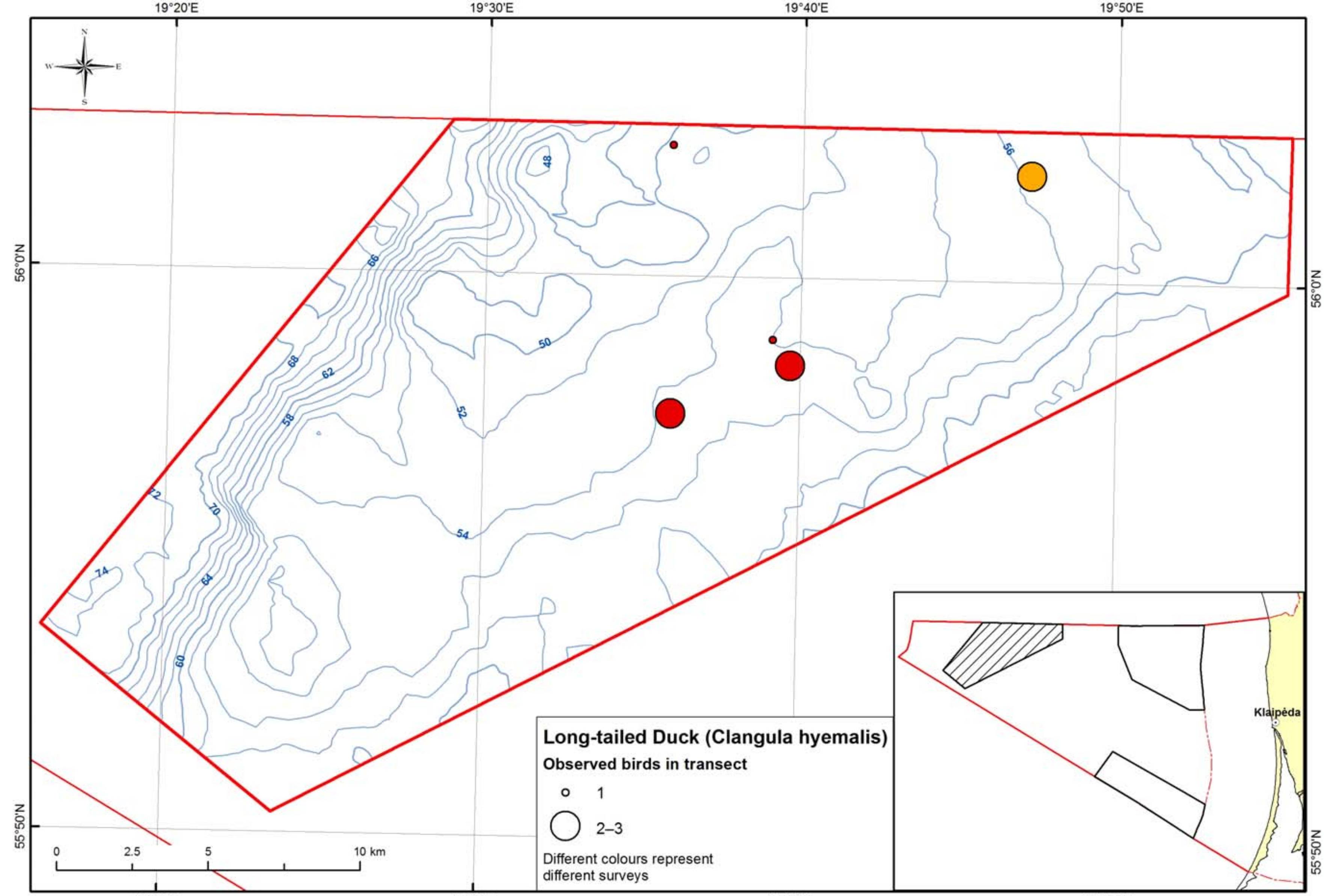

Annex T1B11. Razorbills (*Alca torda*) observed in transect during the ship-based waetrbird surveys in the Klaipėda-Ventspils plateau project area.



