

SHIP BASED OBSERVATIONS ONBOARD MT UIKKU DURING THE WINTER 2003

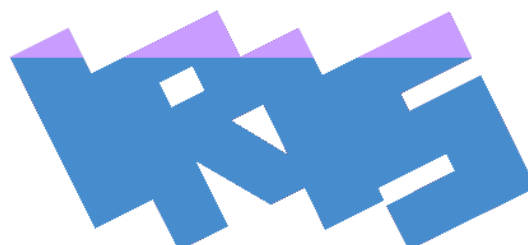
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Abstract: During winter 2003 three manned voyages onboard MT Uikku were made: Porvoo-Oulu-Porvoo (31-Jan-5-Feb-2003), Pori-Kotka (20-21-Feb-2003) and Porvoo-Oulu-Kemi (11-13-Apr-2003). The purpose of these voyages was to conduct ice load measurements, to gather data of ice conditions and to collect data from ship performance. A general description of the voyages is given. Ship speed, propulsion power and measured ice loads are compared to ice thickness information, especially to thickness charts generated using RADARSAT SAR images.	

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TABLE OF CONTENTS

1	INTRODUCTION	1
2	THE MEASURING SYSTEM	1
	2.1 Description of the ship	1
	2.2 Instrumentation	2
3	DESCRIPTION OF THE VOYAGES AND THE RESULTS FROM THE MEASUREMENTS	3
	3.1 Voyage I: Porvoo-Oulu-Porvoo	3
	3.2 Voyage II: Pori-Kotka	12
	3.3 Voyage III: Porvoo-Oulu-Kemi	16
4	CONCLUSIONS	22
5	REFERENCES	23



1. INTRODUCTION

During winter 2003 three manned voyages onboard MT Uikku were made between Gulf of Finland and Bothnian Bay. The purpose of these voyages was to conduct ice load measurements, to gather data of ice conditions and to collect data from ship performance in different operational conditions. During winter 2003 ice cover extent was quite average (max. 232 000 km² on the 5th of March) compared to previous years, but in many areas there were thick ridged and rafted ice. Ice season was also a couple of weeks longer than usually. In that point of view the ice season 2002-2003 for winter navigation was difficult.

In this paper general description of these voyages are given, what was measured and observed. Ship speed, propulsion power and measured ice loads will be compared to ice thickness information given by Finnish Institute of Marine Research (FIMR). Especially ice thickness charts (Karvonen et al., 2003), which are generated using RADARSAT SAR images and ice thickness history, will be utilized. The manned voyages were made between Porvoo-Oulu-Porvoo (31-Jan-5-Feb-2003), Pori-Kotka (20-21-Feb-2003) and Porvoo-Oulu-Kemi (11-13-Apr-2003).

2. THE MEASURING SYSTEM

2.1 Description of the ship

MT Uikku is a double hull ice breaking motor tanker with eight cargo tanks and two slop tanks. The ship was built in 1977 in Werft Nobiskrug GmbH in Rendsburg. The vessel was constructed to the highest Baltic ice class, I A Super. Ship's propulsion system has an Azipod unit and four diesel generators. In 1998 the hull was strengthened to allow her sail more safely in the Arctic waters. After the strengthening the hull was stronger than Baltic ice class I A Super demands. The main particulars of MT Uikku are presented in table 1. The side view of the ship in Oulu harbour is presented in Figure 1.

Table 1. Main particulars of MT Uikku.

Length, overall	164.4 m
Length, B.P.	150 m
Breadth moulded	22.2 m
Draught	12 m
Displacement	22600 ton
Deadweight	15750 ton
Propulsion power	11.4 MW
Speed	17 knots
Block coefficient	0.72



Figure 1. MT Uikku in Oulu harbour in 2nd of February 2003.

During winter 2003 Uikku navigated regularly between the ports in Gulf of Finland and Bothnian Bay. The ship has more power than average Baltic tanker, so she is able to navigate independently without icebreaker assistance most of the time. Normally she uses $\frac{1}{2}$ or $\frac{3}{4}$ of the full engine power in ice, but sometimes in heavy ice conditions she uses full propulsion power.

2.2 Instrumentation

For purposes of ARCDEV-voyage (Kotisalo and Kujala, 1998) MT Uikku was instrumented with 61 strain gauges to measure ice loads from different parts of ship hull. There were together 42 measuring channels (Vuorio, 1998). The bow ship instrumentation was repaired in 2000 (Lensu, 2002). During the winter 2003 this instrumentation were used. Ice loads were measured from 14 still working sensors, which were located in bow and aft ship areas. Measurements included loads on transverse frames in the bow and bow shoulder areas, stresses in the shell plating and frames in the bow and bow shoulder areas, power, torque and propeller revolution of the Azipod-unit. The measuring system was designed for operative ice load monitoring purposes. The description of the measuring hardware and monitoring program has reported Lensu and Karttunen (2001) and Karttunen (2001). In Table 2 ship propulsion variables and their scaling to physical units are given. All channels (propulsion and ice load data) were sampled at 200 Hz.

Table 2. Machinery data corresponding to recorded channels and the scaling.

Variable name	Program channel	Variable number	0-level [V]	Unit	Scaling	Frequency [Hz]
Power set	28	15	5.9753	%	0.007629	200
Power	29	16	3.3132	MW	0.000687	200
RPM	30	17	5.9765	RPM	0.015259	200
Torque	31	18	5.9853	%	0.008392	200



During the time the ship was in ice GPS measurements were made. GPS data includes date, time (UTC), latitude, longitude, speed in knots and course in degrees. GPS sampling frequency was 0.167 Hz.

During the second voyage (between Pori and Kotka, 20-21-Feb-03) EM ice thickness flights were made at the same area as the ship's route. This ice thickness data can be compared to data measured on onboard MT Uikku.

During the third voyage (between Porvoo-Oulu-Kemi, 11-13-Apr-03) laser profilometer was installed onboard the ship to measure ice top profile. This data can be used to estimate the amount of the ridged ice and also to estimate the average ice thickness along the ship route. Laser data was recorded about 24 hours along the route and the sampling frequency was 100 Hz.

3. DESCRIPTION OF THE VOYAGES AND THE RESULTS FROM THE MEASUREMENTS

Next summary of measured results are presented and the description of the voyages are given.

3.1 Voyage I: Porvoo-Oulu-Porvoo

Uikku left Sköldvik harbour in Porvoo at Friday 31-Jan-2003 at 19:20 (UTC+2h) in cargo condition. According to ice chart the ice thickness was about 30 cm. There was some amount of ridged ice east from Helsinki. Air temperature was about -10°C and wind direction was from south. Next stop was Tahkoluoto harbour in Pori (1-Feb-2003 at 00:00). Outside Pori there was mainly newly frozen thin ice. From Pori the ship continued after five hours stop towards Oulu. The ship entered into ice field at the same day in 63 degrees latitude north. In Bothnian Bay there were ridged and rafted ice north from Kokkola. The average ice thickness was approximately 40 cm. During the last part of the voyage near Oulu the ship got stuck in ice and she had to back and ram. Then she had to use full propulsion power for some time in order to carry on. She managed independently to Vihreäsaari harbour in Oulu in 2-Feb-2003 at 08:15. During the difficult part of the route before Oulu it was snowing and dark.

The ship continued from Oulu to Porvoo in 2-Feb-2003 at 22:20 in ballast condition. She got stuck in ice channel quite quickly and needed IB Urho to assist. Icebreaker assisted her for 3.5 hours. After that ice conditions changed much easier. The wind was blowing from south about 18 m/s and it was snowing. In 4-Feb-2003 at 22:00 in Gulf of Finland ice conditions changed into more difficult again. The ship needed full propulsion power and icebreaker Sisu to assist. MT Uikku arrived back to Sköldvik harbour in 5-Feb-2003 at 06:00. In Table 3 the ice observations and general notes of the voyage are presented. It can be noticed that in cargo conditions the ship managed without icebreaker assistance throughout, but in ballast condition she needed icebreaker assistance both in the Bothnian Bay and in the Gulf of Finland.



Table 3. Ice observations of the voyage.

