CONTRACT: „CONDUCTING ENVIRONMENTAL STUDY AND PARTICIPATING IN ENVIRONMENTAL IMPACT ASSESSMENT OF PLANNED OFFSHORE WINDPARK IN THE ESTONIAN COASTAL OFFSHORE WATERS "

REPORT

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Introduction

A greater emphasis has been given to offshore waterfowl in this millennium especially due to fact that Estonia has joined the European Union and the consequent emergence of new obligations for the protection of offshore wildlife areas. Additional impulse for the research of marine biota has been given by impetuous wind energetics and especially planning offshore wind farms in Estonia. The importance of North Hiiumaa sea coast to waterfowl is primarily due to its geographic location, since it is directly on East-Atlantic Flyway used by majority of arctic waterfowl species on their way from breeding grounds to wintering grounds. Sea shallows and banks in the sea of Estonian waters are suitable stopping places on their migratory route where their fat reserves are supplemented for further migration. Additionally the shallows are used as areas for moulting and wintering. The importance of the area on the migration of waterfowl has been proved by systematic visual and radar survey since the end of 1950’s (Kumari 1980, Jõgi 1970, Jacoby & Jõgi 1972, Jacoby 1983), Kotkanen 1995, Ellermaa & Pettay 2006) (Figure 1).

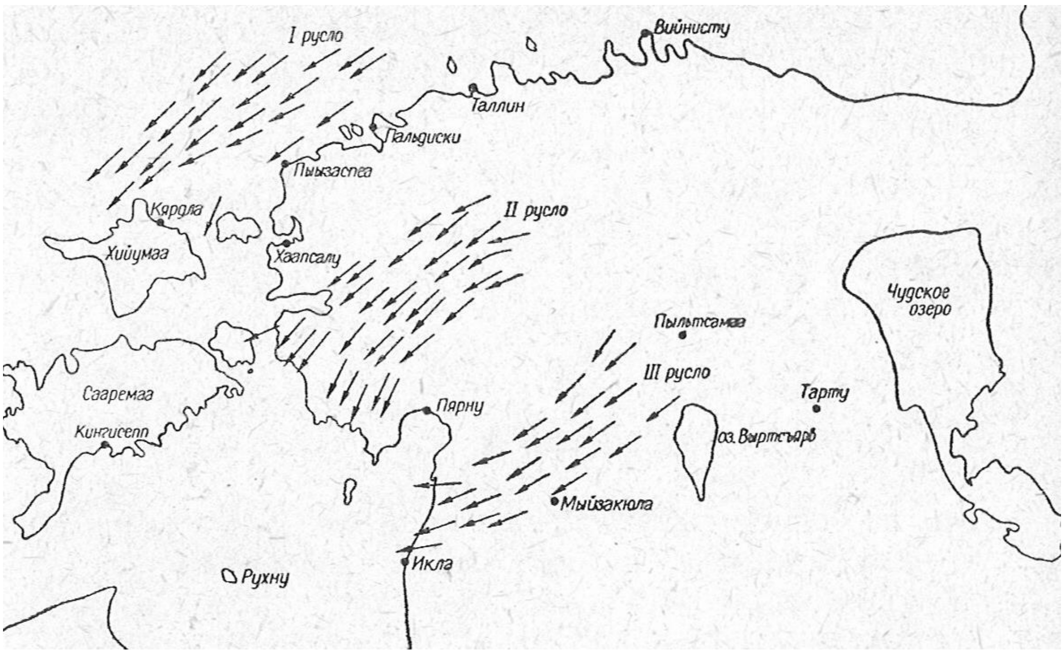

Figure 1. Distribution of summer migration routs of scoters at night time from 23.07 to 04.08.1968, based on radar survey (Jacoby & Jõgi 1972).

The first systematic ornithological studies were carried out by the Estonian University of Life Sciences in 2007, according to the contract (L8005PKPK, 17.01.2008) between the University of Life Sciences (contractor) and Estonian Marine Institute of the University of Tartu (subscriber). The objective of the work was as follows: “The environmental impact assessment of the planned offshore windfarms on the north-west coast of Estonia” (Leito, 2008).

Research of offshore birds and their conservation

Along the lines of bird protection organization *BirdLife International* (BirdLife International, 2004) topics related to sea bird protection can be divided into four subjects:

1) Stop-over and wintering sites of waterbirds. Estonia is located in the East-Atlantic Flyway and due to its central location holds a great value both as a staging sites during migration or as a wintering sites. Benthos-feeding *i.e.* bottom feeders uses shallows where there is suitable depth for diving for this purpose. On the sea coast of Northern Hiiumaa there are 5 such shallow areas – Apollo, Hiiu, Vinkovi and 2 nameless shallow areas – Madal 1 and Madal 2 (Figure 2).

2) Important areas for pelagic species. These are often associated with specific hydrological conditions (upwelling, fonts between water masses), that entail a high biological productivity. Internationally, amongst pelagic species there are representatives of shearwaters of *Procellariiformes* Oder that are of high protection value. In Estonia, shearwaters are extremely rare visitors. Regarding the pelagic species, we have Gulls, Terns and Skuas. Higher protection value of the above mentioned species has Little Gull *Hydrocoloeus minuta* that was not represented in high numbers in the project area.

3) Bottelneck areas. During migration, important part of the populations of many species are passing through Estonia. Migration often follows the coastline, causing massive consentration on the tips of the capes and narrow straits. For example, it is estimated that in autumn 2004, the strait between Põõsaspea peninsula and Osmussaare Island was passed through by 15-20 % Brent Goose *Branta bernicla*, 40-50 % Barnacle Goose *Branta leucopsis*, 11 % European Wigeon *Anas penelope*, 30 % Pintail *Anas acuta*, 13-32 % Greater Scaup *Aythya marila*, 11 % Red-breasted Merganser *Mergus serrator*, 50-95 % Black Scoter *Melanitta nigra* ja 30-65 % Red-throated Diver *Gavia stellata* of the north-west European populations (Ellermaa & Pettay,

2006). A large part of this migratory flow passes through the coastal sea of northern Hiiumaa. Some birds stay to stop and winter on Hiiu shallows. Migration way bottleneck areas' topic has become very vital in relation to creation plans of wind farms in these areas (Väinameri, Sõrve Peninsula). Consequently, in such areas also radar studies should be conducted. It has been done once by the University of Life Sciences both in Suur väin and Põõsaspea area.

4) Breeding colonies. The birds breeding on islands and islets use surrounding sea as feeding area. In earlier materials published by *BirdLife International,* the species are divided into three groups based on their feeding radiuses: 5 km (Little Tern, Black Guillemot), 15 km (Arctic Tern, Common Tern, Sandwich Tern, Common Gull and Cormorant) and 40 km (Lesser Black-backed Gull, Razorbill); (*BirdLife International, 2004*). Although, there are no islets in the project area, a large number of birds of the colonies located in neighboring areas use the surrounding sea for feeding.

All the previously mentioned topics are voluminous and would require separate treatment. In current study, the main focus is on waterfowl that are migrating and consentration in winter. According to the purpose of the work, offshore birds have been taken under review. In order to distinguish coastal sea and offshore, a non-traditional 2 km distance from the shore has been taken into account. This distance was based on purely practical considerations – 2 km is the maximum distance that would be recoverable with surveys from the coast under the right conditions. Marine areas which are further away will require special techniques, such as counting from airplane or ship. In this report counting from airplane was used.

The facts of the study

This report has been prepared in accordance with the ornithological study service provision agreement no 2013-56-AT-7 between Skepast&Puhkim OÜ (client), Estonian University of Life Sciences (contractor) and Nelja Energia AS (developer). The objective of the study was to complement expert opinions of the research of avifauna. In the result of that, model cards of numerous waterfowl converging on research area were to be completed. The duration of the project was from June 2014 to July 2015.

Planning and conducting the study

Regarding the aerial survey, it was taken into account that study area would cover all shallows located north from Hiiumaa, including Apollo, Vinkovi and Hiiu shallow. The size of the study area turned out to be 1900 km^2. Since offshore transect counts (*distance sampling*) was used as a methodology, transects were previously designed to the whole extent of the study area. To avoid possible sun reflection impact, the transects were oriented in north-south direction. To enable greater precision of the model, the distance between transects was decided to be 3 km which is minimal distance for this technique (Petersen & Fox, 2005). The total length of flight transect was 603 km which took on average 4 hours and 20 minutes (Figure 2).

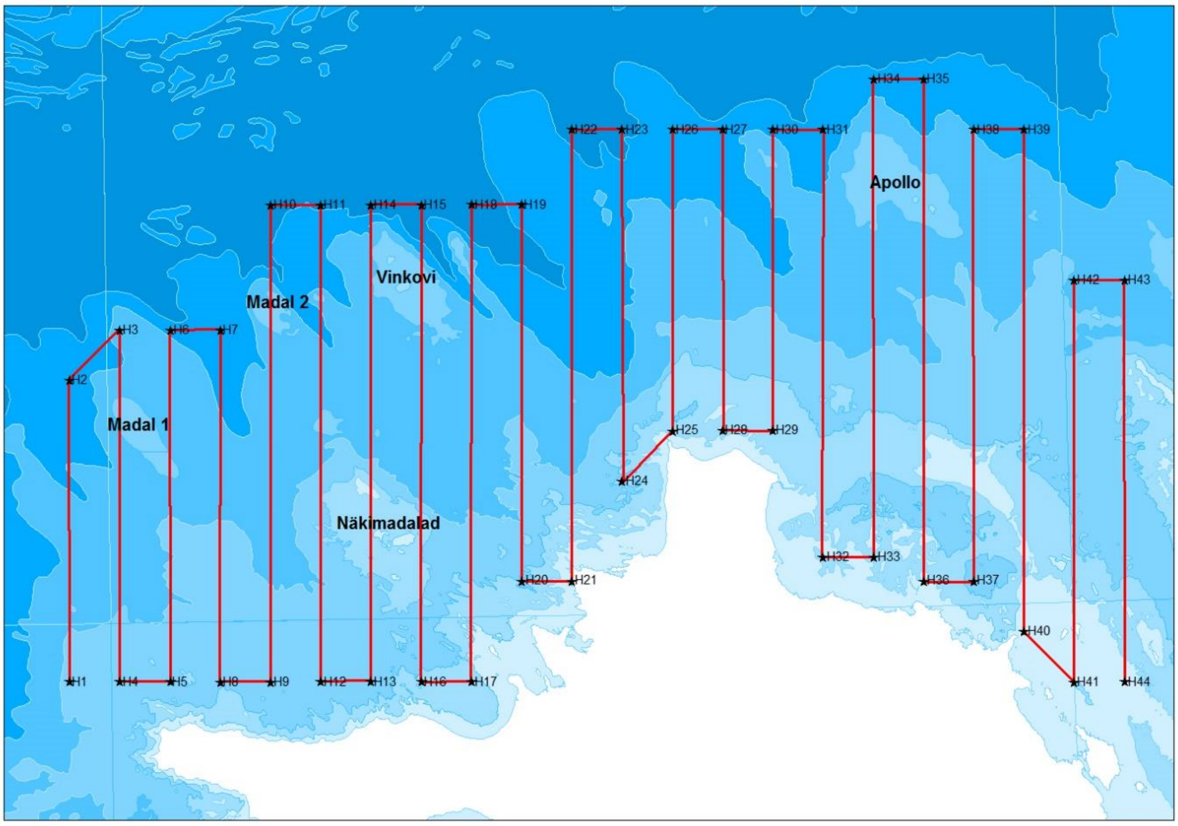

Figure 2. Counting transects and turning points on project area.

It was planned to conduct additional studies to clarify the spread patterns and abundance density of waterfowl migration (October-November 2014, April-May 2015), moulting (August 2014) and wintering (January-February 2014) population on the shallows of northern Hiiumaa. For this purpose 4 aerial surveys were carried out on the following dates: November 30th 2014; February 2nd 2015; May 16th 2015 and August 4th 2015. In autumn, the observers were Leho Luigujõe (left board), Max Nitschke and Triin Kaasiku (right board), in winter Leho Luigujõe (left board), Tarvo Valker and Hannes Pehlak (right board), in spring Leho Luigujõe (left board), Hannes Pehlak and Triin Kaasiku (right board) and in summer Leho Luigujõe (left board) and Tarvo Valker (right board). A planned counting in summer 2014 was cancelled due to the delay of international procurement but it was fortunately managed to perform in August 2015.

Presumed technical conditions for transect counting

The plane that is used for offshore transect counting has to meet certain conditions. All aircrafts that are used for counting birds must have upper wings. Aircrafts with lower wings are not suitable for this purpose, because the wings would obscure a large part of the field of vision. Since offshore operations take place away from the coast, the plane must have twin-engine for security reasons. Observers must have good view from the aircraft windows. A great advantage would be a plane with a "bubble window" which would also provide a great view forward and downward. There must be minimum of three seats for observers, and all seats must be equipped with headphones allowing observers and pilots to communicate with each other at the time of counting. Suggested aircraft type is defined in internationally accepted methodologies. That is Partenavia Observer, Partenavia 68 Observer, Partenavia Vulcanair, Cessna 337 or analogues. Counting speed is 185 ± 10 km/h and the height of the flight is 76 ± 5 m. In the arranged procurement for finding the suitable aircraft, there were two tenderers: Roheline OÜ and Bioflight AS. The procurement was won by Danish airline Bioflight AS (http://bioflight.dk/) that has extensive experience in conducting such aerial counts. Aerial survey was conducted by using two-engine airplane Partenavia 68 Observer (Figure 3).

Figure 3. Partenavia 68 Observer in Kuressaare airport (05.02.2015).

Methodology

Offshore transect count *i.e.* distance sampling (Petersen, I.K., Fox, A.T. 2005) was used for counting. Distance sampling is widely used data collection method to collect information of the size of species populations. The data collected by distance sampling enable to evaluate density of the birds and predict the population abundance. Distance sampling methods are divided as follows: 1) transect sampling and 2) point transect sampling. As previously mentioned, all aspects (spring migration, moulting migration, autumn migration and wintering) were tried to be covered by 4 flights. The best time for air counting is usually between 10 am and 3 pm, when the light conditions are the best. The weather as well as light conditions affect the counting results. The weather has to be quiet which means that there should be no high waves in the sea and they should not exceed 3 point on Beaufort's scale. Certainly the weather should not be foggy and there should not be any low clouds. All this sets are extremely narrow conditions for flight planning. The methodology intends to fly at 250 feet (76 m) with a speed that does not exceed 100 knots (185 km/h). Flying higher and faster makes it difficult to evaluate the number of birds, and it changes the width of counting strips which are necessary for subsequent modelling. The counting is done on 3 observation strips and from both sides of the plane (figure 4). In order to determine and control the boundaries of observation strips, each observer must have a clinometer. By the measured angles, the observer will set the width of the counting strips (Table 1). Currently, the best model for this purpose is *Silva Clino Master*. Voice recorders are used in the plane during the observation because taking notes on paper would be impossible due to the limited time. Digital voice recorders should be preferred because it facilitates the further use of data. All observers use GPS which records the whole flight transect with 3-second increments. The same is done by plane GPS.

The model takes into account a number of factors when making bird's abundance estimations. For every specific observation, the model takes into account the depth of the sea, the seabed character, the distance of flock from the coast, the extent of ice cover, the waive height, the resulting glare from the Sun, the precipitation, the bird behavior, the vessel navigation, the location of the fishing nets, *etc.* of the particular place. Consequently, the observer continuously records the weather changes, the presence of ice, the wave height, the Sun reflection, the number and activity of birds per species during the entire counting period. Given all this, the modelled distribution maps will be created which are expected to objectively reflect the location and number of birds in the study area.