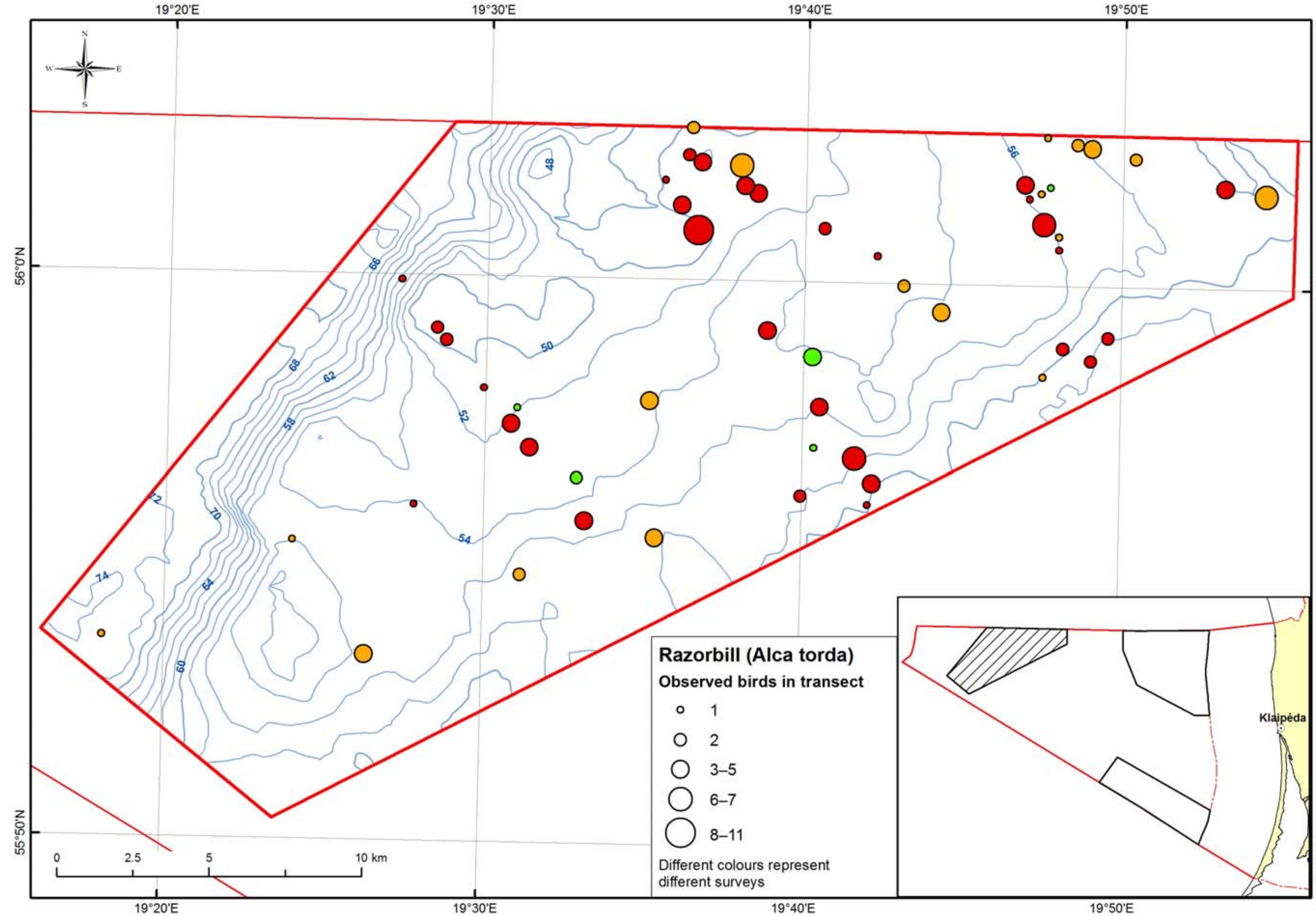
Annex T1B12. Guillemots (*Ura aalge*) observed in transect during the ship-based waetrbird surveys in the Klaipėda-Ventspils plateau project area.