Date	Time (UTC+2h)	Notes
31-Jan	19:20	thin ice. Fore 8.5 m, Aft 8.55 m.
Porvoo- Pori	21:30	$h_i = 5-10$ cm, new ice.
	22:40	Pori harbour. Moving slowly in thick ice channel.
	23:50	Docked Pori, Tahkoluoto.
01-Feb	04:50	Leaving pori, unloaded 1600 m ³ . Fore 8.6 m, Aft 8.75 m.
Pori-Oulu	09:00	New ice (5-10 cm), air -10°C , 6 MW, 133 rpm.
	10:40	Thin ice $h_i=10$ cm.
	11:15	Thin ice $h_i=20$ cm.
	12:10	Thin ice $h_i=20$ cm.
	12:30	Ice ridges, consolidated ice.
	13:00	Level ice $h_i=20-30$ cm.
	13:05	Thick ice $h_i=50$ cm.
	13:20	In ice channel, rafted ice.
	13:30	Consolidated ice $h_i=10$ cm, moving in ice channel.
	14:30	Consolidated ice blocks $h_i=20-30$ cm.
	14:35	Small ice ridges, $h_i=30$ cm, air temperature -7°C .
	15:35	Level ice 40 cm and ice ridges.
	16:00	More ridged ice.
	16:15	Rafted ice $h_i=40-50$ cm.
	16:30	Hitting an ice ridge.
	16:33	old ice channel.
	16:45	Passing 3 old ice channels, moving in ice channel.
	16:50	Thick rafted ice blocks, 0.5m x 5m x 5m.
	16:55	Moving in old ice channel.
	17:40	In ice channel, ice blocks 1m x 1m, $h_i=50$ cm. Snowing.
19:15	Moving in old ice channel.	
19:20	3 channels crossing, close ice.	
21:40	in ice channel, partly OW.	
21:45	Loose ice channel.	
21:55	Wide old channel, thick.	
23:55	Thin level ice.	
02-Feb	00:05	Thin ice.
Pori-Oulu	00:20	Ice ridges.
	00:30	Ice ridges, speed decreases, more power 6 MW->10 MW.
	00:31	9 MW.
	00:45	10 MW, 6 kn. Ram and stop.
	01:00	Stopped.
	01:05	Backing.
	01:10	11 kn ramming.
	01:20	Thin new ice.
	03:20	Thin new ice $h_i=10-20$ cm.
	07:20	Pilot onboard.
08:15	docked Vihreäsaari, Oulu.	



	08:15-22:20	unloading
	22:20	Leaving Oulu harbour, Fore 5.0 m, Aft 6.5 m.
	22:30	In ice channel.
03-Feb	01:30	Pilot got off.
Oulu-Porvoo	01:45	Compressive ice channel, full power 10 MW.
	02:00	Stuck, IB Urho assisting.
	05:30	IB Urho assis., compressive, thick ice.
	06:00	Independently in ice.
	09:30	Thin ice hi=10 cm, newly frozen channel.
	12:15	Level ice hi=40 cm, in channel edge.
	12:20	Level ice and ice channel, southwind 18 m/s.
	12:30	Level ice and channel.
	12:35	Wide ice channel, block size 1m x 1m.
	12:40	Mainly OW.
	12:50	Ice channel, consolidated sludge.
	13:00	Ice channel, ridged ice.
	13:01	Channel get narrow.
	13:15	Wider channel, small blocks, consolidated ice.
	13:55	Level ice hi=20-30 cm.
	14:03	Thin new ice..
	14:30	Sludge.
	14:35	Level ice 10 cm.
	14:37	Ice ridge.
	14:55	Rafted ice..
	16:45	Rafted ice, hi=40 cm, snow cover.
	16:46	In ice channel. Compressive ice.
	17:17	Rafted ice, compression releases.
	17:35	Thin ice.
	17:40	Rafted ice.
	17:50	Thick consolidated ice blocks, wind 17 m/s, snowing.
17:57	Thin ice.	
19:00	Moving slowly in close ice.	
19:10	Ice floes, OW.	
04-Feb	18:10	OW and ice slush..
Oulu-Porvoo	18:40	Small ice blocks loosly, block size 0.5 m x 0.5 m.
	20:10	Ice floes.
	21:00	Ice floes, size 5 m x 5 m.
	21:50	Many other ships near us.
	22:09	More solid ice, consolidated and rafte ice
	22:20	Compressive ice channel. Full power 10 MW.
	23:02	Stuck, backing.
	23:06	Ram.
	23:08	Stuck in ice.
	23:17	IB Sisu cuts off, moving in ice channel.
	23:32	New ice channel, 8 kn, 9 MW.
23:43	Wide ice channel.	
05-Feb	00:15	Wide ice channel, easy.

Oulu-Porvoo	00:23	Stuck in ice.
	00:33	Moving in ice channel, IB Sisu assis.
	00:40	Moving slowly in ice channel
	01:00	Pilot onboard.
	01:13	loose channel, block size 2m x 2m.
	01:45	Ice blocks, turning, snowing.
	02:02	Fast ice.
	02:20	In ice channel.
	02:35	Close ice.
	06:00	Docked in Sköldvik harbour.

In Figure 3 speed histories as a function of time and distance travelled are presented. In cargo condition (left figure) GPS data was gathered for 31 hours in cargo condition and for 28 hours in ballast condition (right figure) in ice. The distance travelled was about 550 nm in both cases of which half was ice-going.

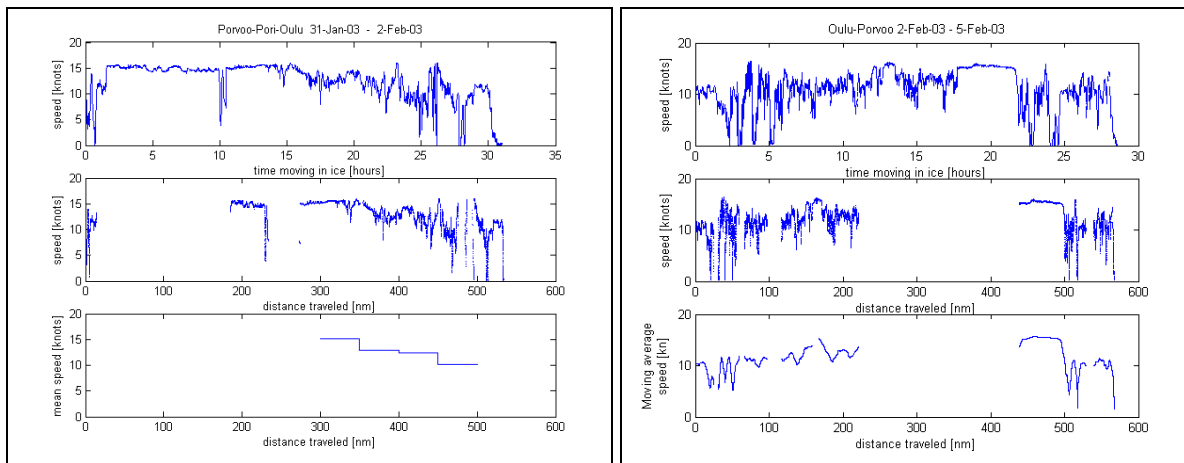


Figure 3. The ship speed as a function of time and distance travelled and mean speed plotted as a distance travelled in cargo and ballast condition.

In Figure 4 the route of MT Uikku from Porvoo to Oulu is plotted on ice thickness map generated by FIMR. The speed of MT Uikku is also presented. In open water the speed was over 15 kn. In thin ice (light blue) the speed decreases to 14 kn. Near to shore where the ice was as its thickest the speed was about 10 kn. It can be seen that speed decreases locations where ship enters to thicker or thinner ice. In this intermediate ice may be more ridged than usually. It can be seen that north from Hailuoto and near Pori and Porvoo the speed was under 10 kn (red color). In these areas the ship got stuck in ice. In areas of thick ice (yellow and orange) the speed varies much more than in thin ice or in open water.