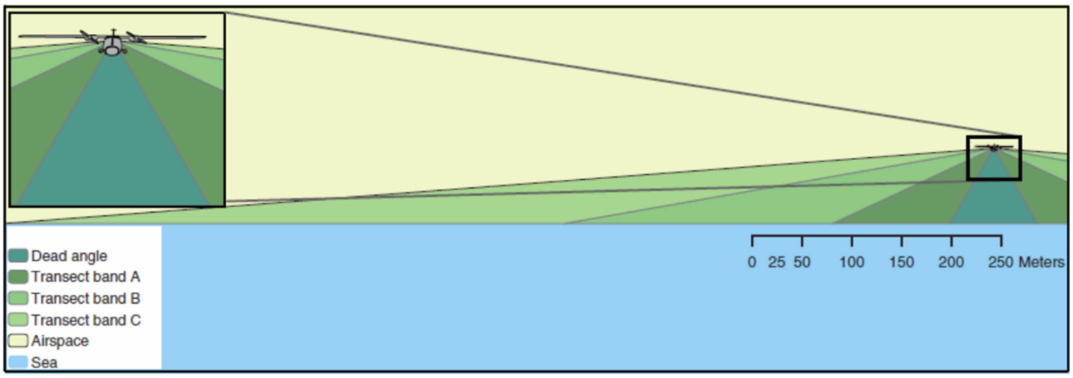

Figure 4. Transect sampling on 3 belts

Table 1. Angles used for verification of borders of counting belts

Strip	Width of the strip (across in respect of transects)	Angle from the horizon
A	44 – 163	60 – 25
B	164 – 432	25 – 10

C	433 – 1000	10 – 4
(D)	(> 1000)	(< 4)

The initial phase of the data processing consisted of organizing the raw data tables and removal of input errors. After the harmonization of data it was aggregated to a data table with a common structure. Spatial data preparation consisted of generation of analysis masks for season counts. Masks were used to separate necessary raster layers from attribute rasters (sea depth, distance from the coast, etc.). Those were used later for modelling the surface of population density. The end-product of modelling is raster map of population density. More specifically three raster layers where the pixel size describes: 1) the mean value of density; 2) the lower confidence limit of density; 3) upper confidence limit of density. In order to model density surface the GAM - *Generalized Additive Model* was used. The model unit is 500 m long section or segment of the air counting transect. Segments coincide with attribute raster pixel grid which means that one segment is in the scope of one raster pixel. The predictive feature of the model is the estimation of actual population density. In additive models, the following features were used: 1) x and y coordinate (two dimensional "surface feature"); 2) depth of sea in meters; 3) distance of a flock from coast in meters; 4) distance of a flock from the closest vessel in meters. For the evaluation of the detection function a number of candidate models were created. The following features were used: 1) sunshine; 2) waves; 3) visibility; 4) ice state; 5) observer. In addition, the combinations with previous features were made. Abundance estimations were made based on prediction maps of population density by multiplying one pixel of a raster by area and thereupon summing up all pixel values of the raster got. For Apollo shallow a mask created by 20 m depth contour which consisted of 99 pixels and an area of 99x5002 m^2 *i.e.* 24.75 km^2 was used. For the entire sea area the mask with an area of 6874 pixels and total area of 1718.5 km^2 was used. More detailed overview of the used methodology and modelling are described in Annex 1 and 2.

Ornithological studies

All waterfowl that can be seen on offshore waters were under observation. Migrating birds (Geese, Cranes) and species related to coast (Swans, Goose, dabbling ducks and Mergansers) were left out of the analysis. During 4 counting periods 21 bird species were noted and 9 species of which were present in all counting periods (Table 2, 3). The most numerous species as expected was Long-tailed Duck (Table 4), followed by Common Eider, Scoters and Gulls. Depending on the weather and lighting conditions, the infidication of some species from the plane is difficult. Therefore, Scoters (Black and Velvet Scoter), Divers (Red-throated Diver, Black-throated Diver) and Terns (Arctic Tern and Common Tern) were analysed together (Table 2). As a comparison, the survey results from the years 2007 and 2008 that were counted in the same area are also given in the table. For the most numerous species - Long-tailed Duck – both counting data and estimations are outlined (Table 4).

Table 2. Counted bird numbers at coastal waters of northern Hiiumaa (year 2007, 2008, 2014 and 2015).

No.	Species	Spring			Summer	Autumn			Winter	
		24.04.2007 ship count	10.05.2007 aerial count	16.05.2015 aerial count	4.08.2015 aerial count	24.09.2008 aerial count	31.10.2007 aerial count	30.11.2014 aerial count	5.02.2008 aerial count	2.02.2015 aerial count
1	Razorbill	15	1	3	22	0	1	0	0	9
2	Tufted Pochard			8	0			80		0
3	Greater Scaup			282	0			0		0
4	Goldeneye	0	0	44	31	0	10	35	0	601
5	Long-tailed Duck	453	1021	6894	258	3	29075	18354	2171	13857
6	Divers	7	0	15	17	0	0	4	0	59
7	Great Black-backed Gull	0	0	2	9	0	5	2	3	7
8	Herring Gull	22	4	6	198	87	361	88	154	890
9	Common Gull	44	6	23	291	263	689	978	86	5540
10	Black-headed Gull	0	0	29	37	0	22	9	3	6
11	Little Gull	12	0	0	23	186	19	7	0	0
12	Skua	0	0	0	6	0	0	0	0	0
13	Scoter	70	210	243	7071	185	19	100	38	300
14	Cormorant	3	0	30	12	0	0	1	0	0
15	Common Eider	29	16	2215	8286	402	406	0	5	0
16	Steller's Eider	0	0	0	0	0	0	0	0	400
17	Caspian Tern	0	1	4	0	0	0	0	0	0
18	Tern	11	7	122	126	0	3	0	0	0
	TOTAL	666	1266	9920	16387	1126	30610	19658	2460	21669

Table 3. Estimations of waterbirds staging at coastal waters and shallows of northern Hiiumaa (Autumn 2014, Winter 2015, Spring 2015, Summer 2015).

	Species	Spring 2015						Summer 2015					
		Whole area	Shallow 1/2	Vinkovi	Tahkuna	Hiiu Shallow	Apollo	Whole area	Shallow 1/2	Vinkovi	Tahkuna	Hiiu Shallow	Apollo
1	Long-tailed Duck	23000	10	170	3560	6550	5400						
2	Herring Gull							1800					10
3	Common Gull		590	620				1800					10
4	Pochard	6200				250							
5	Scoters	1400		50		40	220	12900			60	1590	3900
6	Common Eider	5400			90	770	60	23000	190	90	2650	7840	130
7	Steller’s Eider												
8	Divers												
9	Terns	540	70	150	30			600	80	50	30	80	

No.	Species	Autumn 2014						Winter 2015					
		Whole area	Shallow 1/2	Vinkovi	Tahkuna	Hiiu Shallow	Apollo	Whole area	Shallow 1/2	Vinkovi	Tahkuna	Hiiu Shallow	Apollo
1	Long-tailed Duck	82400	2230	1000	3290	680	46100	38300	230	220	1020	4740	14500
2	Herring Gull	310		10	10	10	110	2300	110	230			10
3	Common Gull	4000	20	60	30	10	1800	15800	520	3560	260	270	50
4	Pochard												
5	Scoter	100						1600					
6	Common Eider												
7	Steller’s Eider							400					
8	Divers							360	10		60	40	
9	Terns												

Table 4. The counted numbers and estimations of Long-tailed Ducks stopping at shallows of coastal waters at northern Hiiumaa (Autumn 2014, Winter 2015, Spring 2015, Summer 2015).

Shallow 1/2						Vinkov					
Spring		Autumn		Winter		Spring		Autumn		Winter	
Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated
37	10	388	2230	37	230	51	170	124	1000	16	220
Hiiu Shallow						Apollo					
Spring		Autumn		Winter		Spring		Autumn		Winter	
Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated
2351	6550	18	680	2351	4740	1980	5400	16756	46100	1980	14500
Tahkuna						The whole area					
Spring		Autumn		Winter		Spring		Autumn		Winter	
Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated
1174	3560	240	3290	244	1020	6894	23000	18354	82400	6894	38300

For numerous species a density model was created which was a basis for abundance estimation for the whole area as well as for the shallows (Shallow 1 and 2, Vinkovi, Hiiu Shallow, Tahkuna and Apollo) (Table 3). For less numerous species (where there was less than 10 flock observations in the sample) density model was not created because it may not describe the realistic situation.

Spring migration

The spring migration of waterfowl starts in the end of February and ends usually in the second half of May but in case of some species such as Brent Goose and Terns, it may last even until the beginning of June. Mass migration which is directly dependent on weather conditions, takes place cyclically from mid-April to the second half of May. Migration predominantly takes place above the sea at heights 1-100 m. Primary migration direction is NE, varying between N-NE-E directions. The impact of coast as an ecological barrier (migration barrier) and guide line is substantial. Birds approaching from offshore SW direction to Hiiumaa west coast turn to NW-N direction before a coast and pass by a top of Kõpu continuing offshore migration predominantly NE-NEE directions. Northwest coast of Hiiumaa functions mostly as a guide line and migration flow proceeds close to Tahkuna peak and will continue from there to E-NE directions on the offshore. In the project area prevailing migration direction is NEE. Migration is most intense in the morning, followed by evening and is the weakest at noon. A very large proportion of the migratory birds make the stop which usually lasts for 2-3 weeks, during which they save energy for the next so-called “migration jump”. The best time for mapping spring migration staging flock is the beginning of May. Unfortunately it was impossible to do so in the spring 2015 due to extremely unfavorable weather conditions, above all taking into account flight safety and counting error because of high waves. The flight was performed somewhat later, still remaining within the migration period. Consequently, the bird population was slightly lower than expected, but an exclusive overview was obtained of the location of flocks (Figure 6).

In spring, 16 offshore related species were noted in the counting area. In mid-May the population density of diving ducks was the highest on Apollo Shallow, in the top of Tahkuna peninsula, on Hiiu Shallow and in the top of Kõpu Peninsula (Figure 7). The overall estimation of the entire area was 36 540 individuals, of whom 18 630 used shallows under observation as feeding areas. The most important feeding areas of the shallows were Apollo, Tahkuna and Hiiu shallow. The most numerous species in spring were Long-tailed Duck and Common Eider, followed by Greater Scaup and Black Scoter. The largest Long-tailed Duck staging flocks were located on Hiiu Shallow, in the top of Tahkuna Peninsula and on Apollo Shallow (Figure 8). In the whole area, the total number of Long-tailed ducks were estimated 23 000 individuals of whom 6550 individuals were feeding on Hiiu Shallow, 5400 individuals on Apollo Shallow and 3560 individuals on Tahkuna Shallow (Figure 9). The overall estimation of Common Eider in the project area was 5400 (Table 3), whose feeding assemblies were located close to the coast. Of shallows, Common Eider used only partly Hiiu Shallow where their number was 770 individuals (Figure 10). Because the determination of Scoters from plane under certain conditions is limited, they were treated together. Scoter’s (Black and Velvet Scoter) feeding assemblies were located relatively scattered throughout the project area (Figure 11). Regarding the shallows, Apollo and Vinkovi Shallow were partly used. By estimate, 1400 Scoters stopped in the whole area, 90% of which were Black Scoters. On Apollo shallow by estimation 220 individuals were made stop-over (Table 3). Small number of Scoters may have been caused by late counting time. Scaups, of whom 80% were Greater Scaups, 6200 individuals were staging in the coastal sea of Hiiumaa. Feeding areas were located north from Kärdla and in the SE side of the Hiiu shallow (Figure 12). Because it is almost impossible to distinguish Common Tern and Arctic Tern from the plane, those two species were treated together. As very intrinsic for pelagic birds, Terns were seen all over the project area. The higher concentration of Terns were noted in west from Vinkovi Shallow (Figure 13). Time of the spring count, the Gulls were almost missing. Single Common Gulls, Herring Gulls and Black-headed Gulls were seen. Caspian Tern and Sandwich Tern were seen in case of other Tern species.

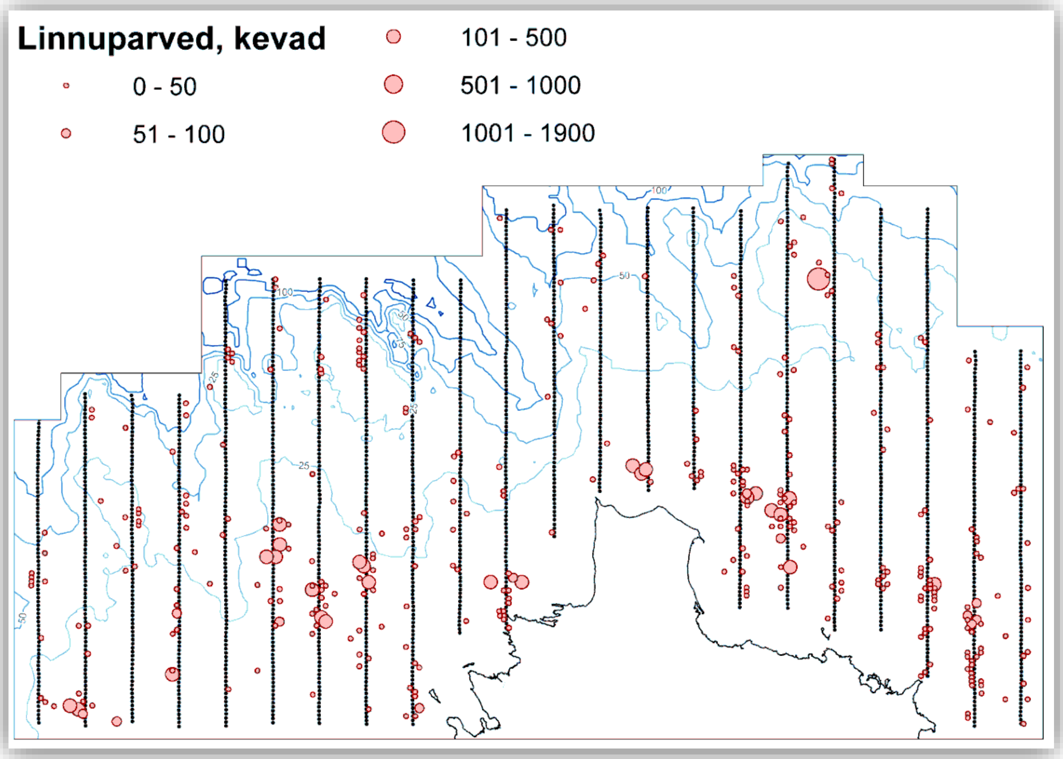

Figure 6. The location of waterfowl flocks in counting area in spring, May 16th 2015.