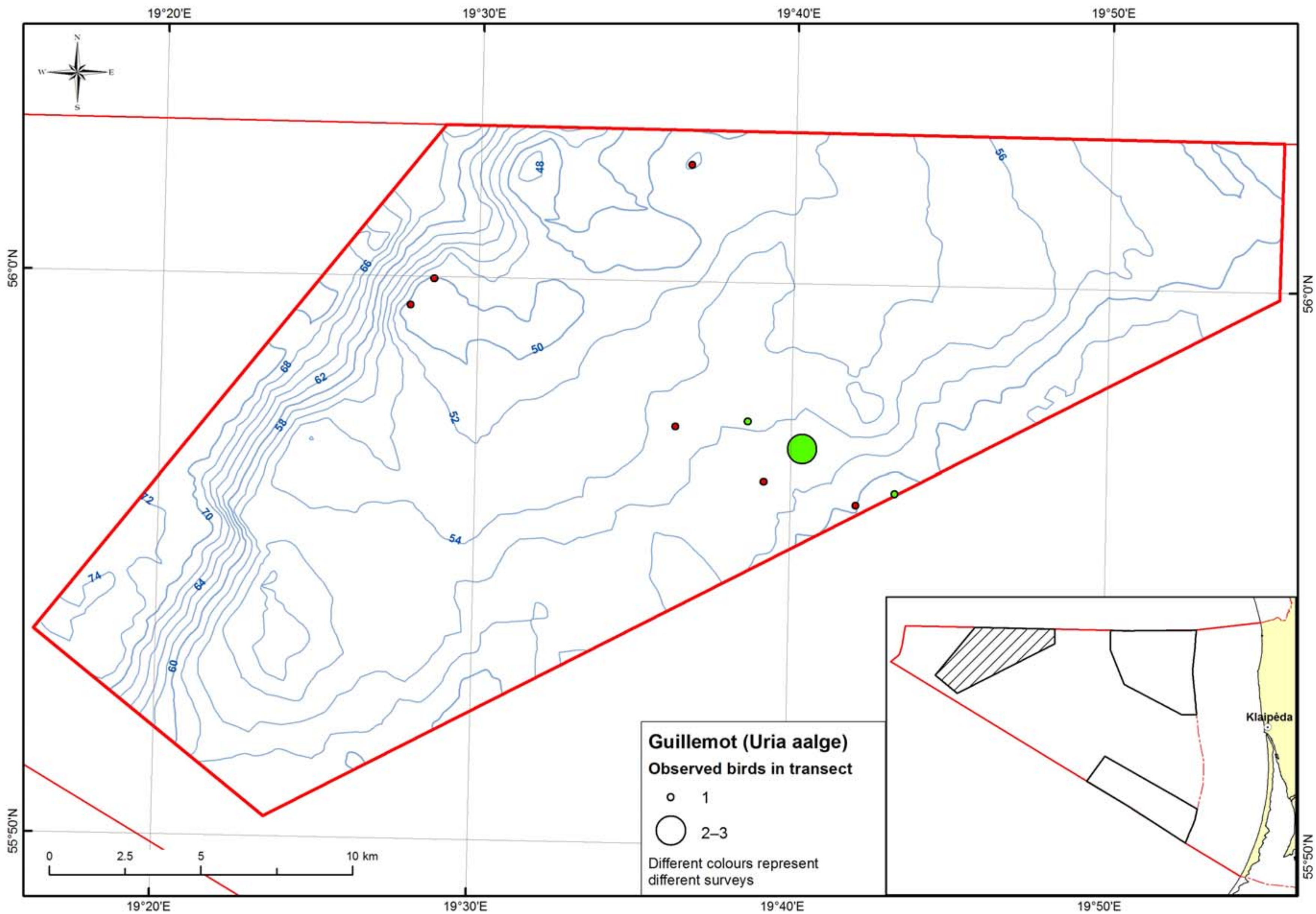

Annex T3B13. Divers (*Gavia* sp.) observed in transect during the ship-based waetrbird surveys in the Klaipėda bank project area.