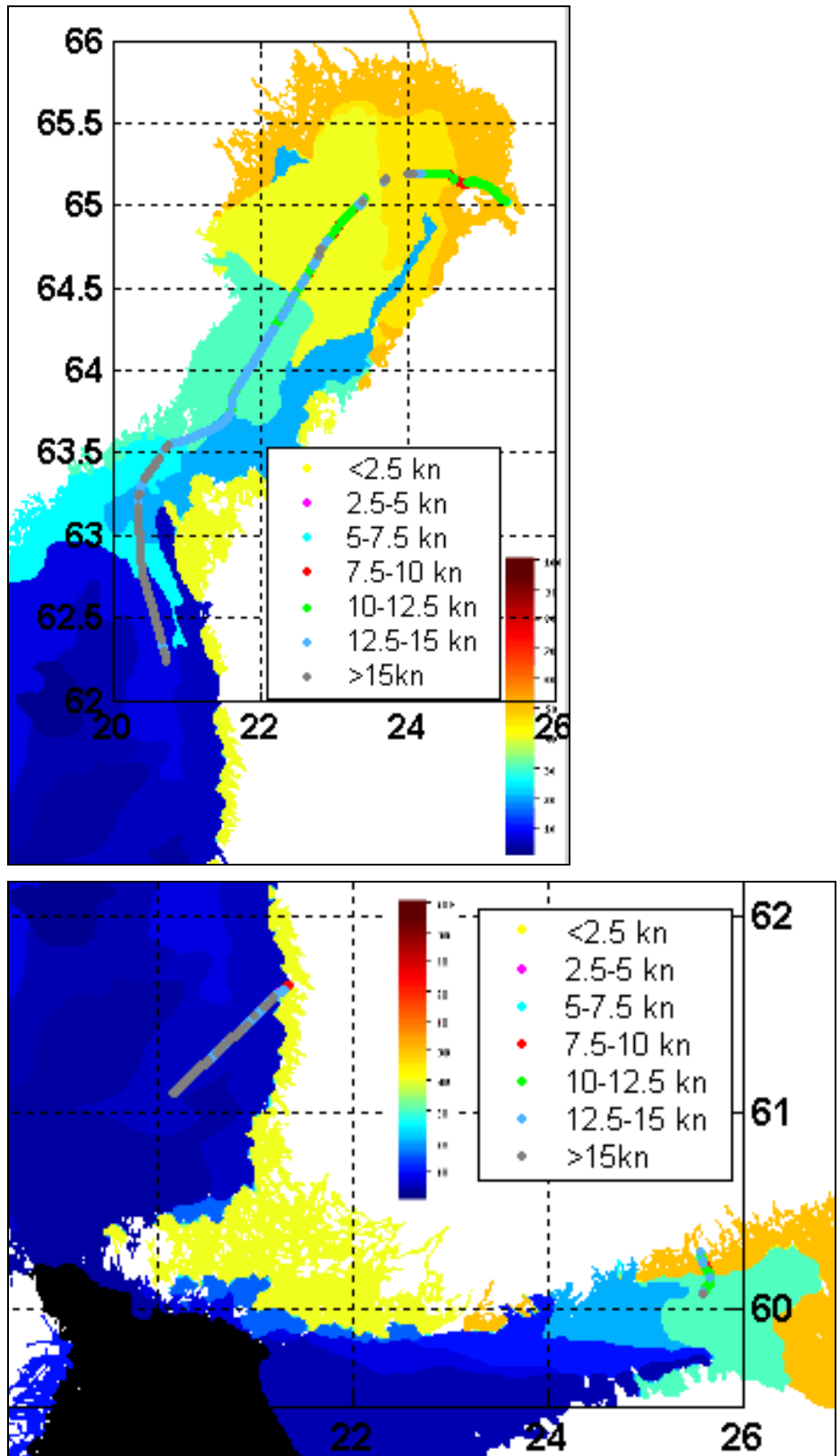


Figure 4. Route of MT Uikku between 31-Jan-03 and 2-Feb-03 from Porvoo to Pori and Oulu harbours plotted in ice thickness chart.

In Figure 5 the route of MT Uikku back from Oulu to Porvoo is presented. The ship was in ballast condition. It seems that the speed variation in thick ice is even larger in ballast than in

cargo condition. In ballast condition she needed icebreaker assistance near Oulu for 3.5 hours and two times near Helsinki. Uikku got stuck in ice five times in cargo conditions and six times in ballast conditions.

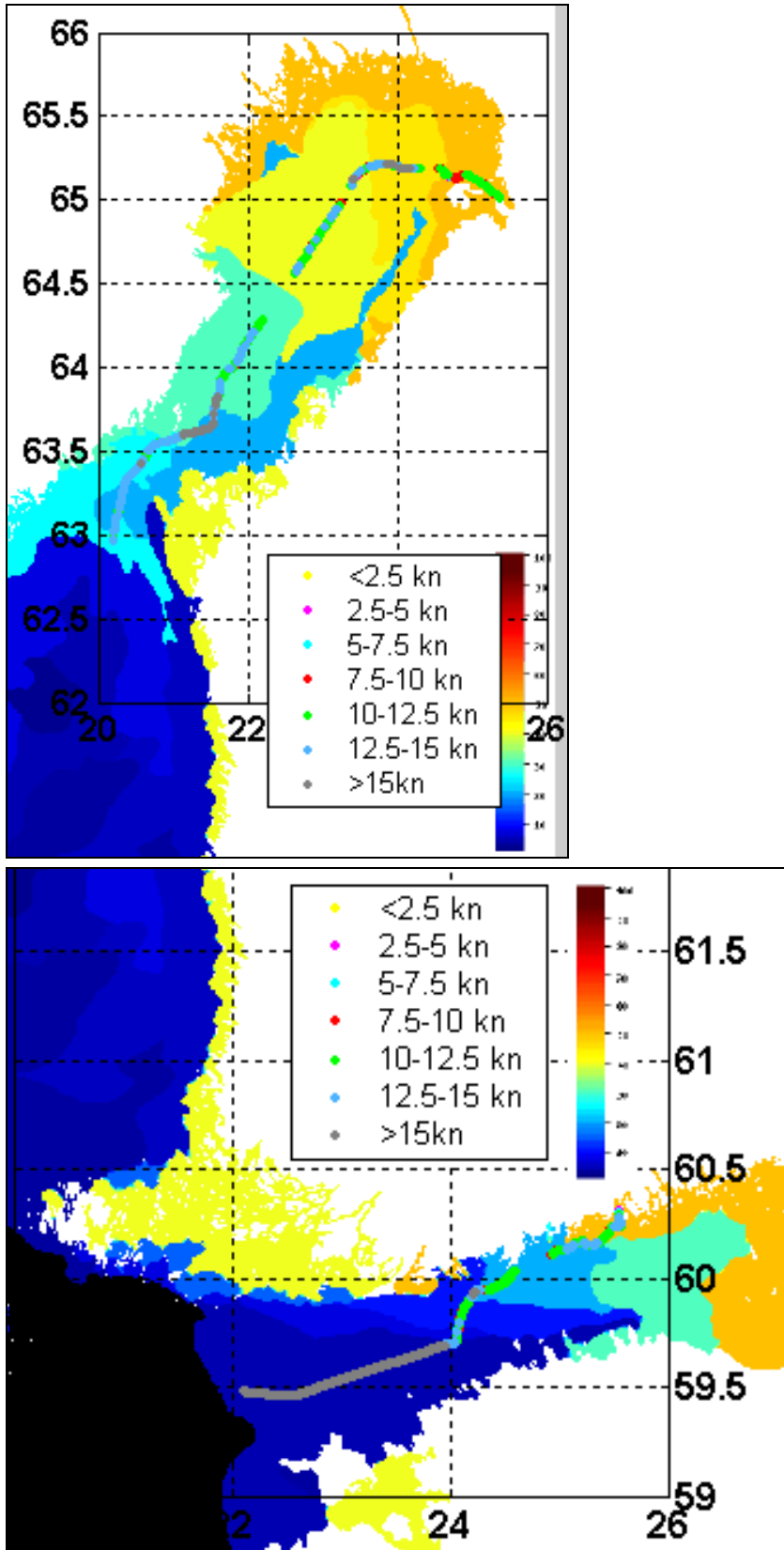


Figure 5. Route of MT Uikku between 2-Feb-03 and 5-Feb-03 from Oulu to Porvoo harbour plotted in ice thickness chart.

In Figure 6 the ship route and speed plotted in ice thickness chart in Bothnian Bay are presented. The speed varies between 5 to over 15 knots being most of the time over 10 knots. Some portion of the GPS data is missing.

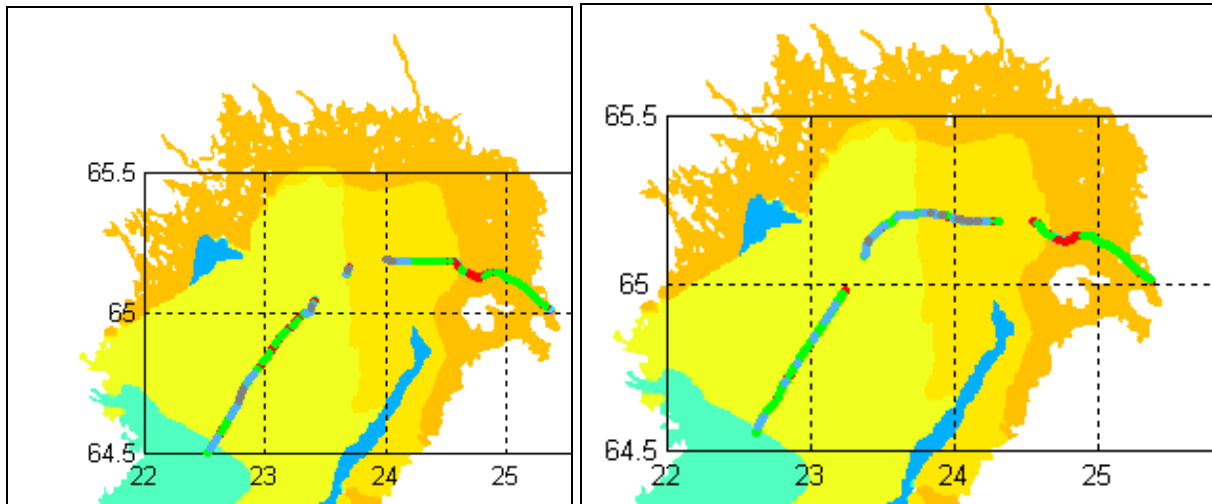


Figure 6. Route of MT Uikku in the Bothnian Bay in cargo (left) and ballast (right) conditions.