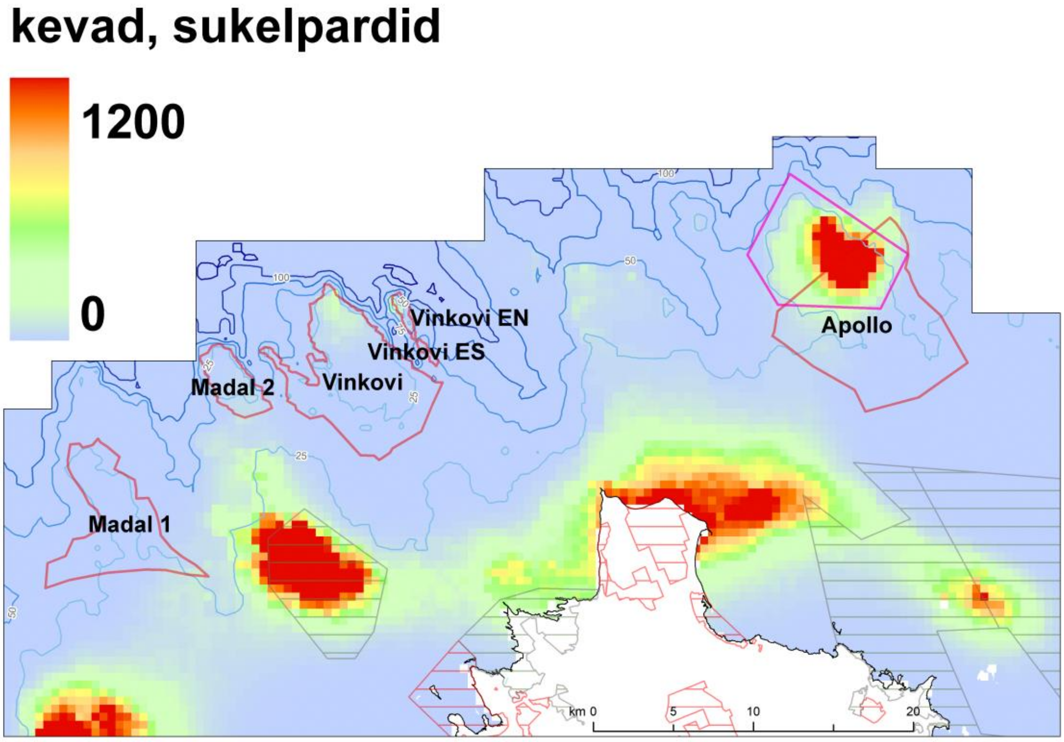

Figure 7. Spring distribution and bird density of diving ducks (Long-tailed Duck, Common Eiders, Scoters, Scaups) in counting area, y. 2015. (individuals km[2], hatched areas – protected areas, red areas - development areas, violet areas – designed protected area)

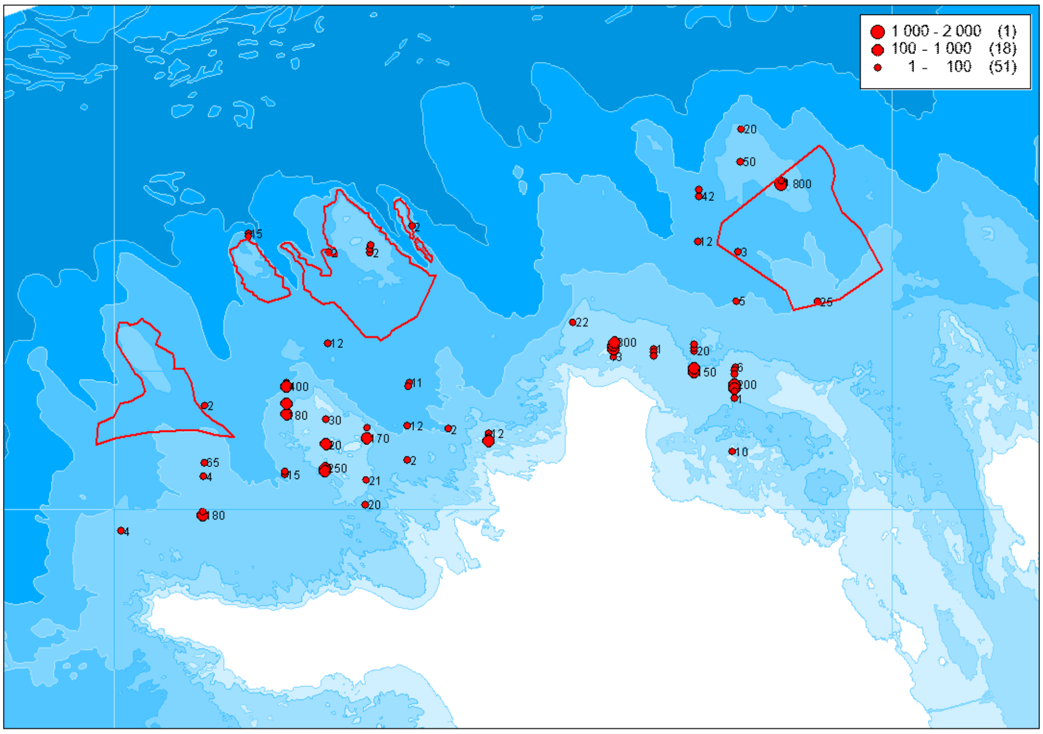

Figure 8. Spring distribution of Long-tailed Ducks in coastal sea of northern Hiiumaa, y. 2015 (counting data).

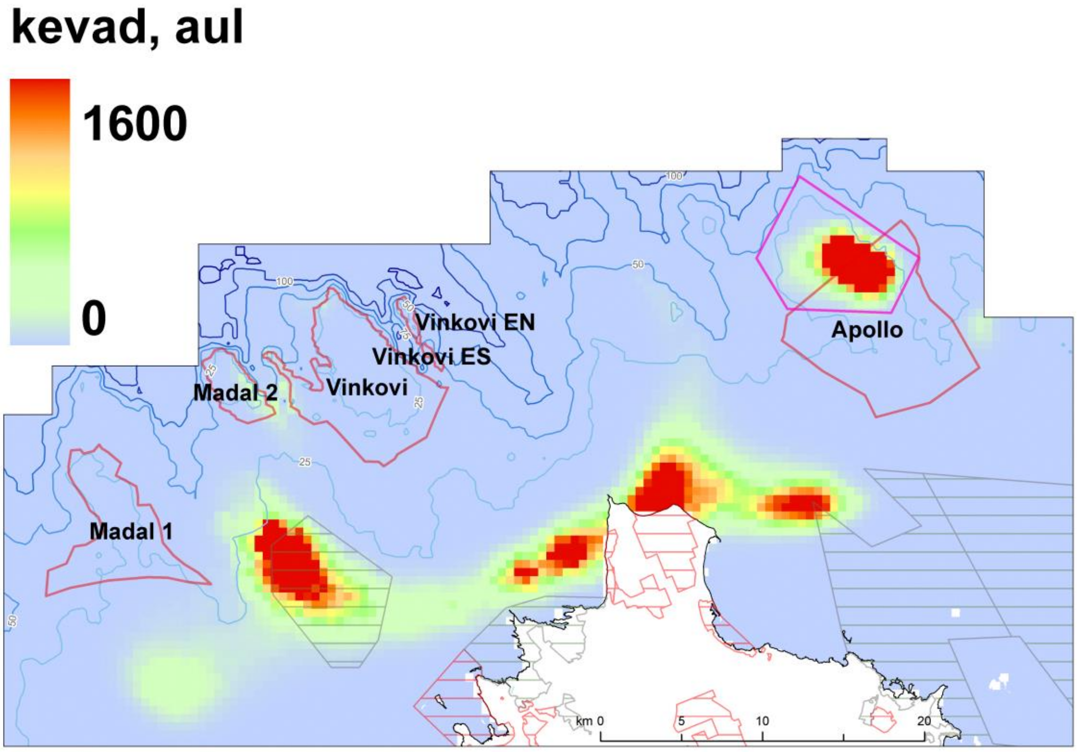

Figure 9. Spring distribution and bird density of the Long-tailed Ducks in the coastal sea of northern Hiiumaa, y. 2015.

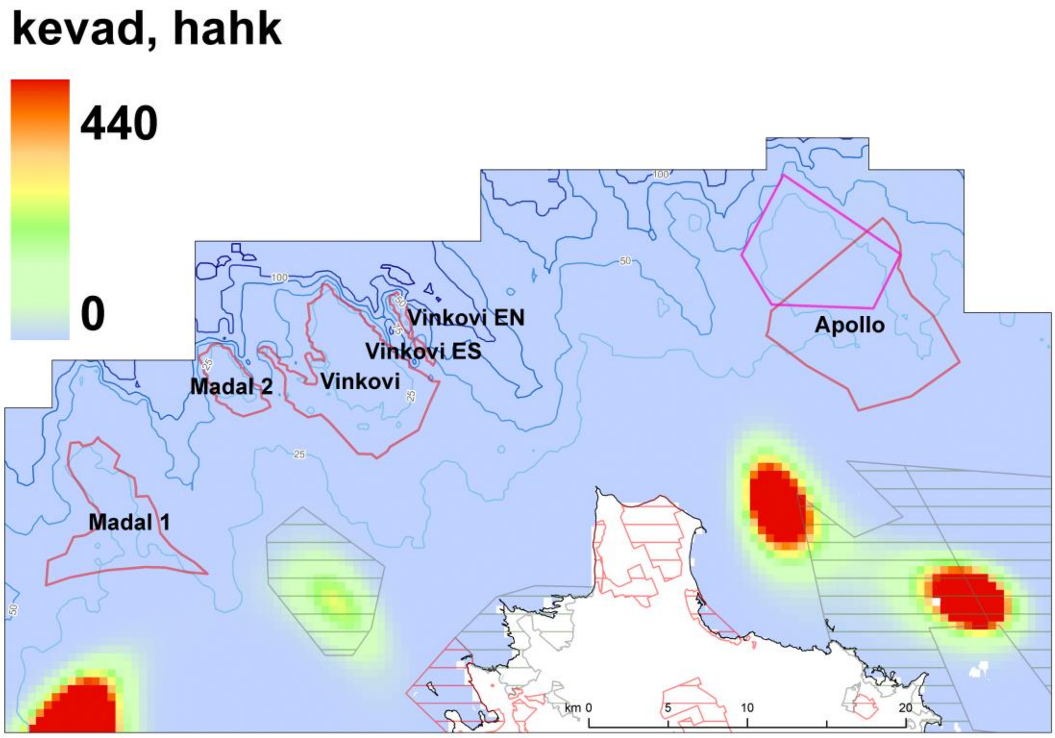

Figure 10. Spring distribution and bird density of the Common Eiders in the coastal sea of northern Hiiumaa, y. 2015.

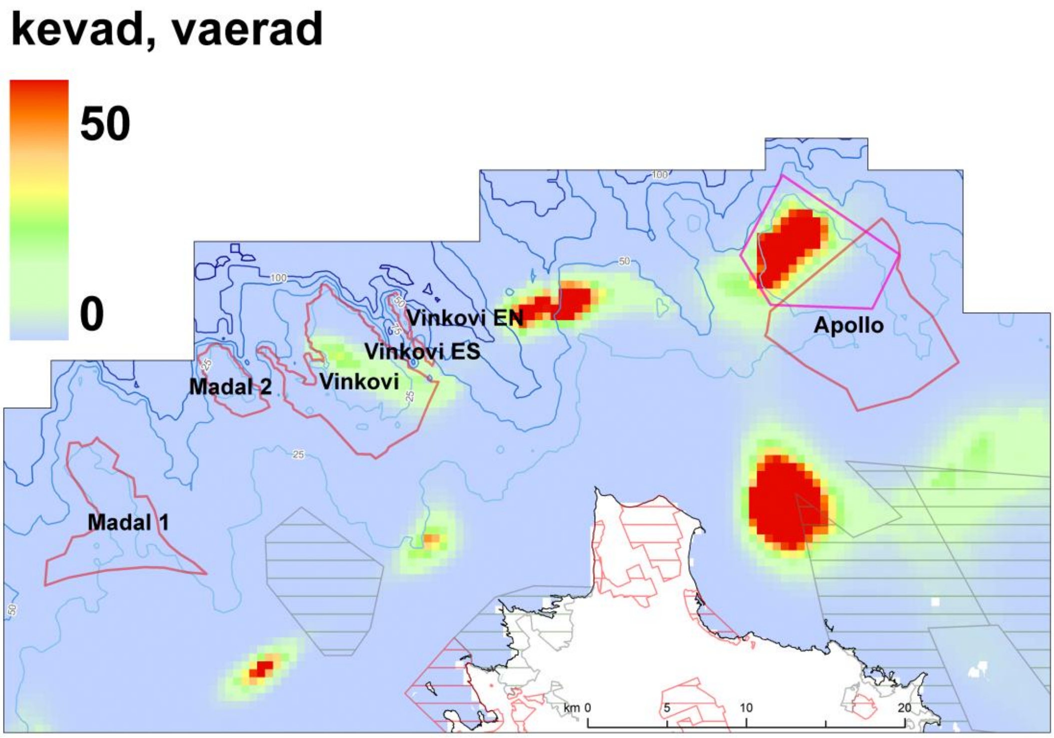

Figure 11. Spring distribution and bird density of the Scoters in the coastal sea of northern Hiiumaa, y. 2015.

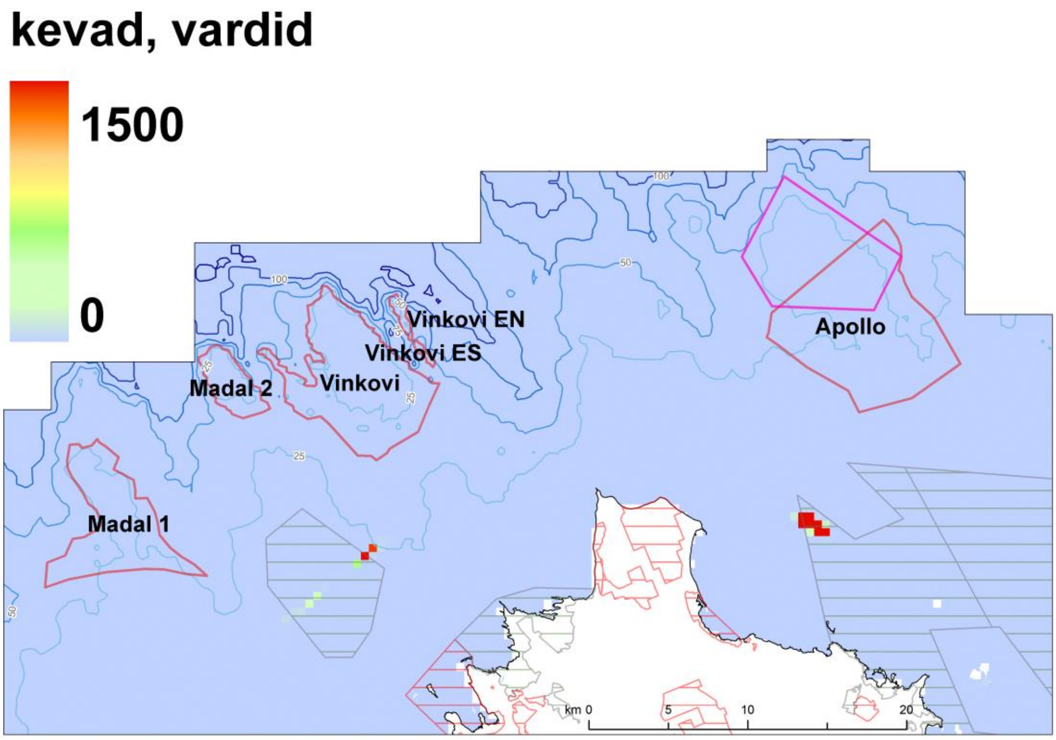

Figure 12. Spring distribution and bird density of the Scaups in the coastal sea of northern Hiiumaa, y. 2015.

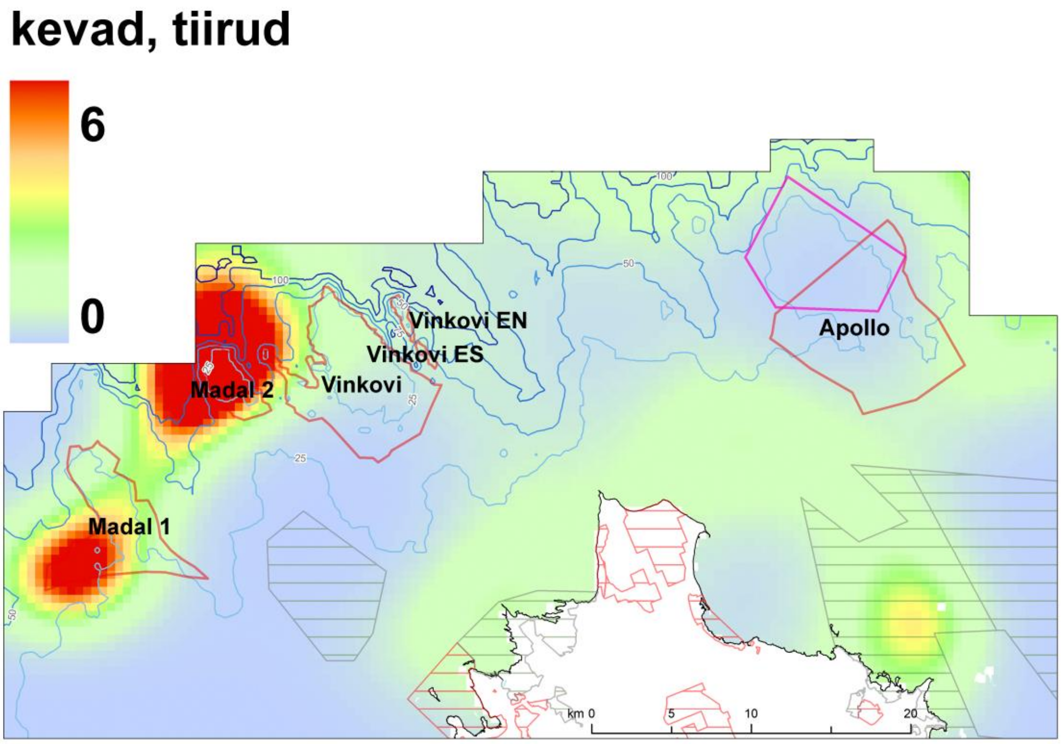

Figure 13. Spring distribution and bird density of the Terns in the coastal sea of northern Hiiumaa, y. 2015.