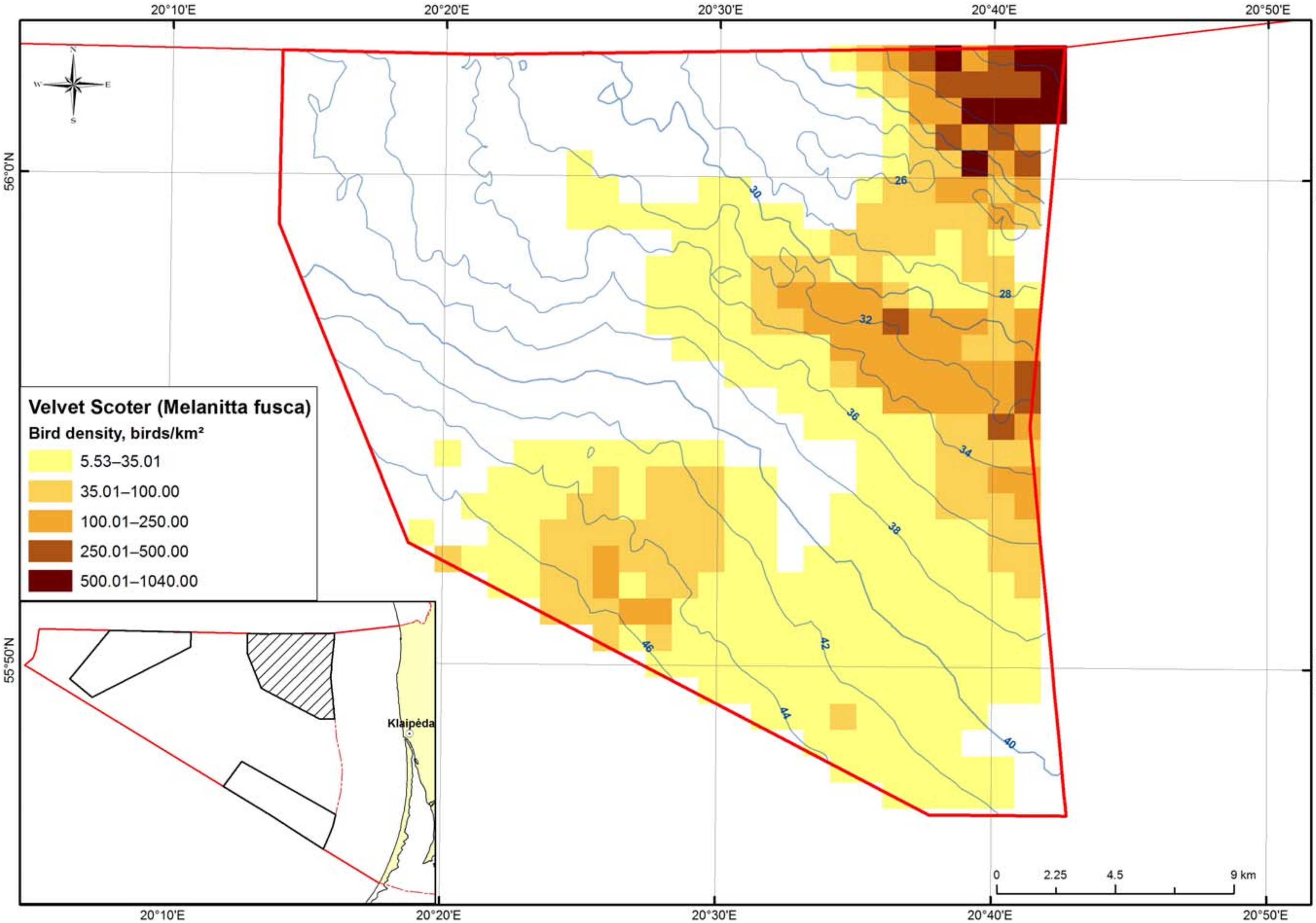

Annex T3B14. Long-tailed Ducks (*Clangula hyemalis*) observed in transect during the ship-based waetrbird surveys in the Klaipėda bank project area.