In Figure 7 speed histograms in cargo and ballast conditions are presented. The speed distribution has two peaks. One is near to the open water speed 16 knots and the other is the ice-going speed, which is typically 10 to 12 knots. Speed values near to zero are mainly due to being stuck in ice. In ballast condition the “ice peak” is higher and a bit more to the left than in cargo condition. In ballast condition the ship has been stuck in ice for longer period than in cargo condition.

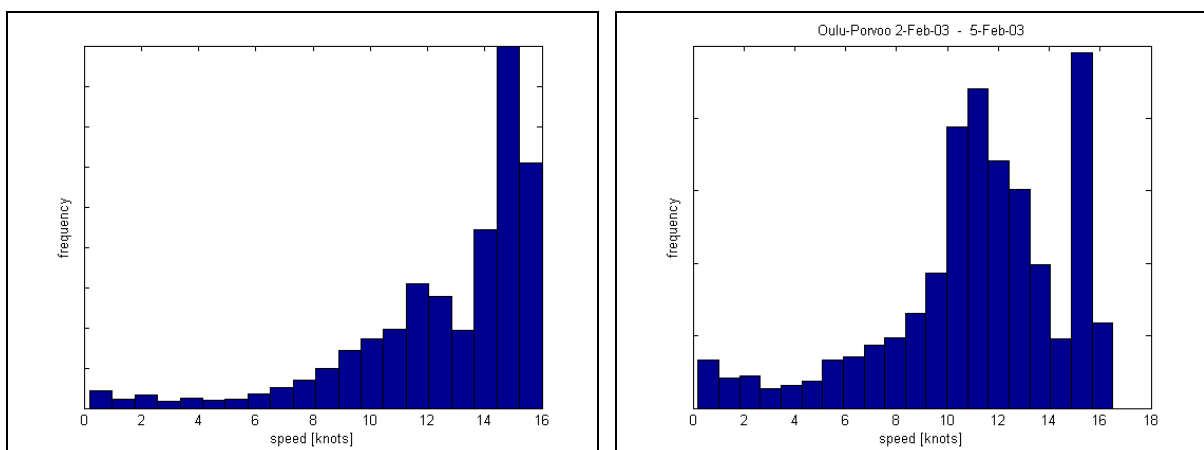


Figure 7. Histograms of speed data in ice in cargo (left) and ballast (right) conditions.

In Figure 8 the distances travelled as a function of time are presented. The voyage from Porvoo to Oulu took 56 hours plus 5 hours stop in Pori. The voyage back to Porvoo took 56 hours. Ice conditions in the Gulf of Finland were more difficult in 4-Feb than in 31-Jan. MT Uikku selected another route in return voyage in the Gulf of Finland and she confronted much more ice during that part of the route than earlier.

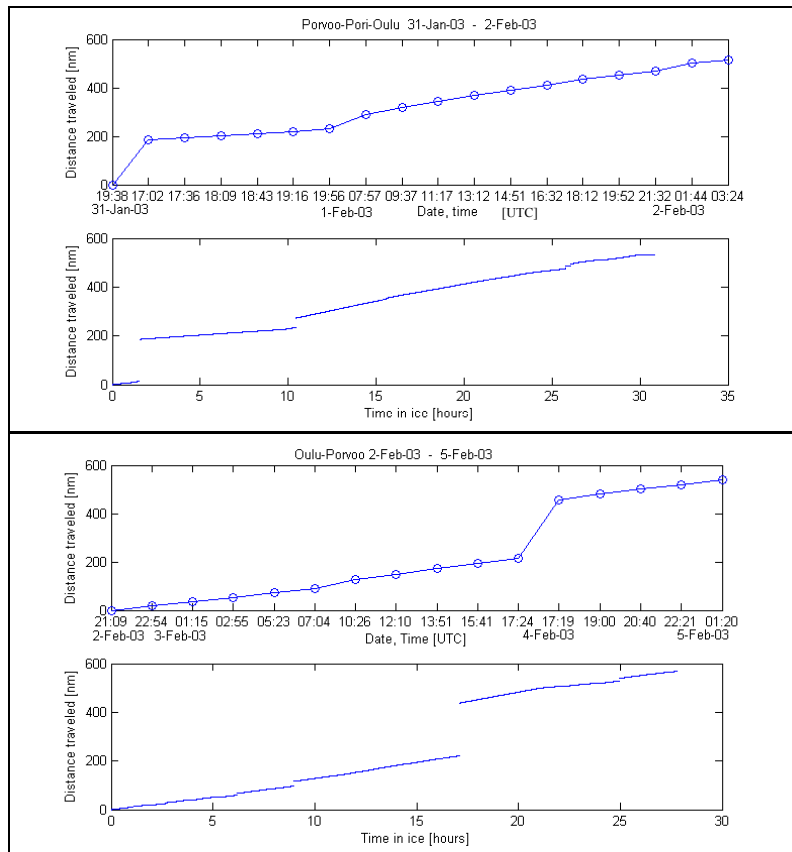


Figure 8. The distance travelled as a function of date/time and as a function of time in ice.

In Figures 9 and 10 the propulsion power, torque, propeller revolution and ice loading histories are presented. From voyage from Porvoo to Oulu (Figure 9) three periods of three hours are selected. These are measured in the Bothnian Bay. Of the total nine hours MT Uikku had to use full propulsion power 10 MW for 5 hours. According to propeller revolution history it can be seen that MT Uikku got stuck in ice for 5 times during first 6 hours. Then she had to back and ram. The highest load peak in the bow frame, 900 kN/m, was observed in February 2nd at 01:10. The ship had just confronted an ice ridge that she could not get through at first attempt. Then she backed and hit the ice ridge again with speed of 11 kn. In that situation the high ice load value was observed. In Figure 9 (the lower) the ship arrived to Oulu harbour.

From voyage from Oulu to porvoo (Figure 10) four periods of three hours are selected. Two upper figures are measured in Bothnian Bay and the lower are from Gulf of Finland. Of the total six hours in Bothnian Bay she had to use full propulsion power 10 MW for 4 hours. The ship got stuck in ice for 4 times during first 6 hours. During this period IB Urho assisted her. Also the icebreaker got stuck in ice for couple of times. The highest ice load value 1500 kN/m was observed quite near to Oulu in old ice channel. It might be due contact with ice edge with relatively high speed. In the Gulf of Finland (lower figures) the ship had to use full propulsion power for 1.5 hours of total six hours. She got stuck in ice two times. When she got first time stuck IB Sisu cut the ship free. The highest ice load value 1100 kN/m was observed when the ship was turning in easy-going floe ice.

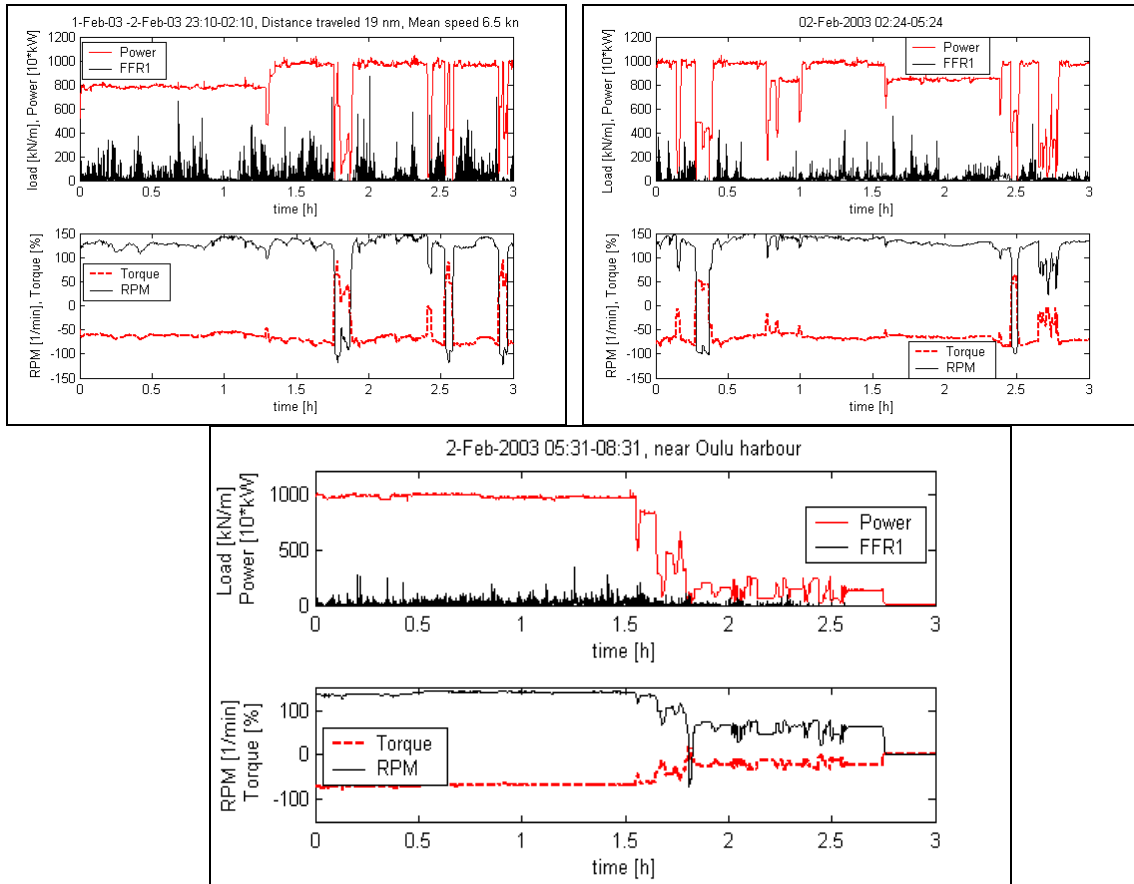


Figure 9. Machinery data and ice induced loads during 1-2-Feb-2003 near Oulu.