Moulting

Moulting migration of arctic waterfowl takes place in July and August. As dominant species, Scoter (Black Scoter with great eminence) and *Charadriiformes* are present. Daily migration takes place in low altitude above the water, copying coastline in general. More intense migration takes place in the morning followed by evening and day time when migration intensity is the lowest. Some of the Scoters use for their stop-over shallows located north from Hiiumaa. In the first few days of August, by estimate ca 40 100 waterfowl stopped in the project area and of whom 16 710 used shallows as feeding places (Figure 14, 15). The most numerous species were Scoter and Common Eiders. Scoter were located in four bigger groups – Apollo shallow, in NE of Hiiumaa, in West from Tahkuna peninsula and in Hiiu Shallows (Figure 17). In the whole area about 12 900 Scoters staged and of whom 3 900 individuals used Apollo shallow. Relatively large number of Scoters stopped and fed also in Hiiu shallow – 1 590 individuals. Hari kurk and sea area of northern Hiiumaa is known to be the biggest moulting area of Common Eiders in our region which was proven also by the present study. By estimate, 23 000 birds were moulting in the whole area. The largest moulting populations were located in Hiiu Shallows (7 840 ind.), Tahkuna Shallow (2 650 ind.) and south from Apollo Shallow (Figure 16). Gulls were distributed fairly sparse in the study area but still accounted for two larger groups that followed the two fishing vessels. Those birds were not much related to sea shallows (Figure 18). Terns as pelagic birds were evenly distributed forming the largest bird density in the western side of the study area (Figure 19). Other waterfowl species in the area were represented in small numbers and thus models for those species were not created.

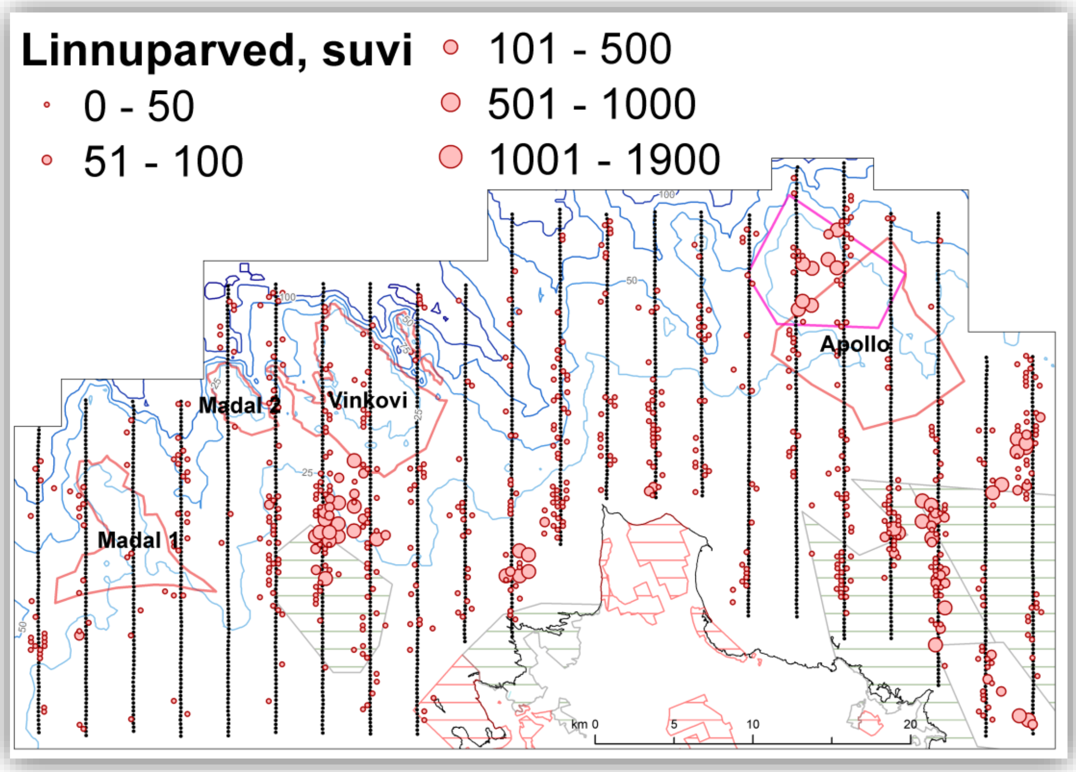

Figure 14. The location of waterfowl in the study area during their summer stop-over, August 4th, 2015.

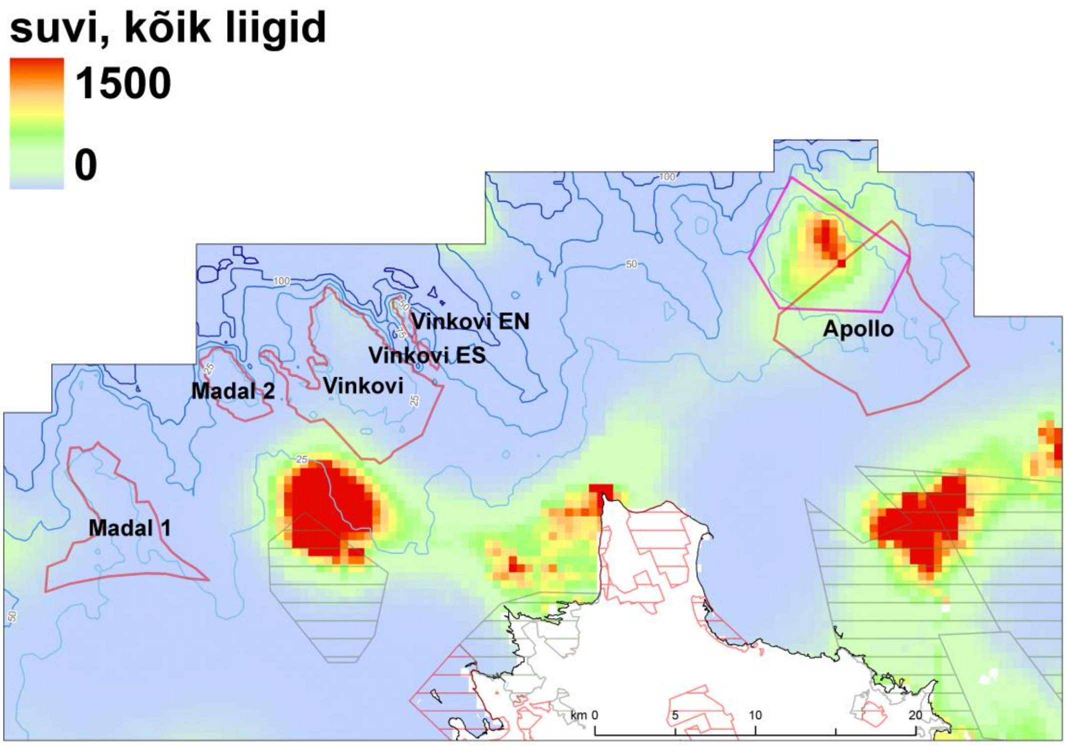

Figure 15. The summer distribution and bird density of all waterfowl in the coastal sea of northern Hiiumaa, y. 2015.

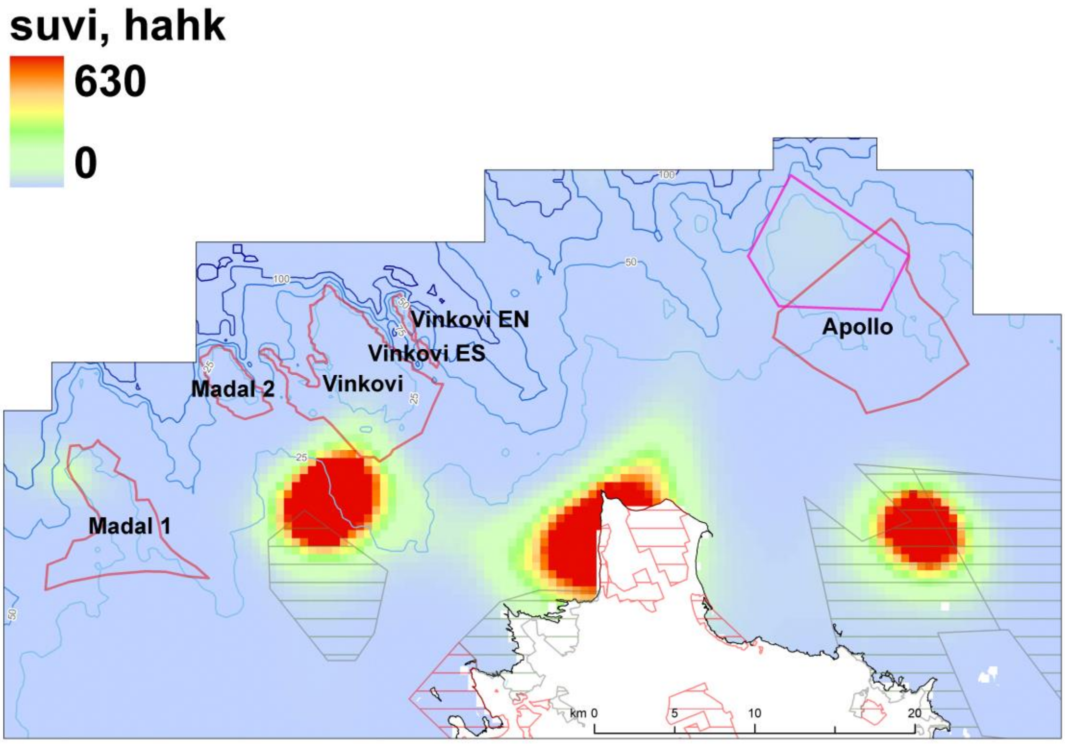

Figure 16. Summer distribution and bird density of the Common Eider's in the coastal sea of northern Hiiumaa, y. 2015.

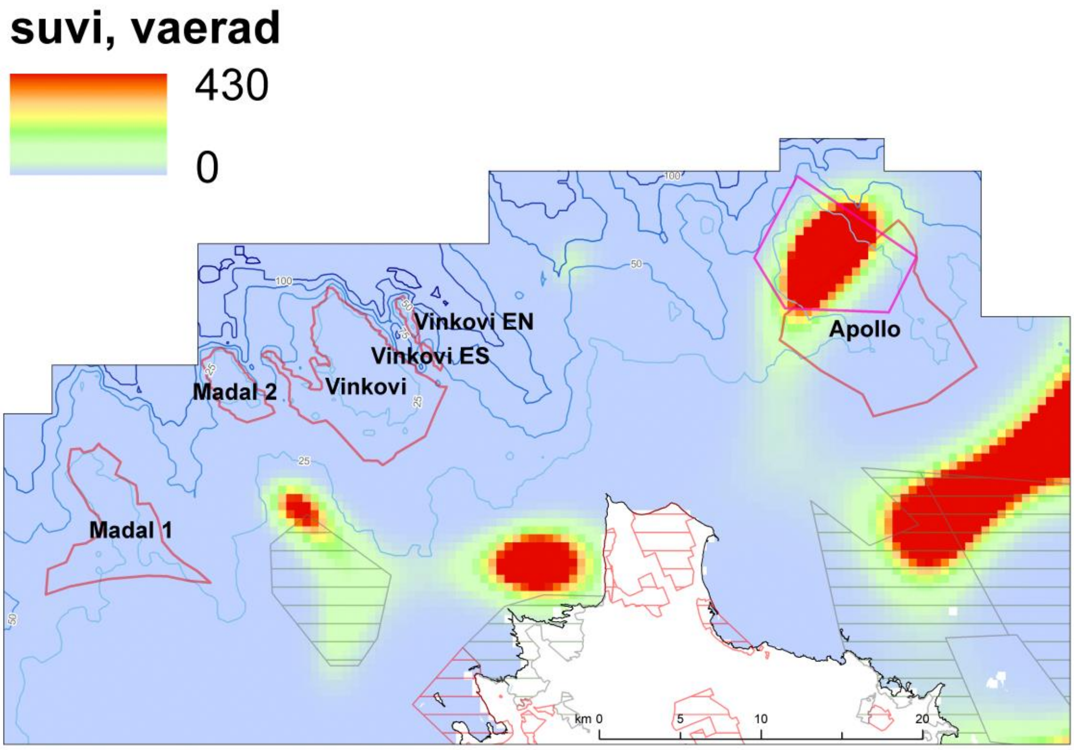

Figure 17. Summer distribution and bird density of the Scoter's in the coastal sea of northern Hiiumaa, y. 2015.

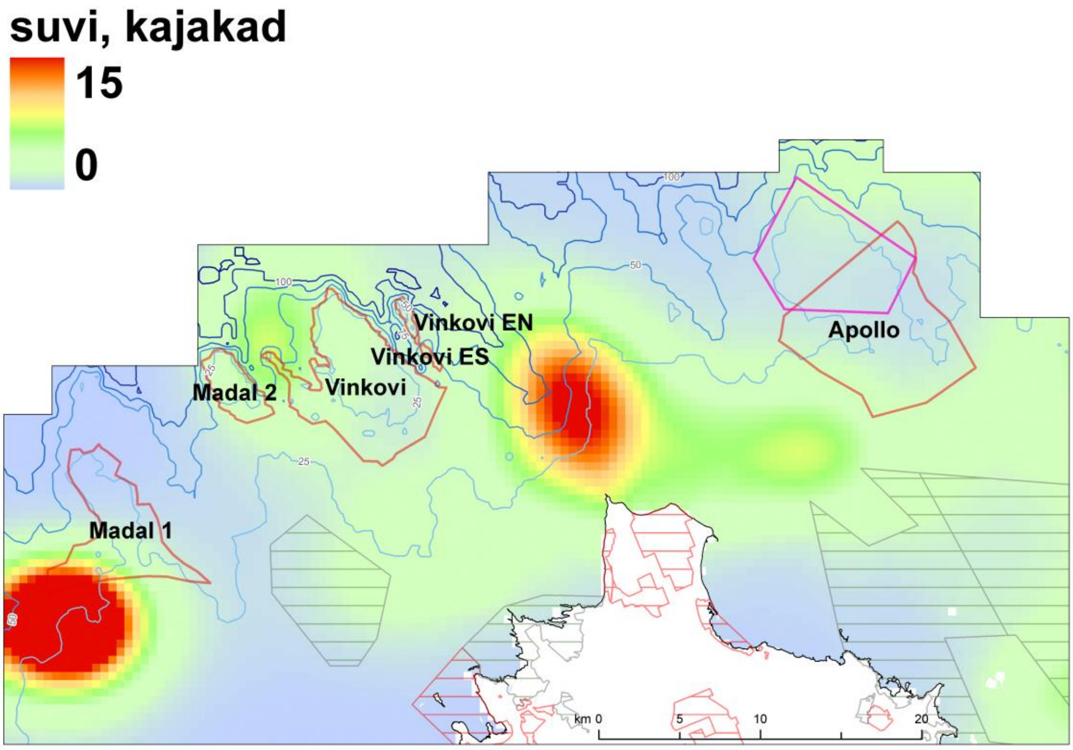

Figure 18. Summer distribution and bird density of the Gulls in the coastal sea of northern Hiiumaa, y. 2015.

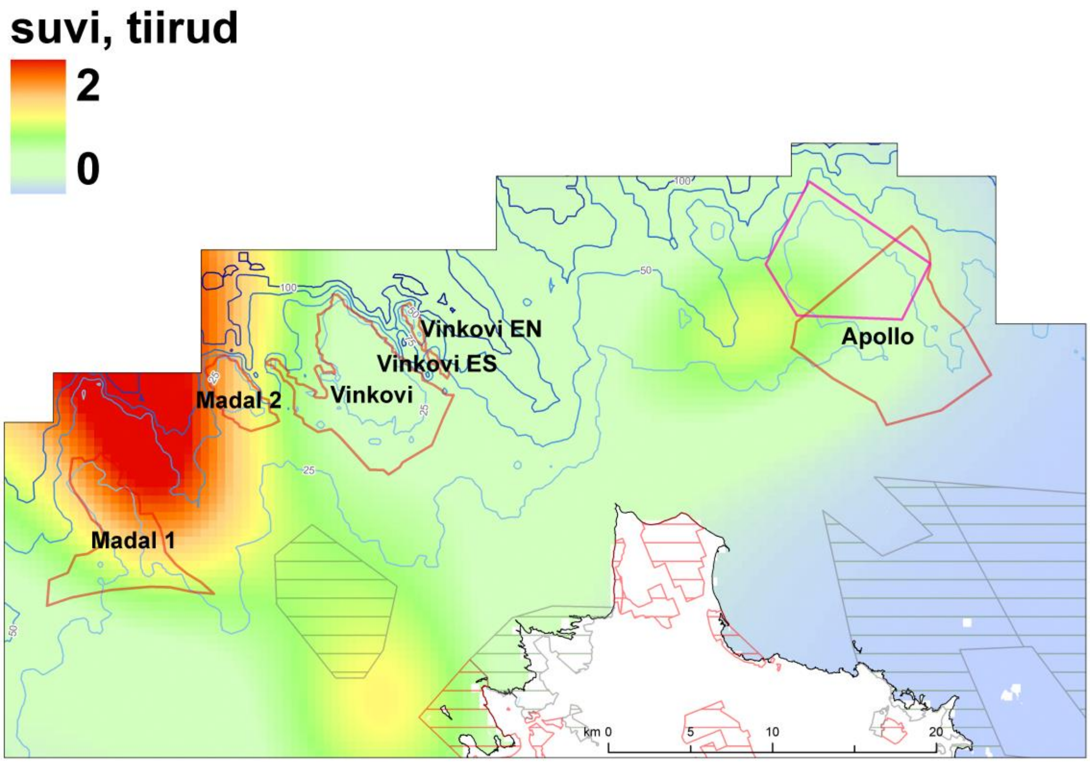

Figure 19. Summer distribution and bird density of the Terns in the coastal sea of northern Hiiumaa, y. 2015.