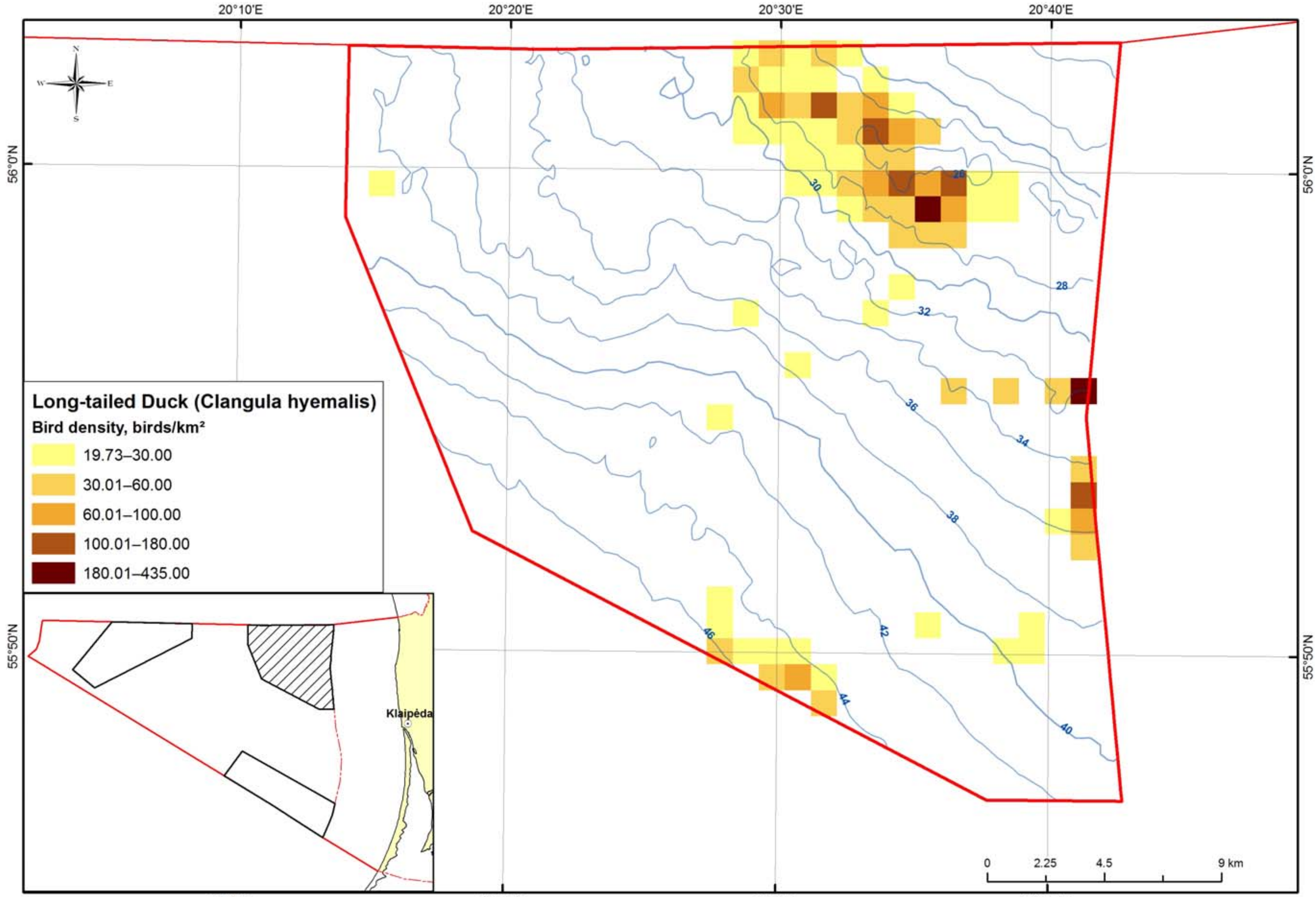

Annex T3B15. Razorbills (*Alca torda*) observed in transect during the ship-based waetrbird surveys in the Klaipėda bank project area.