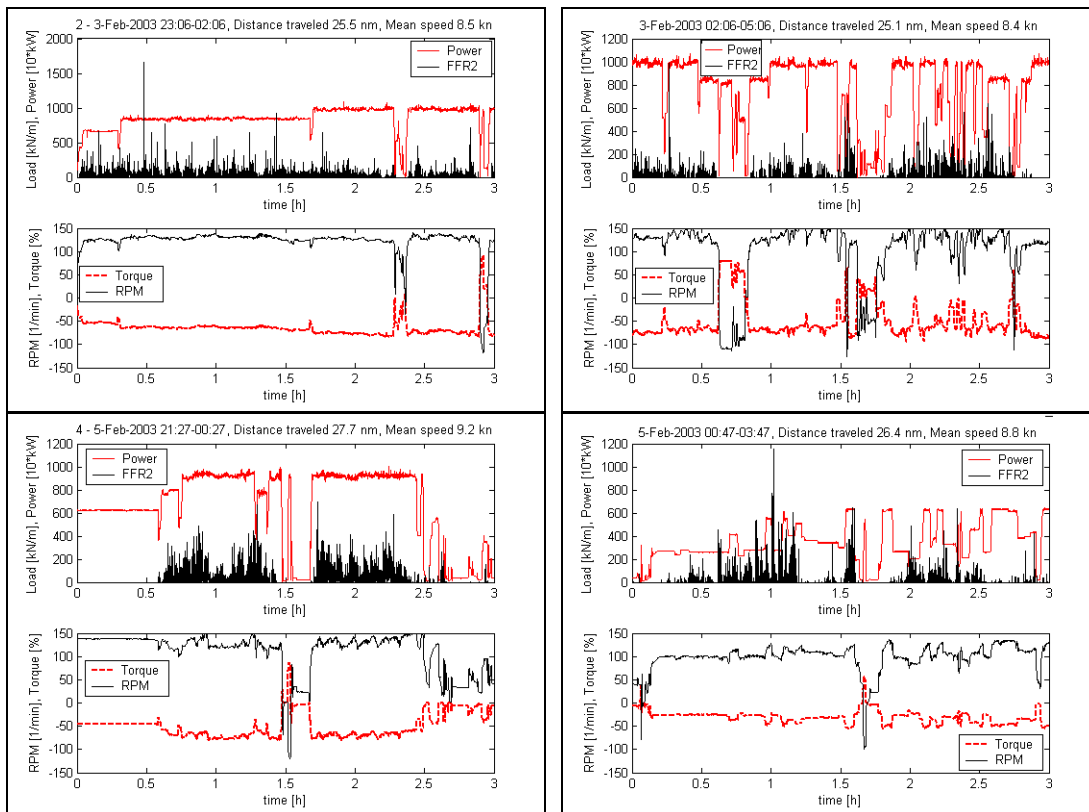


Figure 10. Machinery data and ice induced loads during 2-5-Feb-2003 from Oulu to Porvoo harbour.



3.2 Voyage II: Pori-Kotka

This voyage was done between 20-Feb-2003 and 21-Feb-2003 from Tahkoluoto harbour in Pori to Mussalo harbour in Kotka. The ship was half loaded so that Uikku had 6 m draught in the fore ship and 7.35 m in the aft ship. Ice conditions were light from Pori to Helsinki. East from Helsinki to Kotka there were thick (50 cm) rafted ice. During the voyage there were three black outs and due to black outs the ship could not keep up full propulsion power for longer periods. The air temperature was about +5°C during the daytime and -5°C during the night. The weather was very bright during the day, but during the nighttime there were fog. Wind was from NE about 4 m/s. In Table 4 the ice observations and general notes of the voyage are presented. One purpose of this voyage was to do ship based observations simultaneously with ice thickness measurements conducted by another research group in the same area. Ice thickness was measured airborne using EM-technique.

Table 4. Ice observations of the voyage.

Date	Time (UTC+2h)	Notes
20-Feb	06:15	Leaving Tahkoluoto harbour in pori. Fore 6 m, Aft 7.35 m.
	06:35	Ice channel.
	07:00	Floe ice.
	07:10	Stop, pilot off. Rafted ice.
	07:39	Large ice floes and rafted ice.
	07:45	Thin ice and ice ridges.
	07:56	Thinner ice hi=10 cm.
	08:47	Thin ice floes.
	09:00	Thin new ice hi=10 cm.
	09:30	Thin level ice hi=10 cm.
	10:22	Thin ice hi=20 cm.
	10:55	Ice floes 1m x 1m.
	11:30	Thin ice, MS Kontula.
	11:46	Rafted ice.
	12:00	Thin ice, OW.
	13:30	Level ice hi=20 cm.
	13:47	Ice floes, air +5°C, sunny.
	14:05	Floe ice..
	14:50	”Black Out”, engine down for one minute.
	15:11	Moving again..
	16:25	”Black Out” again.
	17:10	Thin ice floes.
	18:00	OW.
	21:45	Thin ice.
	22:15	Thin ice floes.
	23:45	Ice floes..
21-Feb	00:10	Ice floes Diameter = 2-3 m, hi=10 cm.
	00:12	Beside ice channel.
	00:17	Rafted ice, speed decreases.
	00:30	Thin level ice and ice floes.

00:40	Ice floes Diameter = 2 m.
01:00	Compression.
02:40	Rafted ice.
03:55	Ice channel
04:15	Floe ice Diameter = 4 m.
05:23	Level ice.
06:00	Rafted ice, fog.
07:48	Stuck, backing. hi=50 cm and snow thickness 10 cm.
07:55	Ridged ice hi = 50 cm, fog.
08:17	Ridged ice. Power 10.5 MW, speed 10 kn.
08:30	Easy-going rafted ice hi=20cm.
08:40	Loose, wide ice hannel, 6.5 MW.
08:55	Ice floes Diameter = 2 m.
09:17	Old wide ice channel.
09:40	Turning.
09:48	Stop, pilot onboard.
10:00	Moving again in ice channel.
13:22	Ice channel, 3 times wider than the ship.
13:32	Mussalo harbour in Kotka.

In Figure 11 the route and the speed of MT Uikku from Pori to Kotka is plotted on ice thickness map. Thicker ice can be found east from Helsinki. East from 25 degrees longitude the ship speed was drop to 7.5-10 kn (red line). There were thick rafted ice and the ship could not use full propulsion power due to risk of “black out”. After that the ship found an old ice channel and the going was less difficult. In Figure 12 is plotted the route of the ship and the EM thickness flight paths. EM thickness measurement gives an ice thickness distribution along the flight track. This data is possible to compare to ship observations.

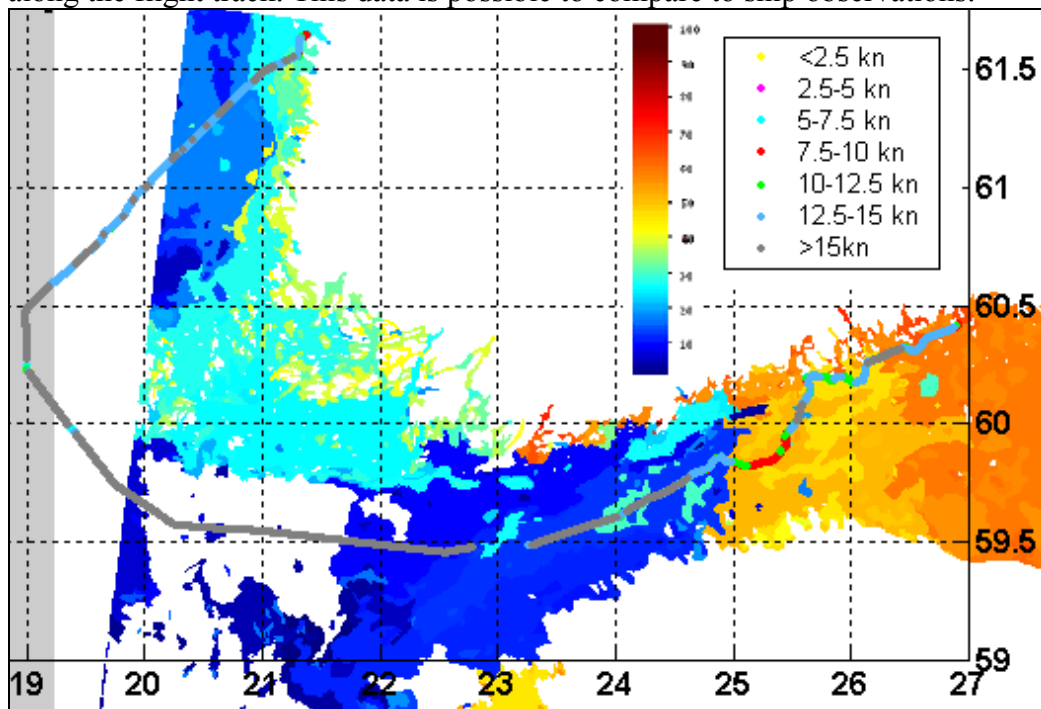


Figure 11. Route of MT Uikku during 20-21.2.2003 from Pori to Kotka harbour plotted in ice thickness chart.