Autumn migration

Autumn migration of waterfowl starts in the mid-August and lasts until December which partly goes over wintering. The migration peak of Dabbling Ducks and Scaups is from mid-August until the beginning of October. Maximum abundance of Long-tailed Ducks and Divers is from the end of October until the end of November. Since the latter group *i.e.* arctic waterfowl are more related to high seas, the flight was planned to be committed in November. During the day-time migration takes place predominantly low above the sea, up to 100 m high. The prevailing migration direction is SW, varying depending on the coast line to W-SW-SSW directions. The impact of coast as an ecological barrier (migration obstacle) and guiding line, is important. Birds approaching from offshore NE and E direction to Hiiumaa west coast turn to NW direction before a coast and pass by a Tahkuna cape, continuing offshore migration predominantly SW-SWW directions. In the project area, prevailing migration direction is SWW-SW. Migration is most intense in the morning, followed by evening and is the weakest at noon, just like in spring. Hiiumaa Shallows will most likely stay on the edge areas of migration flow because in bigger part, migration is concentrated in tops of Tahkuna and Kõpu peninsulas, in so-called “bottle neck areas”. However, passing migratory waterfowl use Shallows as feeding areas. The density of diving ducks was the highest in Apollo Shallow in the end of November (Figure 20). By estimate, 86 810 birds were stopping in the project area. There were 82 400 Long-tailed Duck individuals of whom more than half (46 100 ind.) were feeding in Apollo Shallow (Table 3). This number exceeds two times the Ramsar criterion which is 20 000 individuals for waterfowl (Figure 21, 22). In terms of abundance, the second species was Common Gull that by estimate was represented with 4 000 individuals. There was much less of Herring Gull (310 individuals). Both Gull species partly used Apollo Shallow as feeding area but not very abundantly (Figure 23, 24).

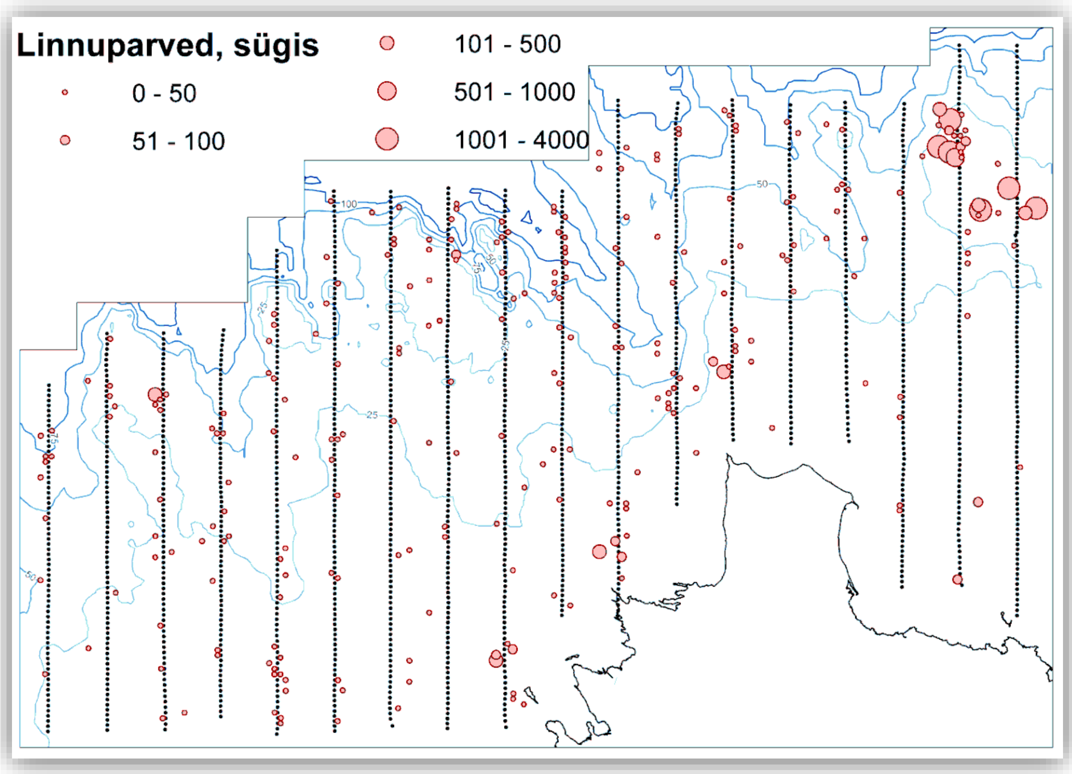

Figure 20. The location of staging waterfowl flocks in the study area, November 30th 2014.

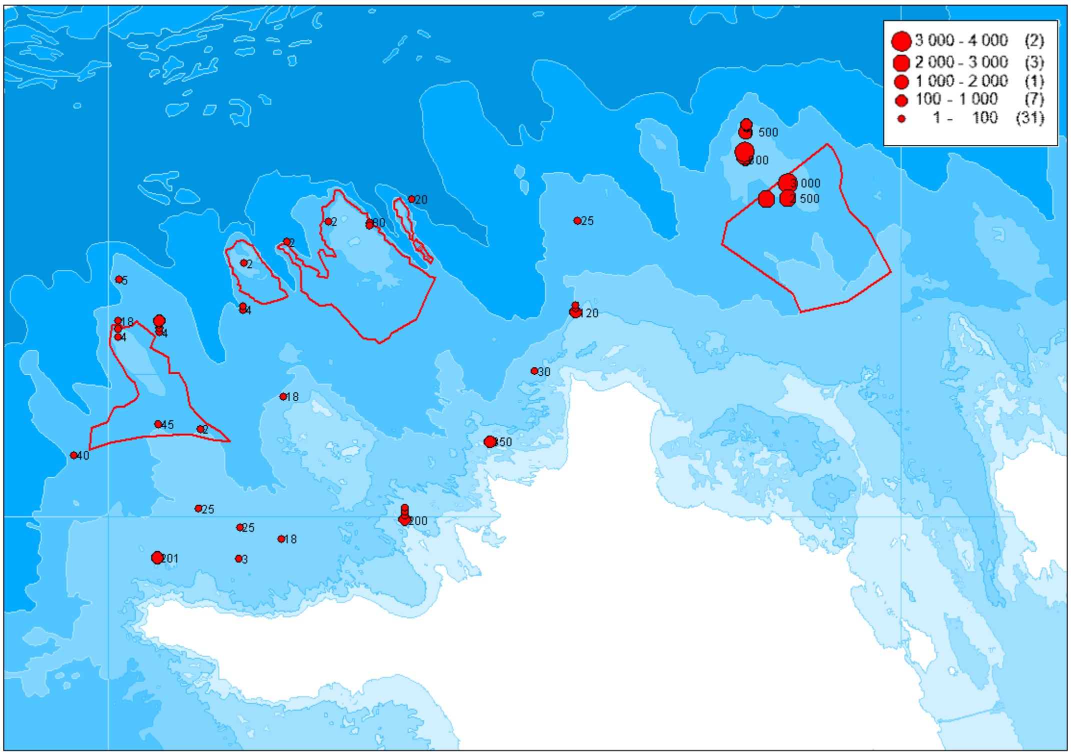

Figure 21. The autumn distribution of Long-tailed Ducks in the coastal sea of northern Hiiumaa, y. 2014 (counting data).

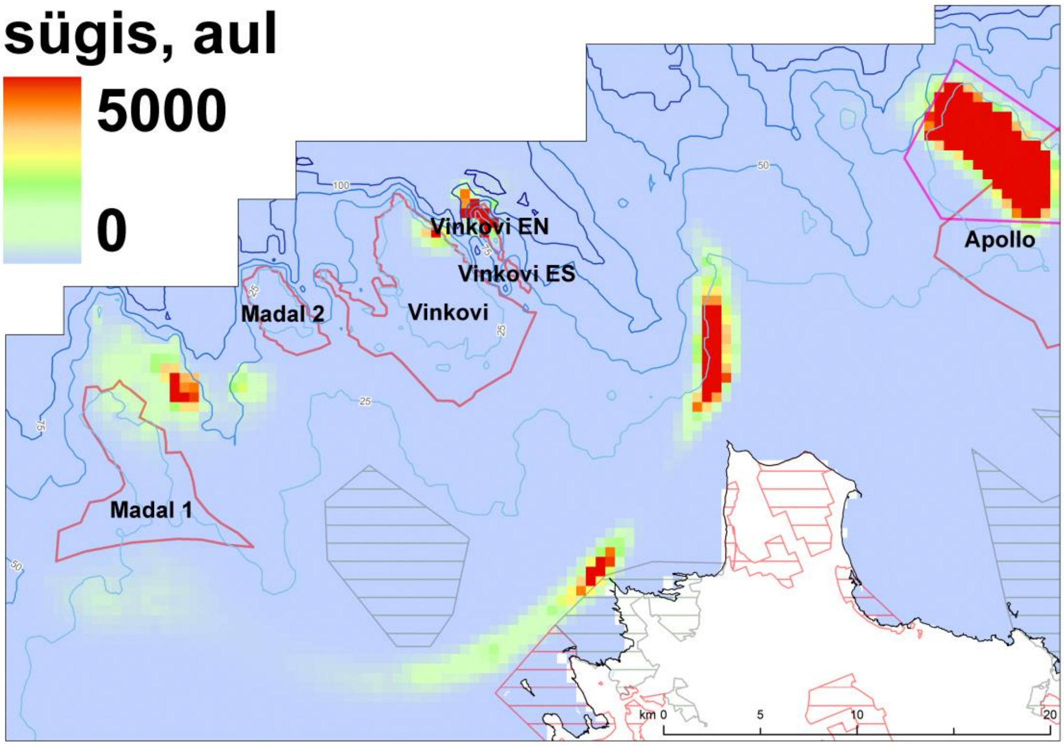

Figure 22. The autumn distribution and bird density of Long-tailed Ducks in the coastal sea of northern Hiiumaa, y. 2014.

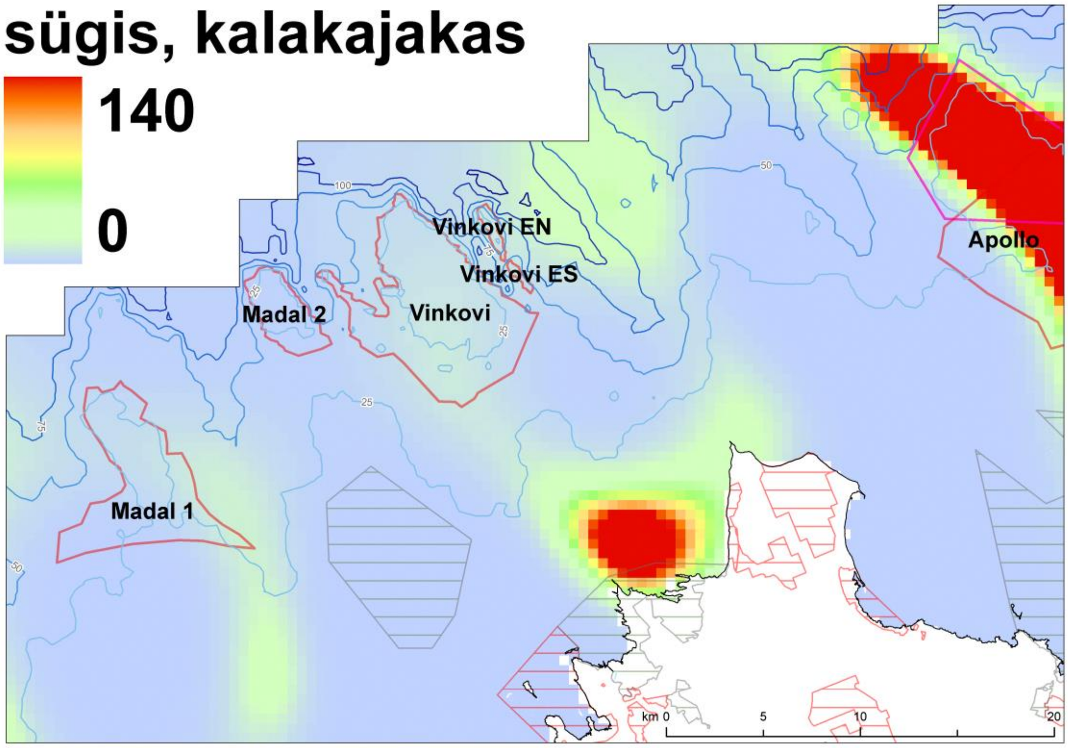

Figure 23. The autumn distribution and bird density of Common Gull in the coastal sea of northern Hiiumaa, y. 2014.

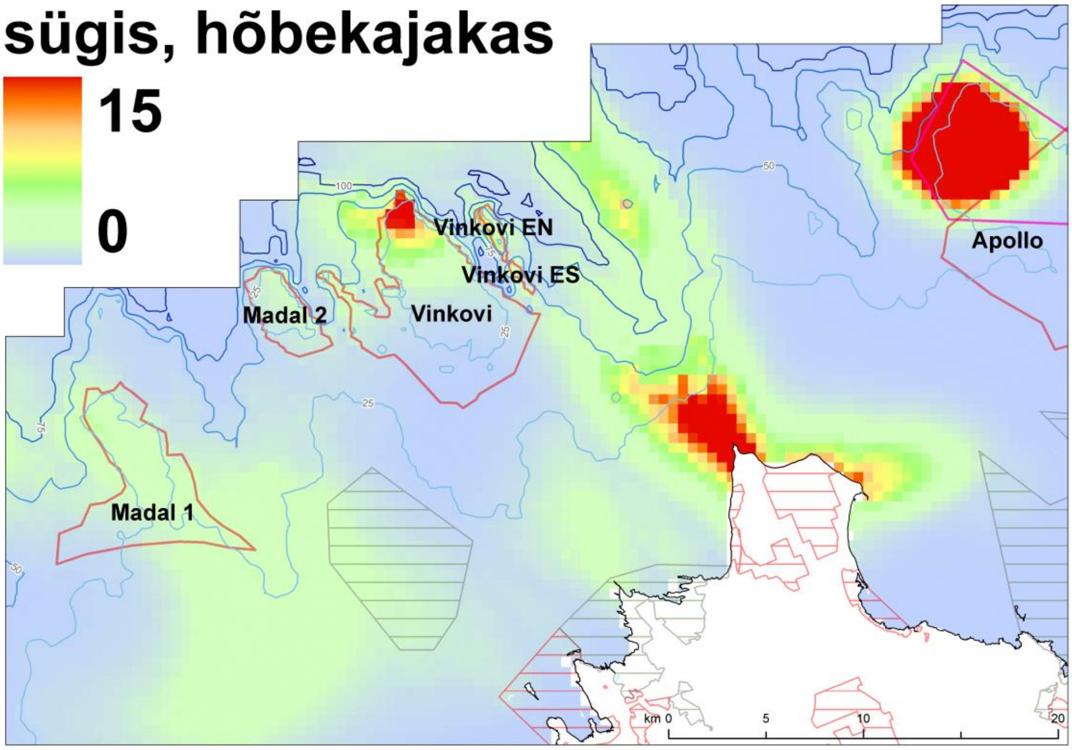

Figure 24. The autumn distribution and bird density of Herring Gull in the coastal sea of northern Hiiumaa, y. 2014.