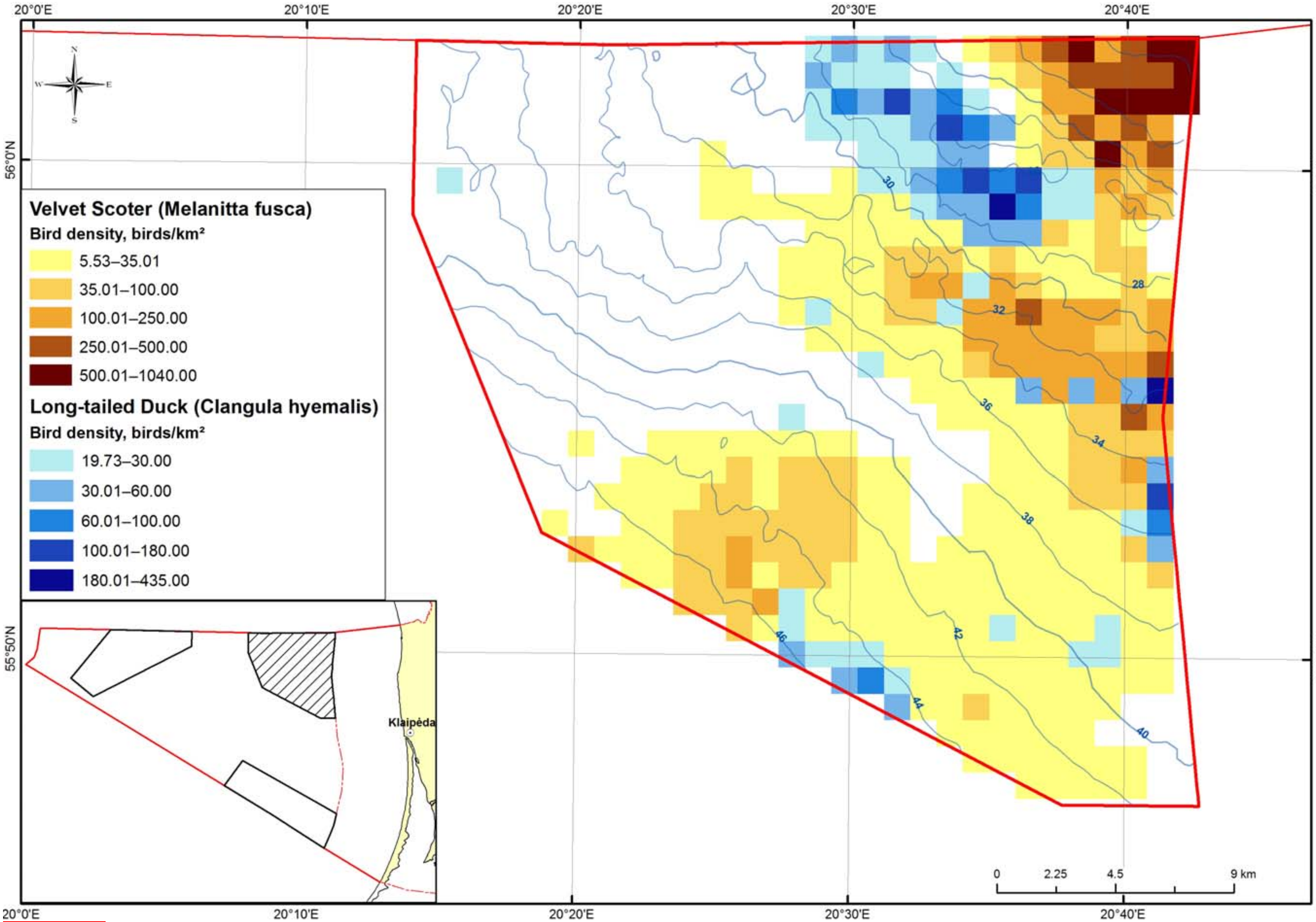

Annex T3B16. Guillemots (*Uria aalge*) observed in transect during the ship-based waetrbird surveys in the Klaipėda bank project area.