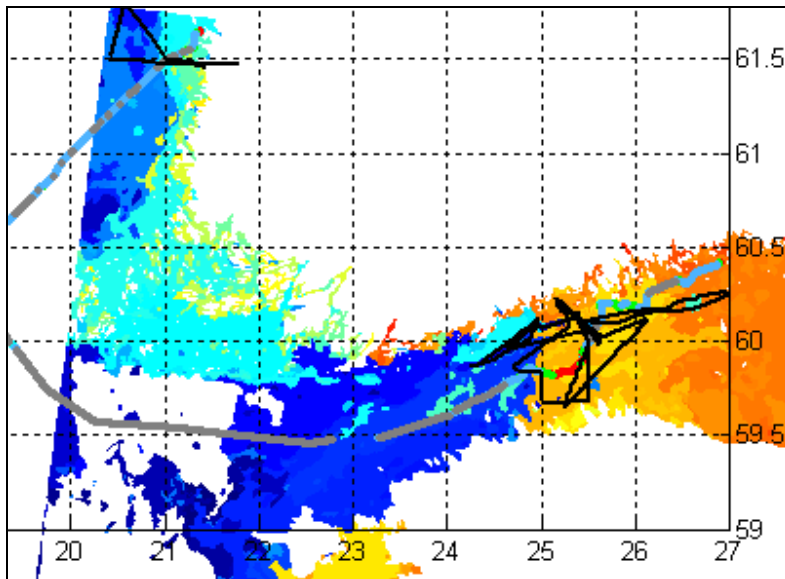


Figure 12. Route of MT Uikku and EM thickness flight paths 17-23-Feb-2003 (black lines).

In Figure 13 (left) the histogram of the speed data of MT Uikku is presented. The speed distribution has two peaks. One is near to open water speed 16 knots, but the other is about 9 knots. This is due to difficult ice conditions in the Gulf of Finland. It is a bit lower value than during voyage I (Figure 7). That is probably due to fact that the ship could not use full propulsion power in ice, because there was a risk of engine malfunction. In Figure 13 (right) the ship speed history is presented. GPS data was gathered for 32 hours and the distance travelled was 400 nm. The data was gathered throughout the voyage even if there wasn't ice present. During the last 100 nm there was a lot of variation in speed data and the average speed was below 10 kn.

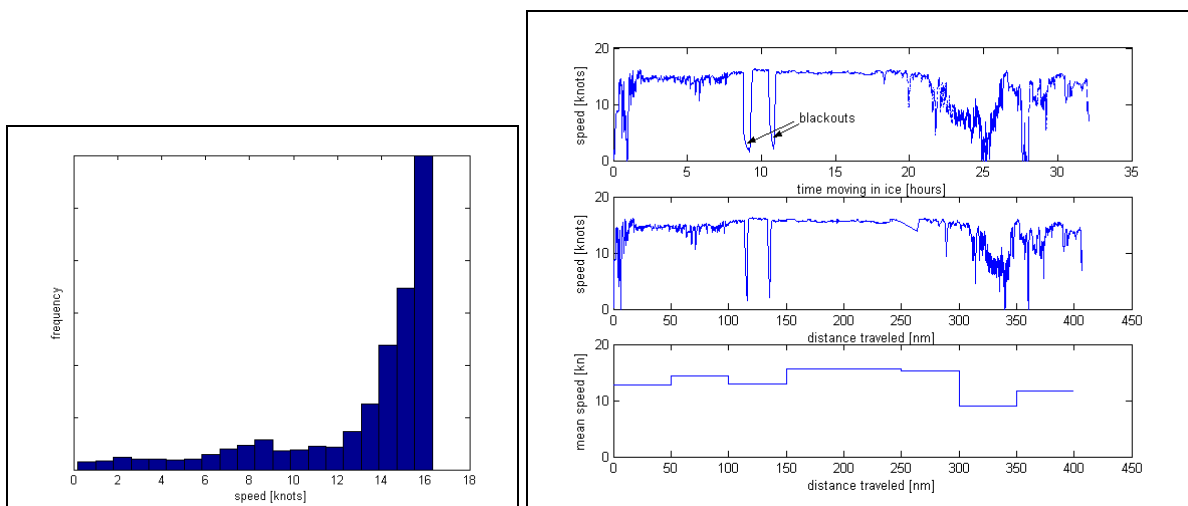


Figure 13. Histogram of the speed data in ice and the ship speed as a function of time and distance travelled and mean speed plotted as a distance travelled.

In Figure 14 the distance travelled as a function of time is presented. The voyage from Pori to Kotka took 32 hours. It can be seen a slight change in the slope of the distance-time curve when the ship entered to thick and rafted ice field in the Gulf of Finland.

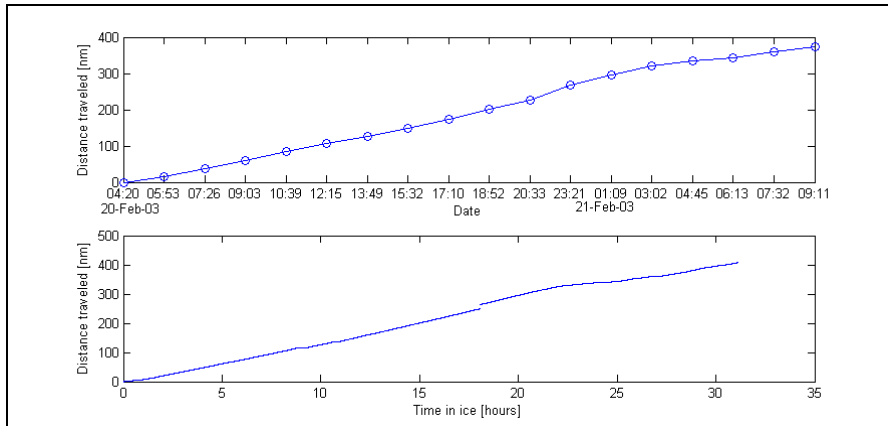
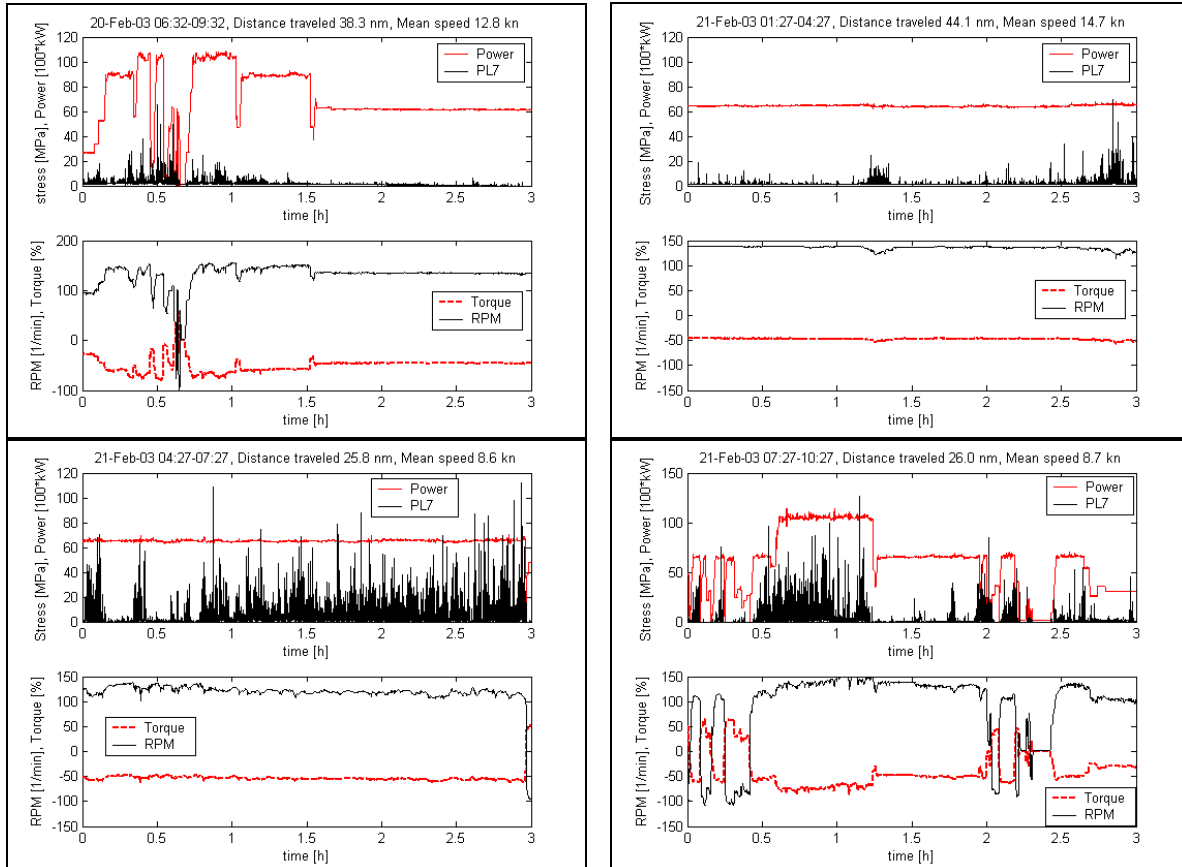