Wintering

Many arctic waterfowl also winter in our areas. This is a continuing and increasing trend due to the mostly warm winters which make the sea ice-free. The coastal sea of northern Hiiumaa is important wintering area for many arctic waterfowl. In winter, 11 bird species related to high sea were counted. Compared to the spring and autumn, the distribution of flocks in study area was more even and bitty (Figure 25). A general estimation of waterfowl in winter was 58 760 individuals. In winter, the waterfowl abundance and bird density was the greatest in Apollo Shallow (14 560) and in the area south from it and also in NW coast of Hiiumaa and in Hiiu Shallow (Figure 26). There were 38 300 individuals of Long-tailed Ducks wintering in the sea coast of northern Hiiumaa and of whom 14 500 individuals used Apollo Shallow. A great Long-tailed Duck concentration was also south from Apollo Shallow and in NW coast of Hiiumaa (Figure 27, 28). Regarding the Gulls, the most numerous was Common Gull whose population was estimated as high as 45 800 birds. Herring Gull was the second in abundance – 2 300 individuals. “Migrations” of Gulls in the Baltic Sea can be distinguished from other birds’ migration motion by the fact that they are more irregular which makes it more a matter of wander motion. In a non-nesting period, the birds concentrate in locations where there is plenty of food. Thus, they are wheedled by fishing vessels and as a result, the spread pattern of large Gulls (Herring Gull, Common Gull) is determined by the location of fishing vessels (Figure 29, 30). Since Black-throated Diver and Red-throated Diver are very hard to distinguish from the plane, they are traditionally treated together. By estimate, 360 individuals of Divers were stopping in the area. As fishfeeders, they are not related to shallows because they are able to get the food from deep water (Figure 31). The biggest discovery was made on Steller’s Eider. During the waterfowl counting in mid-Winter there were several observations on NW coast of Hiiumaa. Based on that, it was suspected that somewhere farther offshore there may be located previously unknown wintering place of that species (Figure 32). As expected, during the flight in winter new wintering place in Hiiu Shallow was discovered with three flocks, total 400 birds (Figure 33).

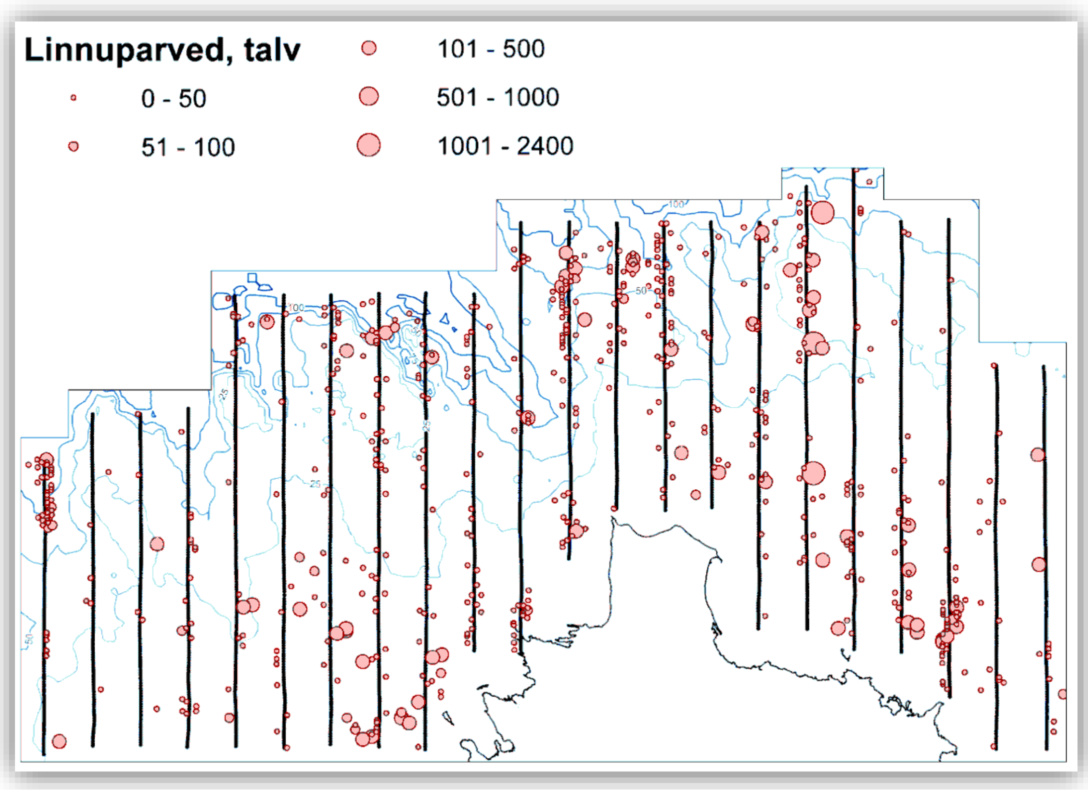

Figure 25. The location of wintering waterfowl in counting area, February 2nd 2015.

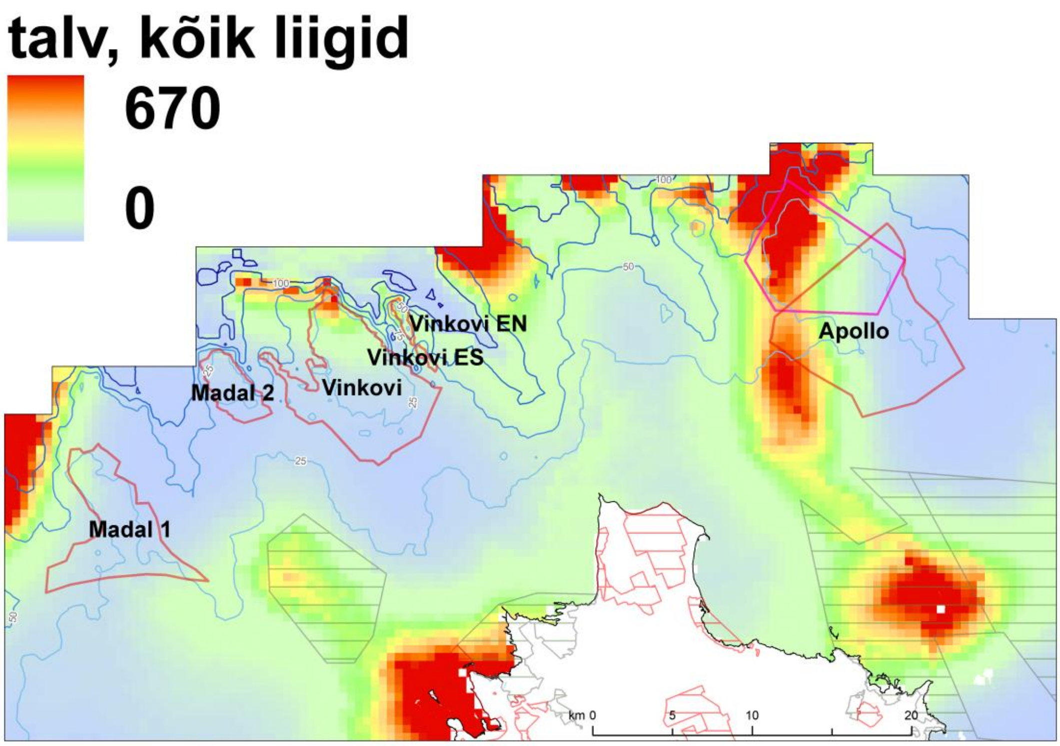

Figure 26. Winter distribution and bird density in the coastal sea of northern Hiiumaa, y. 2015.

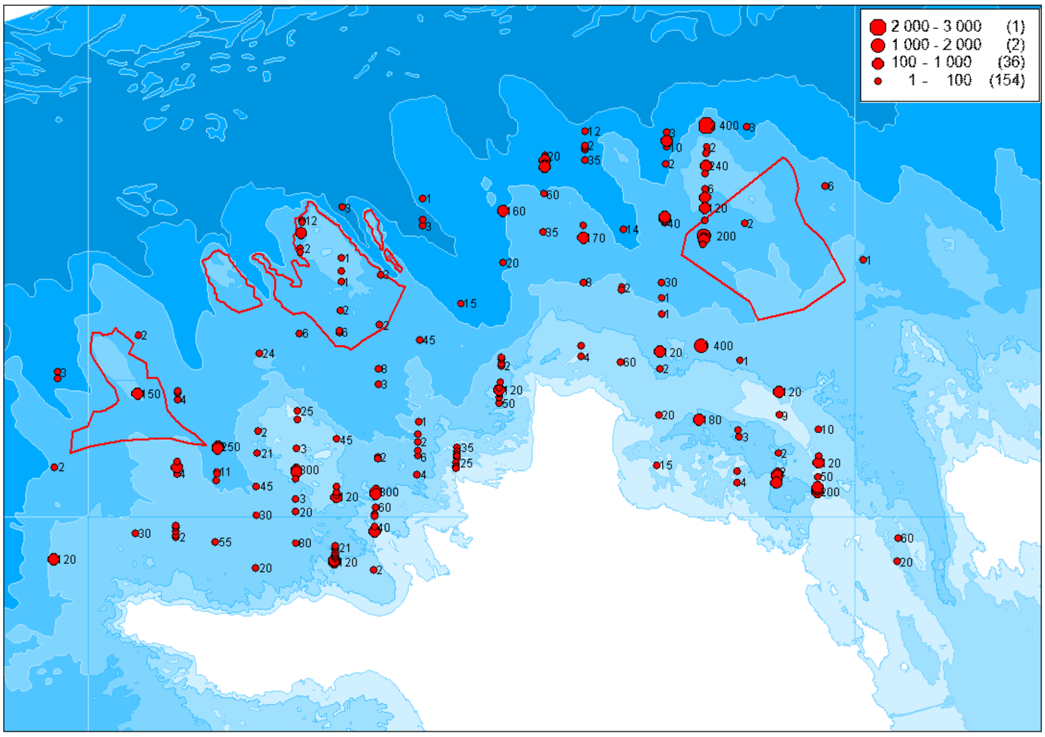

Figure 27. Winter distribution of the Long-tailed Ducks in the coastal sea of northern Hiiumaa, y. 2015 (counting data).

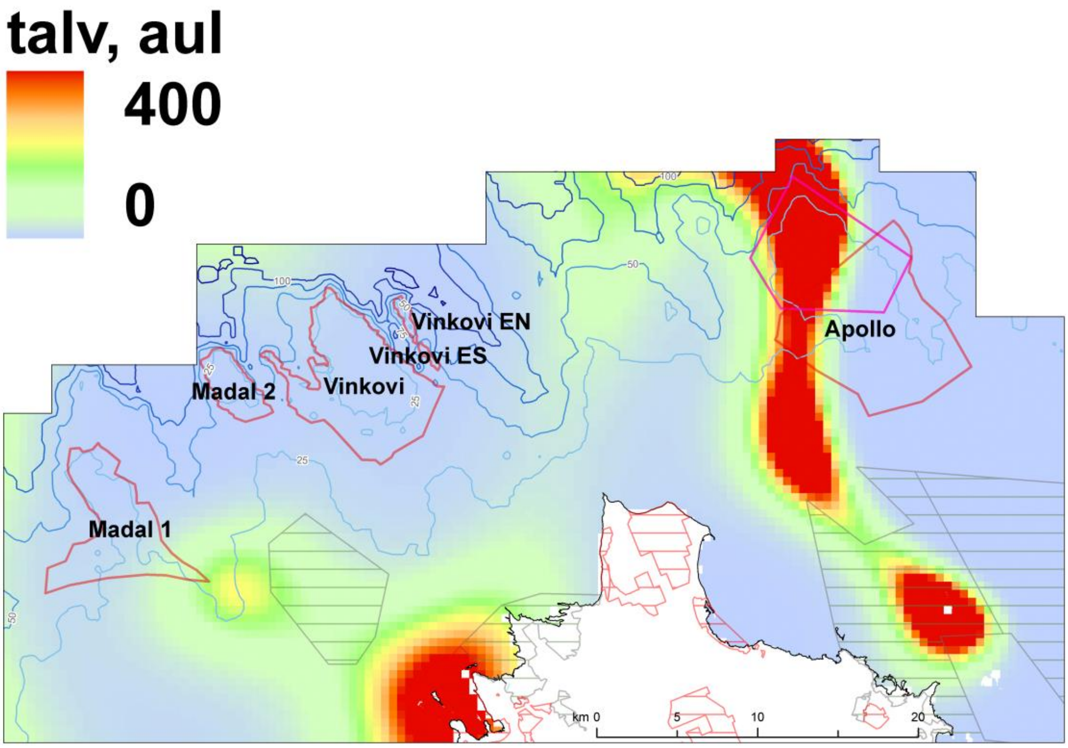

Figure 28. Winter distribution and bird density of the Long-tailed Ducks in the coastal sea of northern Hiiumaa, y. 2015.

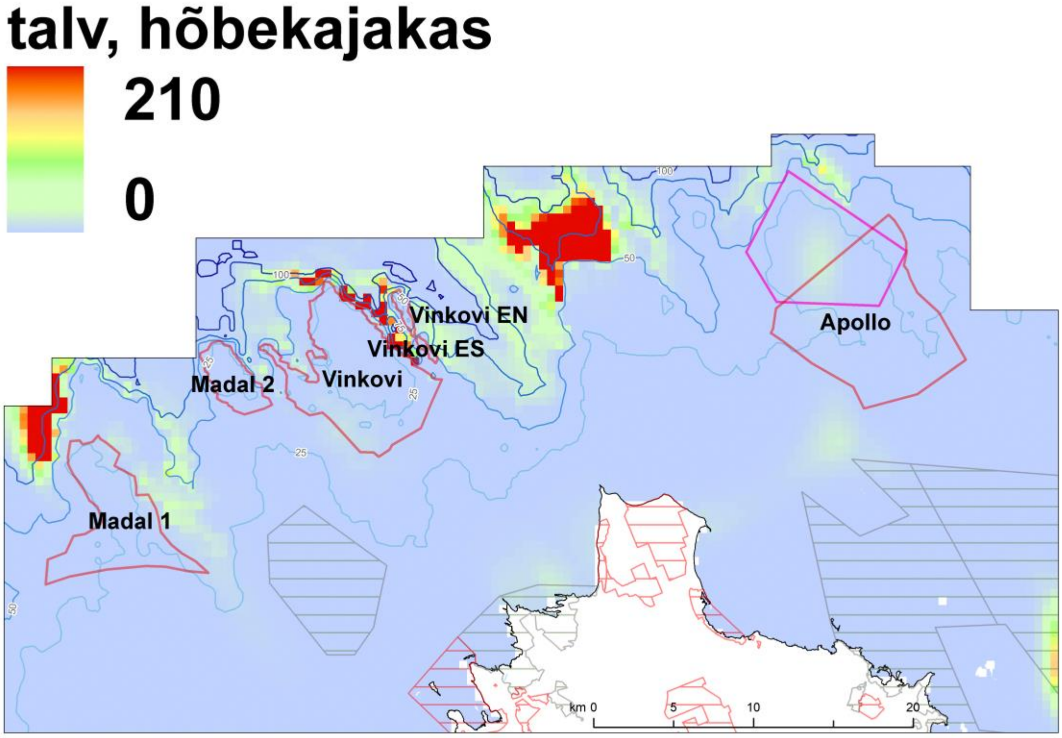

Figure 29. Winter distribution and bird density of the Herring Gulls in the coastal sea of northern Hiiumaa, y. 2015.