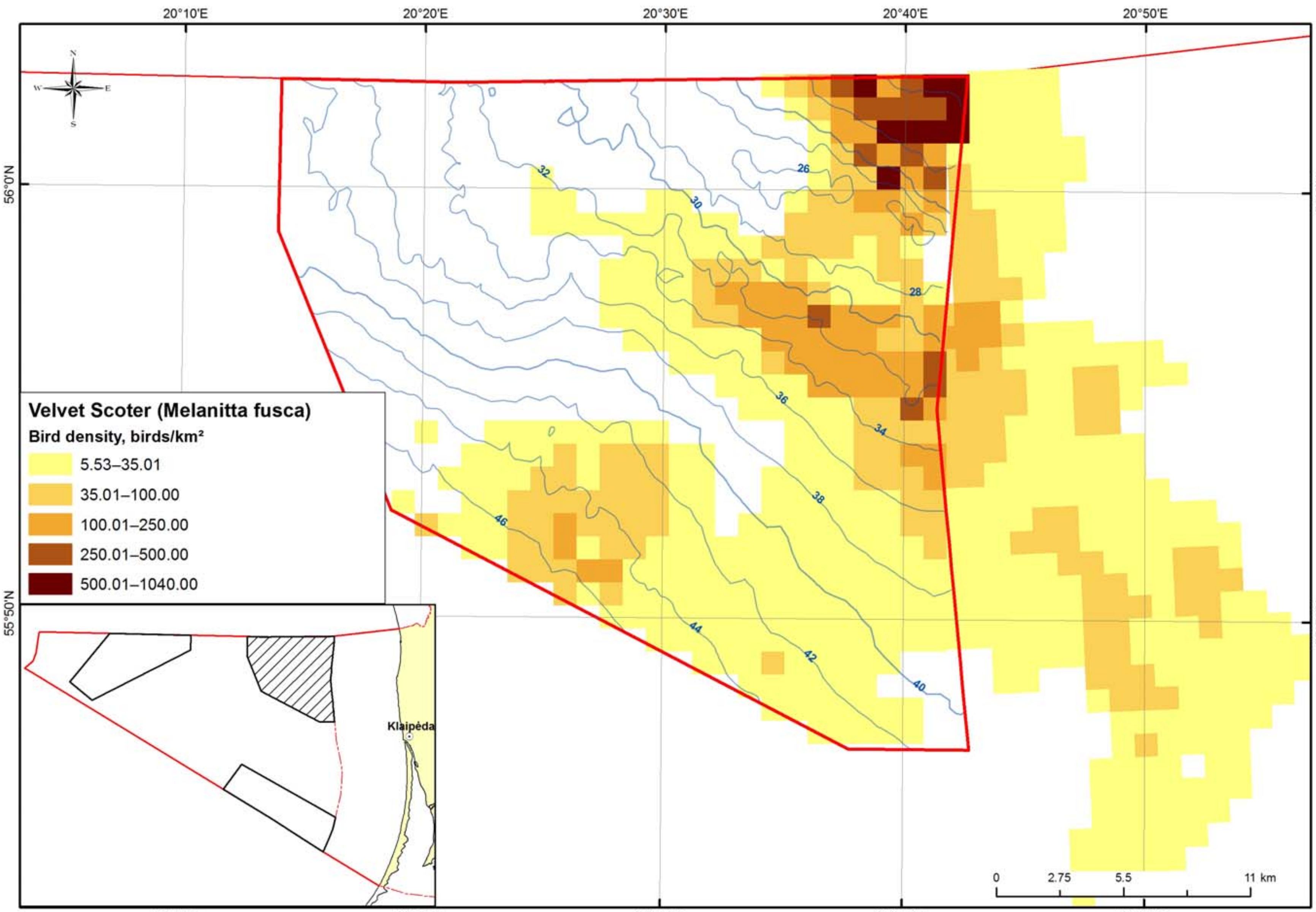

Annex B17. Areas of Velvet Scoter distribution, exceeding the threshold bird density values (5.53 birds/km²) for SPA designation.




Annex B18. Areas of Long-tailed Duck distribution, exceeding the threshold bird density values (19.73 birds/km²) for SPA designation.




Annex B19. Areas of Velvet Scoter and Long-tailed Duck distribution, exceeding the threshold bird density values for SPA designation.




Annex B20. Areas of Velvet Scoter distribution (including 2007–2008 data), exceeding the threshold bird density values for SPA designation.