Figure 14. The distance travelled as a function of date/time and as a function of time in ice.

In Figure 15 the propulsion data and ice-induced stresses in the bow plating are presented. There is 6 time periods covering over 15 hours presented. It can be seen that the ship used full propulsion power only near Pori for 0.5 hour and in the Gulf of Finland in 21-Feb-2003 at 08:00 for 0.5 hour. The ship got stuck in ice for three times in one particular location. That was situation when the ship tried to break her way to an old ice channel. Ice-induced stresses exceeding 100 MPa were observed three times in the Gulf of Finland. Those were measured during a period when the ship travelled in thick rafted ice field with average speed of 8.6 kn. One of the peaks was observed when the ship used 10.5 MW power and the others with 6.5 MW.



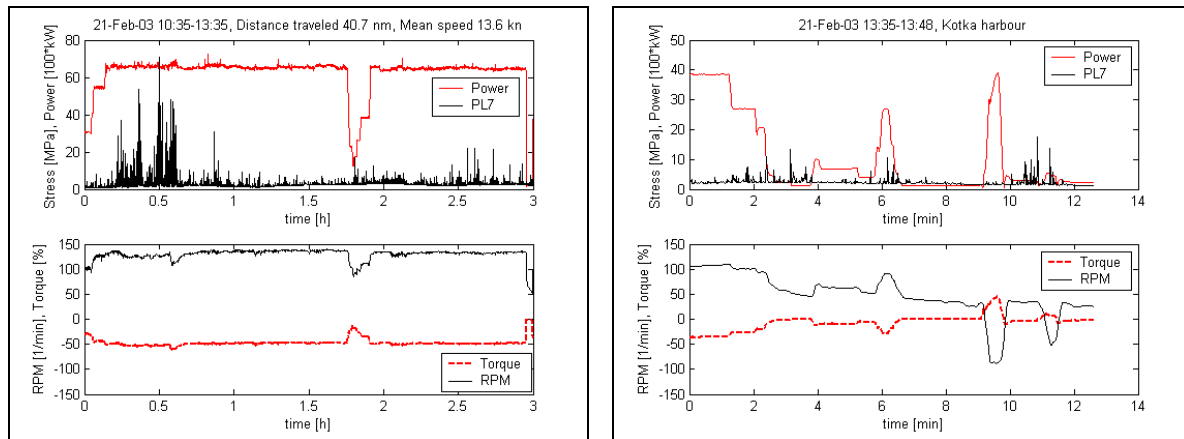


Figure 15. Machinery data and ice induced stresses in the plating during 20-21-Feb-03 from Pori to Kotka harbour.

3.3 Voyage III: Porvoo-Oulu-Kemi

This voyage was done between 11-Apr-2003 and 13-Feb-2003 from Sköldvik harbour in Pori to Vihreäsaari harbour in Oulu and from Oulu to Ajos harbour in Kemi. The ship was in cargo condition. There was thick ice (over 50 cm) in the Gulf of Finland and in the Bothnian Bay. However, the ice cover extent was decreasing. The air temperature was about +5°C during the daytime and 0°C during the night. There was east wind for most of the time. The wind speed was less than 10 m/s. The ship had some difficulties due to heavy ice in the Gulf of Finland and outside Hailuoto (Oulu). From Oulu to Kemi the ship traveled in old ice channel without any difficulties. In Table 5 the ice observations and general notes of the voyage are presented. During this voyage ice top profile was measured using laser technique. This data can be used to estimate the amount of the ridged ice and also to estimate the average ice thickness along the ship route.

Table 5. Ice observations of the voyage.

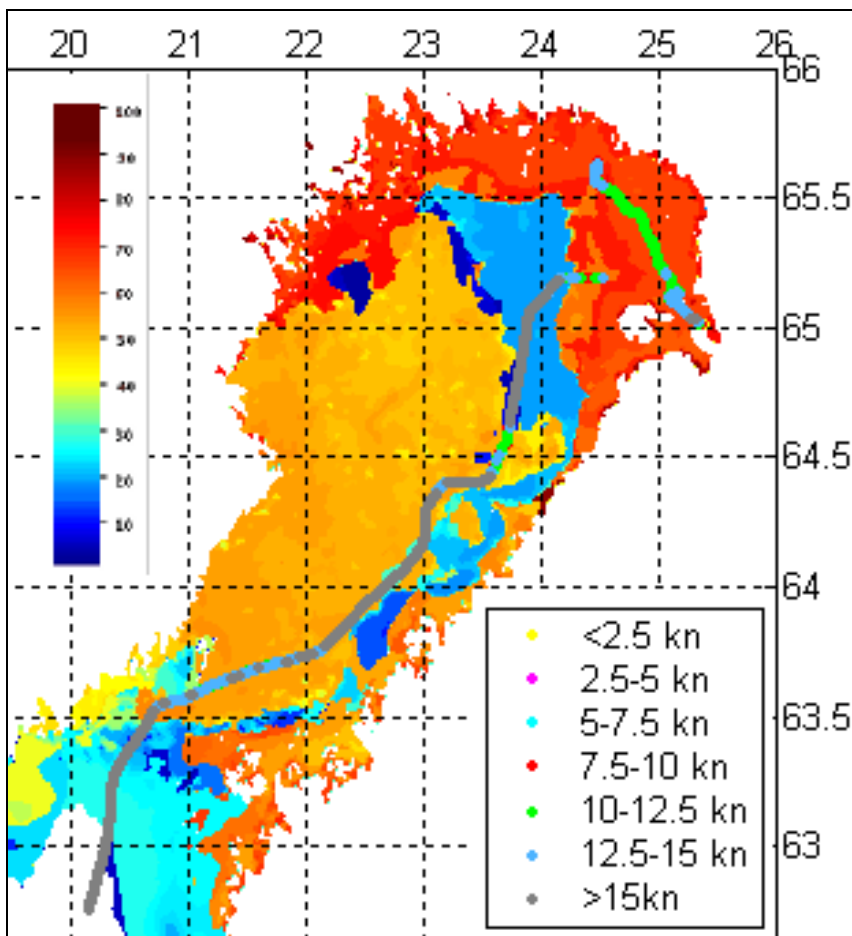
Date	Time	Notes
11-Apr	03:45	Leaving Sökldvik, Porvoo. OW. Fore 9.3 m, aft 9.3 m.
PORVOO-OULU	04:10	Loose ice channel.
	04:24	Turning in ice channel.
	04:30	5.9 MW.
	04:35	Ice floes..
	04:50	Pilot off, hi=15 cm.
	05:05	thicker, ridged ice. 7.4 MW.
	05:06	Ice ridge, back and ram.
	05:25	Ice floes Diameter = 10 m.
	05:35	level ice.
	07:45	Ice ridges.
	07:49	7.5MW, 133 rpm.
	07:52	Thin ice.
	08:33	Ridged and rafted ice h=90 cm.
	08:39	Ice floes D=3m.
08:51	Rafted ice.	