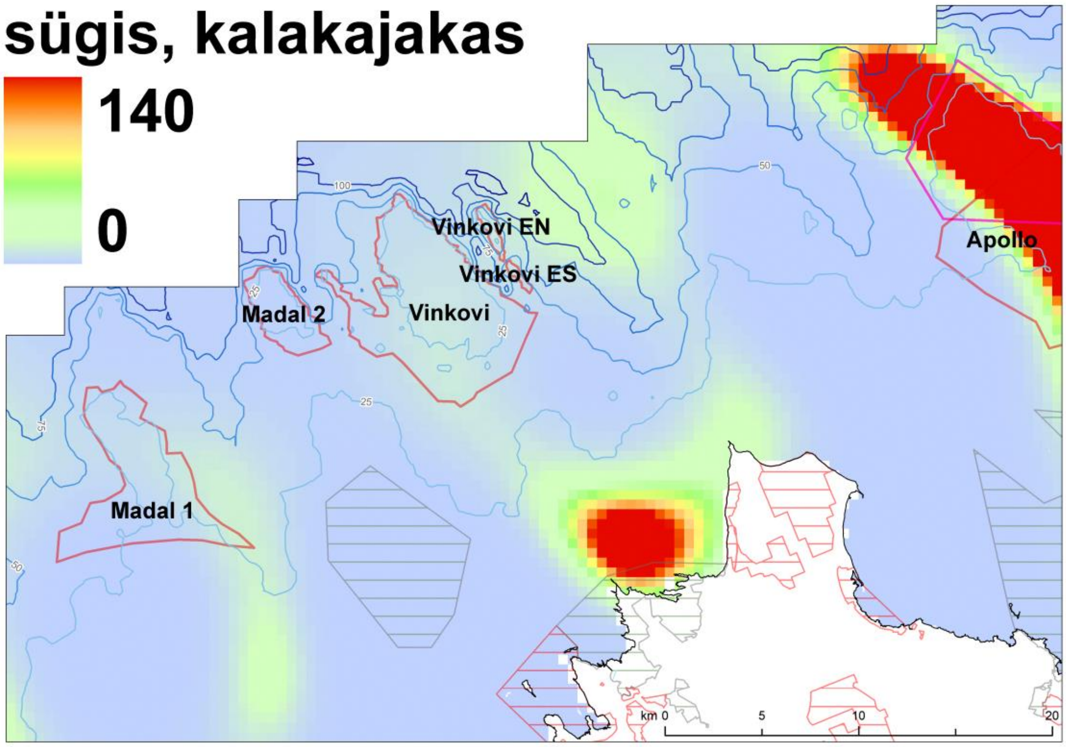

Figure 30. Winter distribution and bird density of the Common Gulls in the coastal sea of northern Hiiumaa, y. 2015.

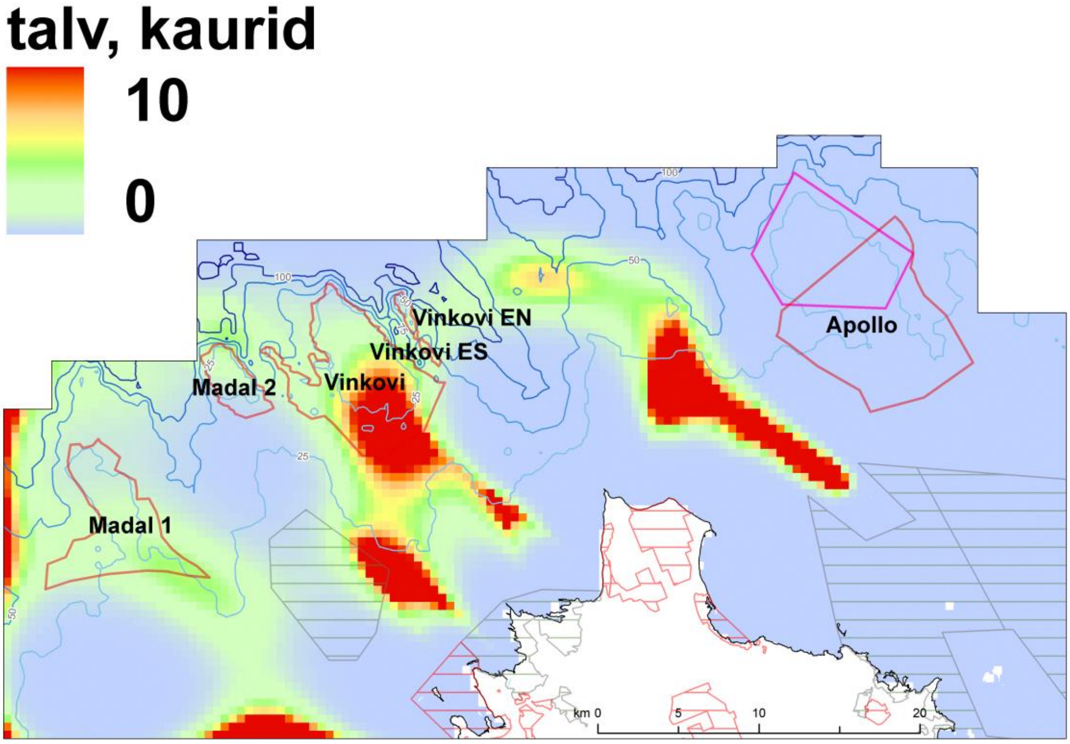

Figure 31. Winter distribution and bird density of the Divers in the coastal sea of northern Hiiumaa, y. 2015.

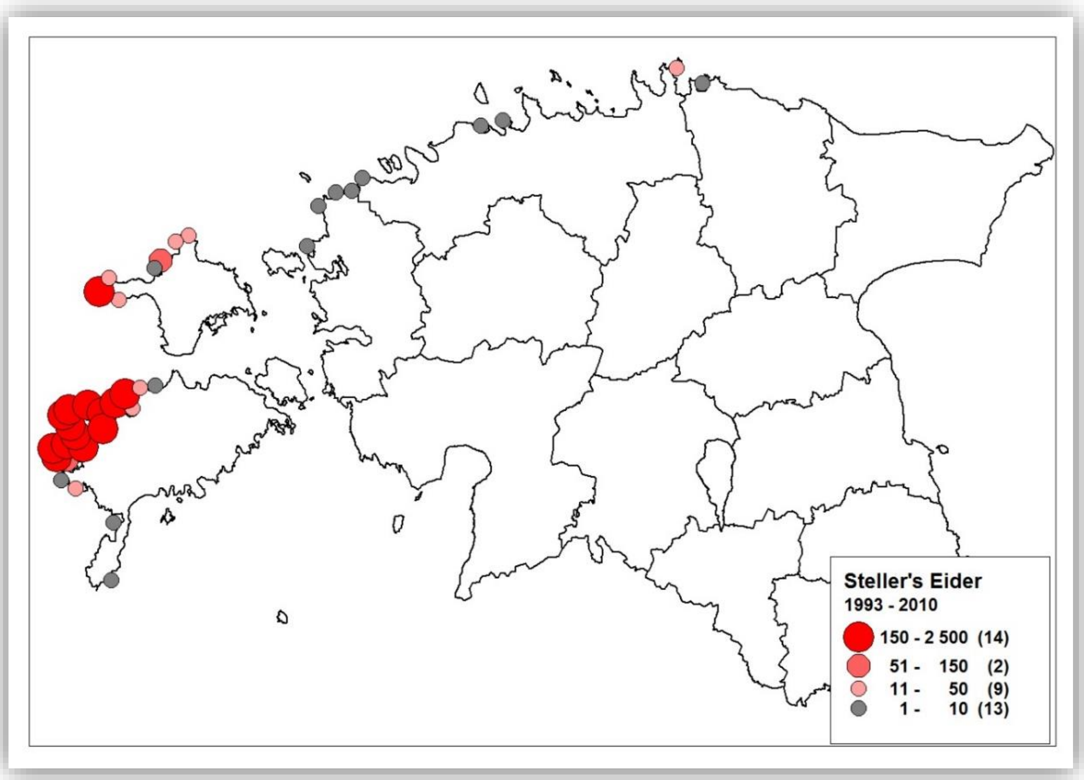

Figure 32. Winter distribution of Steller's Eider based on the mid-winter waterfowl counts during the years 1993-2010.

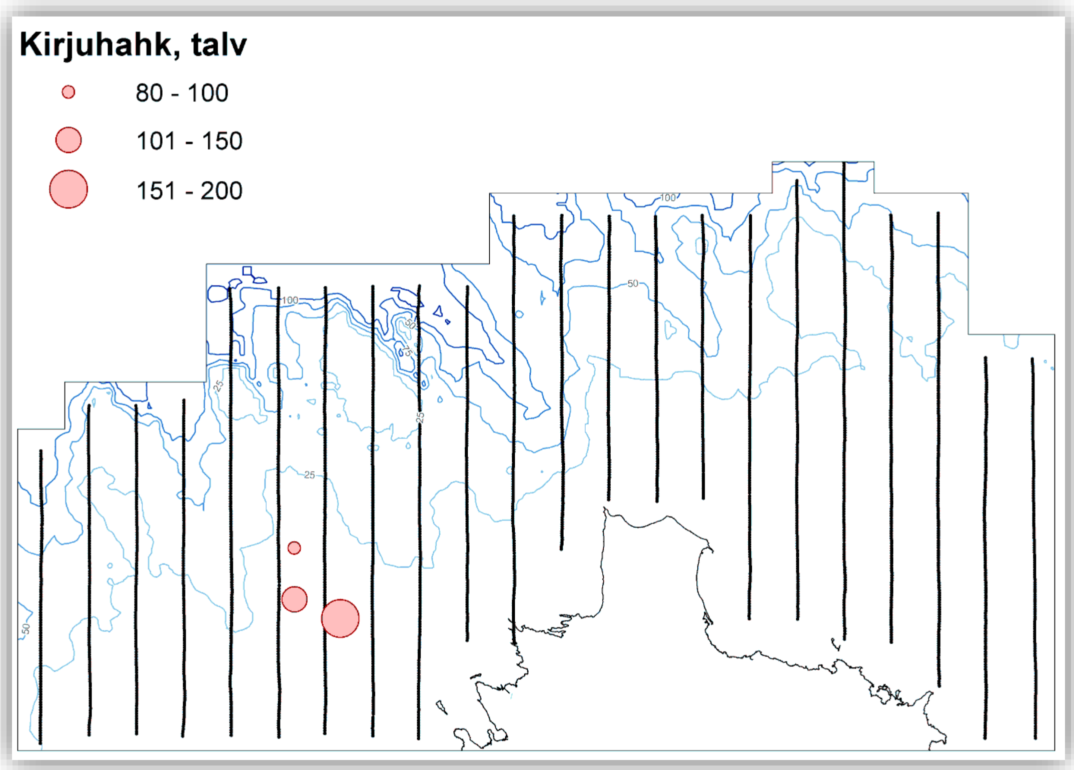

Figure 33. Wintering area of Steller's Eider in the Hiiu Shallow – Winter 2015.

The impact of offshore windfarms on birds

Direct risk factors arising from wind parks:

Through **food resource and feeding conditions** (significant influence) waterfowl species that are feeding in sea shallows are the most vulnerable. Typically, in this case, those waterfowl are feeding from the sea bottom and the depth of diving is up to 30 m. These are particularly benthos feeding Long-tailed Ducks, Common Eiders, Scoters and Greater Scaups. The biggest threat for destruction of seabed habitats are changes in the seabed associated with the construction of wind turbines which in turn causes changes also in the biota of the seabed. For fish feeding (Divers, Mergansers) and pelagic species (Gulls, Terns) it does not pose a particular threat because these species can manage in deep water and they are not directly related to shallows. Although they may converge to the edge of shallows where there may be more abundant fish stocks. This research showed that the biggest concentration of waterfowl wintering and making migration stops were in Apollo and Hiiu Shallow (Table 3). Waterfowl avoid wind turbines with working rotors – most likely due to the vibration and noise associated with working rotors (Petterson, 2005, Hötker *et al.,* 2006), it is not recommended to design and construct wind farms in those areas. The significance of Vinkovi Shallow did not come out in this study but the reason for it may be slightly delayed counting both in spring and autumn. The importance of Vinkovi and Glotovi Shallows to sea birds shows the counting in the end of October 2007, when about 40 000 individuals stopped in these shallows, which exceeds twice Ramsar criteria. According to this criteria protection is necessary in the areas, where regularly stops at least 20 000 waterfowls (Leito 2008). A special attention is needed for globally threatened Steller's Eider. Although it is known that Steller's Eiders operate mainly in coastal shallows and feeding areas would not reach deep offshore wind farm areas, the contact with wind farm during migration is still possible and risk factor due to global endangerment of the species is still high.

Wind turbines as obstacles for migrating birds (significant influence). Operating wind farms are an important obstacle to migrating waterfowl (Madsen *et al.* 2009, Larsen & Guillemete, 2007, Topping & Petersen, 2011). Thorough radar studies have been made in many parts of Western Europe to clarify the impact of offshore wind farms to waterfowl on transit migration. Studies have shown that migrating birds avoid offshore wind farms and neither enter these areas nor fly through them (Desholm, 2006, Madsen *et al.* 2009). Due to the fact that radar observations have never been conducted in the project area, we can only guess the main migration flow in the coastal sea of northern Hiiumaa. Visual observations from the coast show that both spring and autumn migration is basically concentrated in tops of Kõpu and Tahkuna peninsulas. Against this background, there will be only Kuivalõuka dry (former Neupokojevi Shallow) that will remain on the migration path and very likely the shallows of northern Hiiumaa will remain north from primal waterfowl migration corridor and therefore will not constitute a major obstacle to birds on transit migration.

Risk of collision with wind turbine vane (significant impact). Bird species with the greatest risk are species that use rising air currents when migrating (Hawks, Storks, Cranes, Cormorants and Gulls). As the rising air currents emerge above the land then the risk of collision is the highest in wind farms located in the coast and in mainland. Given that the rising air currents are practically missing in offshore areas, then offshore wind farms do not pose a significant threat to above mentioned species, especially if to consider that so-called "soaring" species avoid large water bodies and when surpassing them, use active fly in low altitudes. Because waterfowl avoid wind farms, their risk of collision with wind turbines is relatively low. However, it may still happen in very bad weather conditions. The probability is still very low because in migration usually does not take place when the weather conditions are bad. Offshore wind farms may pose a serious threat to night time migrants who are mostly passerines and waders. Given the height of the migration of these two groups of species, the greatest risk of collision is for passerines who fly on lower heights. The lights of wind farms may increase the risk especially to migrating terrestrial birds, because they attract migratory birds to wind farm areas. Based on visual observations from the coast, the closest terrestrial birds' migration corridor to project areas runs from Dirhami and Spithami point over Osmussaar to Hanko and vice versa. Radar surveys have not been carried out in project area, therefore the data of other terrestrial birds' migration corridors is not available.

Other important risk factors to migrating waterfowl or waterfowl on their migration stop

Other important risk factors in project areas that may induce an increase in the cumulative impact on birds are oil spills, by-catch, shipping, mining, dredging, dumping, construction and eutrophication.

Oil spill is one of the most important potential hazard to waterfowl stopping and feeding on the sea, causing their death due to hypothermia and ingested toxic agents. The most endangered are big migratory populations who feed in shallows. During two decades the population of Long-tailed Ducks have decreased up to two times and is considered to be the primary cause of oil spills (Larsson & Tyden 2005) and by-catch. To avoid the risk, it is important to take nationwide measures to prevent, detect and eliminate oil spills.

By-catch is one of the most important risk factors for all diving bird species (Žydelis *et al*. 2009). Also, other possible factors related to fishing have been mentioned, such as changes in food base. Because fishing in offshore wind farms are usually prohibited, by-catch is irrelevant risk factor.

Ship traffic can disturb waterfowl who are stopping and increases potential risk of oil spills and other contaminants. Using crafts with low draft and powerful engines like scooters in shallow sea areas may basically threaten benthos communities as a food base for birds. However, it should be noted that the use of scooters is very unlikely on the shallows of off-shore waters, but still not very far from Apollo Shallow there is one of the most important shiproute in the Baltic Sea. Some ships that head to Hiiumaa Lehtma and Suursadama ports, pass also through the project area but due to their small number do not pose a major threat to avifauna. Besides, ships avoid sea shallows.

Mining, dredging, dumping and construction activity will lead to destruction of benthic communities which in turn directly affects waterfowl food sources but which over time will very likely be restored. However, in mining and dumping areas the transparency of water will temporarily decrease and which in turn affects also benthos communities and the fish fauna. Sand mining in Hiiu Shallow should certainly be avoided, especially if to consider that it's the wintering place for globally endangered Steller's Eider. The construction activities related to wind farm will directly affect benthos communities but with great probability they gradually recover. At the same time, mitigation measures can be used, for example the creation of suitable substrates for mollusks.

Alternative solutions

Alternative solutions for the location of wind farms in the shallows of northern Hiiumaa and the resulting impact on wild birds

0-alternative. Situation where wind farms will not be established. In such case the impact is clearly positive (2).

Initial alternative of the development area of wind farm is shown in figure 34, which included Kuivalõuka, Vinkovi, Apolli, Shallow 1 and Shallow 2 areas.

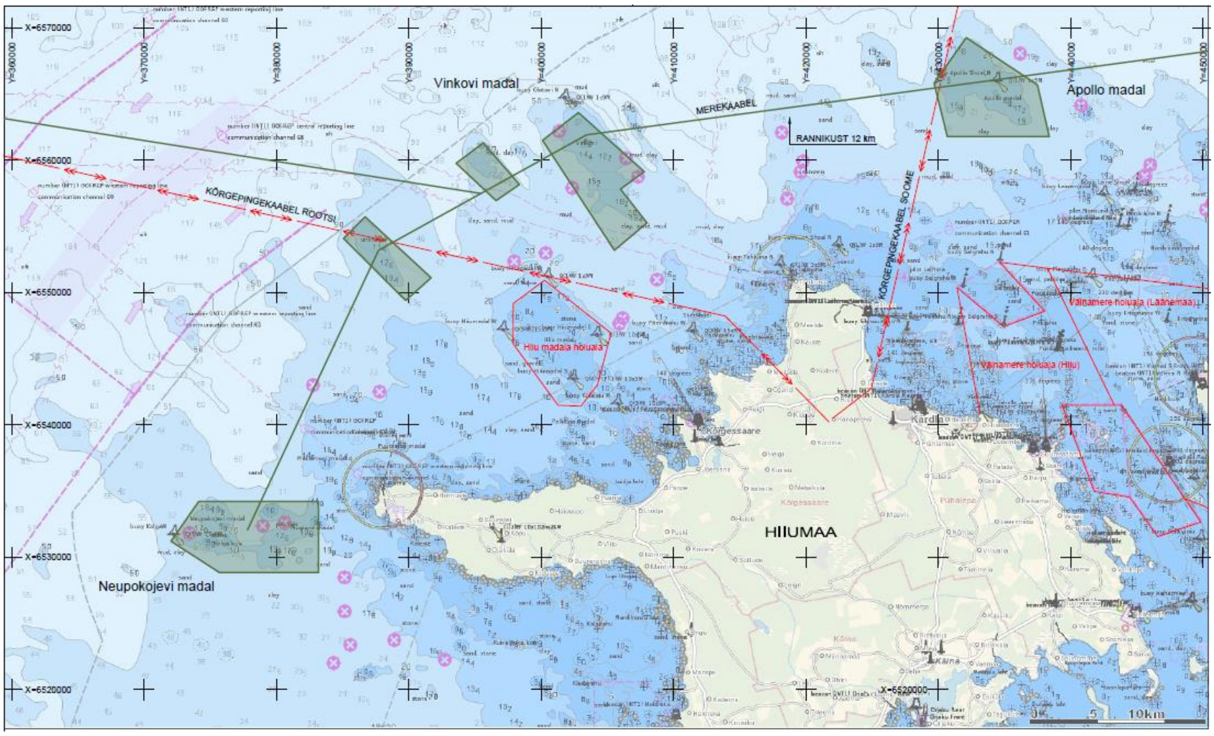

Figure 34. Initial development areas of wind farm y. 2006.

1-alternative. A situation where wind farm will be built in development area which consists of four shallows – area south from Apollo Shallow, Shallow 1, Shallow 2 and Vinkovi Shallow (Figure 35). In this case Apollo Shallow, which is the most important stopping area of waterfowl in the coastal sea of northern Hiiumaa will not be occupied. In case Apollo Shallow will be left out, it is clearly a compromise and mitigation measure.

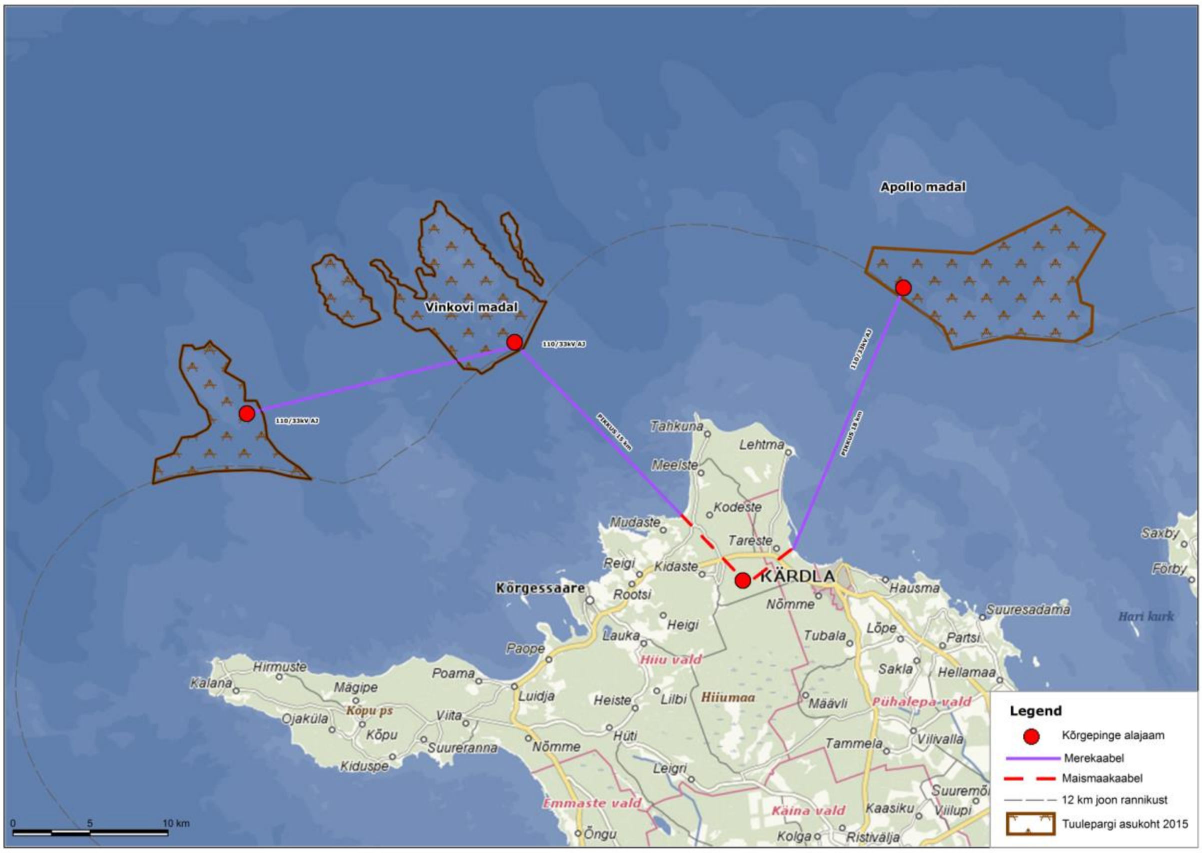

Figure 35. The new development area of wind farm in the coastal sea of northern Hiiumaa proposed by avifauna expert

The location of wind turbines within the wind farm

1-alternative. The situation where the direction of the migration of birds is not taken into account. Significant impact (-1).

2-alternative. The situation where the direction of the migration of birds is taken into account. Significant impact (-1).

In both cases it is a great obstacle and therefore it has been rated as a significant impact. One possible mitigation measure could be related to the placement of wind turbines in the direction of migration. In this case to the E-W direction in Apollo development area and to the NE-SW direction in Vinkovi, Shallow 1 and Shallow 2 areas. **In this case the alternative 2 is better.**

The stages of the development

Construction of the wind farm

During seabed preparation and construction, the biota of the seabed is likely destroyed in “construction sites” and its immediate vicinity. Remarkable impact is from the spreading suspended solids to areas between wind turbines during construction. This process is not irreversible and the benthos is likely to recover over time.

Operation of the wind farm

The wind farms do not have a positive impact on sea birds, therefore their location should be carefully chosen in order to reduce the negative impact. Comparing the presence and actions of wind farm that accompany with the maintenance and operating, the latter has considerably less impact than the first one.

Demolition of wind turbines

When demolishing the wind turbines, the removal of foundations should be avoided because it would destroy the benthic biotopes for the second time.

Mitigation measures

The choice of the location of wind farms. As previously mentioned, the greatest threat from offshore birds perspective is the location of wind farms in the areas of migration stops. Therefore, the choice of location of wind farms is likely the most important of all the other activities. From offshore bird’s perspective, the two most important shallows are Hiiu Shallow and Apollo Shallow. Therefore construction of wind parks should be avoided to these shallows. The significance of Vinkovi Shallow did not come out in this study but the reason for it may be slightly delayed counting both in spring and autumn. The importance of Vinkovi Shallow to sea birds shows the counting in the end of October 2007, when in Vinkovi and Glotovi Shallows about 13 900 waterfowls were counted, which gives an estimation of 40 000 individuals in these shallows.

The types of wind turbines. The choice of wind turbines in case of offshore wind farms is not essential for avifauna. The wind farm itself is an important source of risk for the birds stopping and migrating through the area. The types of wind turbines which have the lowest possible noise and vibration level should be preferred.

Demolition and construction of wind turbines. When choosing various types of foundations, the environmental impact to the biota of the seabed associated with their construction must be taken into account. The construction of the foundations would most likely destroy the seabed biota completely, therefore the foundations' underwater part should be covered with rough coat as a mitigation measure to encourage the spread of shellfish on the foundations of wind turbines. This has been experimentally done for offshore wind turbines of the North Sea. In relation to construction and demolition of wind turbines, the risk of oil spills would theoretically increase but comparing it to the similar risk from the outside of the project area, it is negligible.

The risk of collision with wind turbines. The greatest risk of collision with wind turbines is for passerines. Depending on the location, computationally 100 – 1000 passerines are killed per offshore wind turbine per year. In case of terrestrial wind farms, the collision risk is significantly lower – 2-60 birds per year (Bellebaum *et al.*, 2010).

Location of wind turbines within the wind farm. Constructing wind farms along the migratory routes of birds the prevailing direction of migration must be considered. The rows of wind turbines in the wind farm should be placed parallel to the direction of migration. The rows of wind turbines in wind farms located on the shallows of northern Hiiumaa should be planned by the direction of migration – Apollo E-W and in other areas (Vinkovi, Shallow 1 and Shallow 2) NE-SW direction.

The hazard warning lights of wind turbines. Hazard warning lights of wind turbines pose a serious risk to terrestrial birds migrating at night, attracting birds to wind farm area and significantly increasing the frequency of birds' collision with wind turbine vanes. Therefore it's a rule – the fewer the lights, the safer for birds. The importance of the colour range of the lights is still being examined.

To mitigate the impact of the lights there are currently number of different ways:

1. Pulsing lights are safer.
2. Certain types and colours of lights are safer.
3. The pulsing frequency must be as long as possible and it should be synchronized to the whole extent of the wind farm.
4. More and more the so-called “intelligent lights” are under discussion. Such lights are switched on only when a vessel or an aircraft will enter the danger zone of the wind farm. At other times the wind farm is dark and does not endanger night time migrants.

A great number of studies of lights have been made in the world in order to decrease the risk of collision of birds with high constructions. For example, it has been found out that light type „L-864 strobe “(24 blinking cycles per minute) does not attract birds as much as other types of lights. At the same time it has been determined that continuously burning lights attract more birds. Many authors say that white lights are much safer than red lights. However, it should be noted that many of the research articles are conflicting and, when choosing lights, the wind farm location has to be considered and any specific development requires a separate approach.

The necessary monitoring methods

1. Radar surveys. The best overview of the location of waterfowl migration flow in a particular area would give a radar survey that would be needed to carry out in the project area. Radar survey gives an accurate picture of birds’ movement directions, migration “bottlenecks” and migration heights. Prior establishing big wind farms, generally radar surveys are conducted. The construction of the radar station near planned or already existing wind farm may become an obstacle in case of offshore wind farms, because it may be located far from the coast. In Denmark, radar station has been constructed within the wind farm for this purpose. This gives results with significant quality. Such radar stations are also used after starting the wind farm for follow-up monitoring and for experimental surveys by international research groups. The best places for the location of radar station are the tops of Tahkuna and Kõpu peninsulas. The University of Life Sciences has the required radar and know-how.
2. The follow-up survey of birds stopping in constructed wind farm areas.
3. One of the important component of follow-up monitoring is registration of collision of birds and monitoring of a running wind farm. Several techniques have been developed for this purpose (Wiggelinkhuizen, et al, 2010).

The conservation value of birds in the coastal sea of northern Hiiumaa

The spread pattern of birds feeding and migrating through coastal sea of northern Hiiumaa and also temporal distribution of populations are important components that need to be taken into account when planning activities in these areas. Marine waters of northern Hiiumaa as a whole is an important migratory stopover and passing locations for many arctic waterfowl. When comparing spring and autumn migration, the migration is more intense in autumn because many waterfowl do not enter Väinameri and follow northern Hiiumaa and western Saaremaa coast line. In contrast, a large part of spring migration passes through the Väinameri and smaller part of it follows Saaremaa and Hiiumaa coast line (Figure 36). Therefore, there is significantly greater number of birds who stop during migration in the autumn. The bird species of the greatest conservation value in this area are Steller's Eider, Red-throated Diver and Black-throated Diver (Council of Europe Bird Directive Annex I species). From Annex I species also Little Gull, Caspian Tern, Sandwich Tern, Arctic Tern, Common Tern and Little Tern are present in the area. From the species presented in Annex II, the most important are Long-tailed Duck, Greater Scaup, Common Eider, Velvet Scoter and Black Scoter. Particular attention should be given to greater protection deserving Long-tailed Duck whose numbers have dropped very dramatically in recent years. Internationally, Long-tailed Duck conservation Action Plan which is currently compiling, sets out the need to protect stopping and wintering areas of Long-tailed Ducks. For the bird species who stop on the sea, the protection purpose is regularly habitat protection of numerous species whose number in the area accounts for a significant part of the population abundance. One of the internationally accepted measure for choosing important areas is so-called Ramsar criteria (Heath and Evans, 2000). The Ramsar Convention criterion no 6 states that the internationally important wetland is an area where regularly stop 1% of the population of some species or subspecies. Another criterion no 5 says that areas where regularly stop 20 000 or more waterfowl also need to be protected. As a result of this study, Apollo and Hiiu Shallow would classify for those areas that are one of the most important stopping areas for waterfowl during the autumn migration and wintering in the coastal sea of northern Hiiumaa and where also the regularity criterion is fulfilled. Previous studies also show great value of bird conservation for Vinkovi Shallow particularly in autumn (Leito 2008), but in this study, the significantly high bird density of waterfowl in that area was not noticed.

Spring Autumn

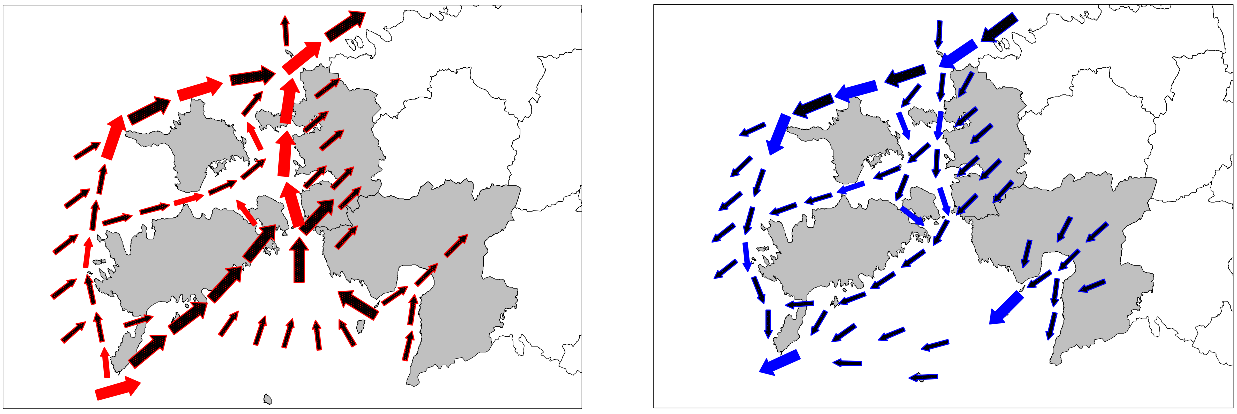

Figure 36. Transit migration of Arctic waterfowl in the west coast of Estonia

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