	09:06	hi=40 cm, hmax=100 cm. Rafted ice. 6.1 MW, 128 rpm.
	09:41	Hitting an ice ridge.
	09:42	Sludge, 6.15MW, 125 rpm.
	09:50	Sludge and ice floes.
	09:54	6.2 MW, 128 rpm. Rafted ice.
	10:25	Ice ridges, 6.2 MW.
	10:40	Thin ice floes.
	10:45	6 MW, 130 rpm. Thin ice floes. about 10 other ship stuck in ice.
	11:15	Ridged and rafted ice, hi=40 cm.
	11:41	Transfennica ro-ro pass us with speed of 19 kn.
	11:47	Floe ice, 7.7MW, 139 rpm. 15 kn.
	12:11	Loose ice channel, OW begins.
12-Apr	07:30	OW.
PORVOO-OULU	08:47	6.15 MW, 135 rpm, 15.6 kn.
	09:30	Sludge.
	09:40	Hitting a large ice floe 15 kn.
	11:00	10.3 MW, 150 rpm. Rafted ice.
	11:13	9 MW, 137 rpm. Ridged ice.
	11:15	In ice channel.
	11:23	Rafted ice hi=100 cm.
	11:52	Passing IB Sisu ja MS Flintersky. Beside old ice channel.
	12:11	Loose ice channel.
	12:12	Passing MS Apollokraft via rafted ice field hi=100cm.
	12:34	In ice channel
	13:15	Thin ice.
	13:35	OW.
	14:12	OW and ice floes.
	16:34	More ice floes.
	17:30	Rafted ice hi= 100cm. Speed decreases, compression.
	17:50	No more compression.
	17:55	Rafted ice hi=40cm.
	18:02	Ice ridges, hi=40 cm.
	18:20	Compression, hi=100cm.
	18:37	Rafted ice.
	18:39	Old consolidated ice channel, 9.2MW.
	19:00	OW.
	21:35	Wide ice channel.
	21:57	Turning in ice channel. 9.2MW, 125 rpm.
	22:02	Changing the ice channel.
	22:10	New ice channel..
	22:15	Stop, back and ram.
	22:26	Between two ice channels.
	22:32	Stop, back and ram.
22:42	Stop, back and ram (same location as previous).	
22:56	Stop, back and ram (same location as previous).	
23:20	Stop, backing (same location as previous).	
23:26	Waiting for icebreaker.	
23:48	IB Urho assis.	

13-Apr	00:05	Loose old ice channel.
	00:30	Pilot onboard.
	02:55	Docked in Vihreäsaari, Oulu.
OULU-KEMI	07:50	leaving Oulu. Fore 8.05 m, Aft 8.2 m.
	08:13	Old consolidated ice channel, level ice..
	09:07	In ice channel, larger ice blocks.
	09:08	Changing the ice channel.
	09:11	Level ice.
	09:14	Old wide ice channel.
	10:11	Narrow ice channel 6MW.
	11:27	Ice channel 6MW.
	13:00	Docked in Ajos, Kemi.

In Figure 15 the route and the speed of MT Uikku from Porvoo to Oulu and Kemi are plotted on ice thickness map. In the Gulf of Finland the ship speed in ice was 12.5-15 knots for the most of the time. In the Bothnian Bay the ship used open water areas near to Finnish coast. From Oulu to Kemi MT Uikku moved in old consolidated ice channel with speed of 10 knots. Overall the speed seems to vary more in areas where ice is changed to more thicker or thinner one.



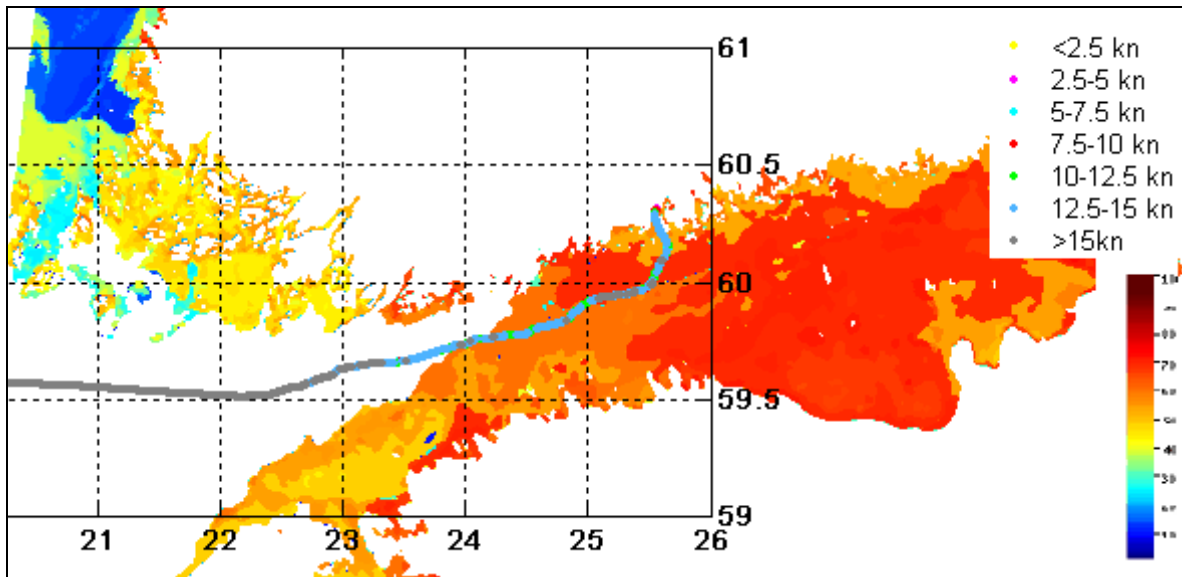


Figure 15. Route of MT Uikku during 11-13-Apr-2003 in the Gulf of Finland and in the Bothnian Bay plotted in ice thickness chart.

In Figure 16 (left) the histogram of the speed data of MT Uikku is presented. In Figure 16 (right) the ship speed history is presented. GPS data was gathered for 42 hours and the distance travelled was 700 nm. The ship moved in ice about 400 nm.

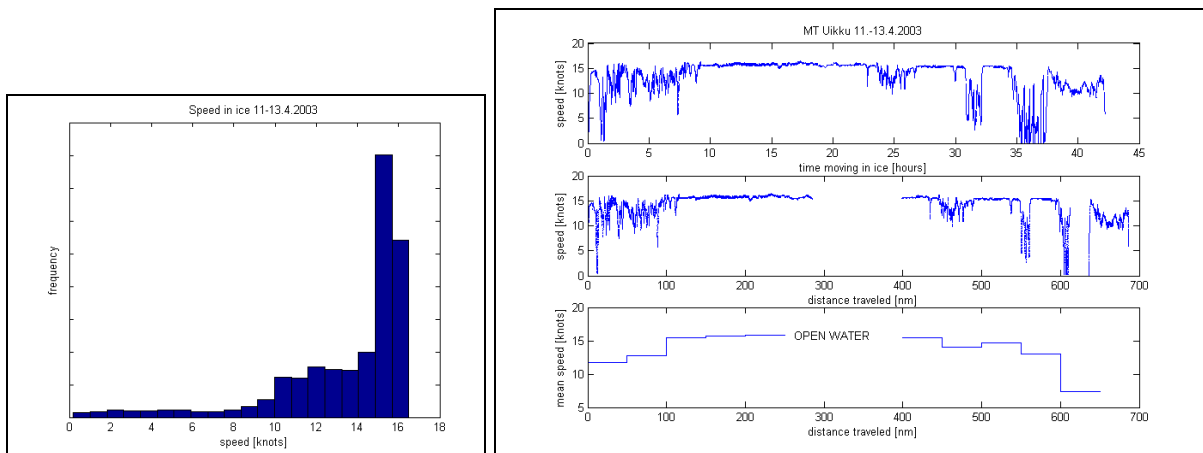


Figure 16. The ship speed as a function of time and distance travelled and mean speed plotted as a distance travelled in cargo and ballast condition.

In Figure 17 the distance travelled as a function of time is presented. The voyage from Porvoo to Oulu took 48 hours and from Oulu to Kemi 5 hours.

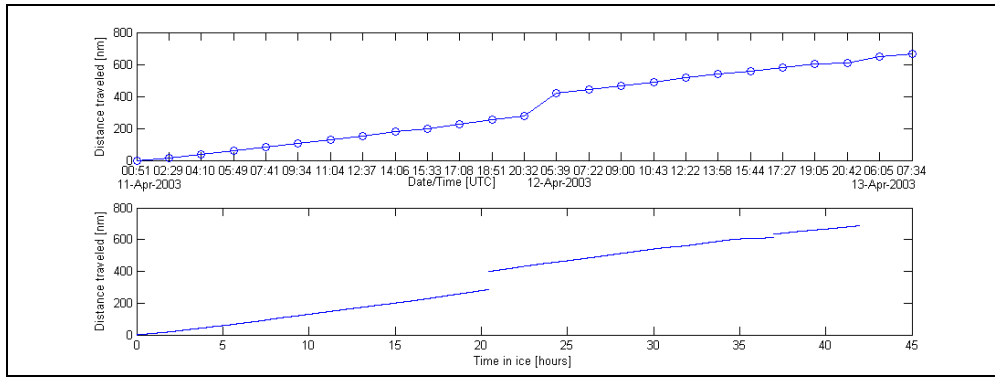
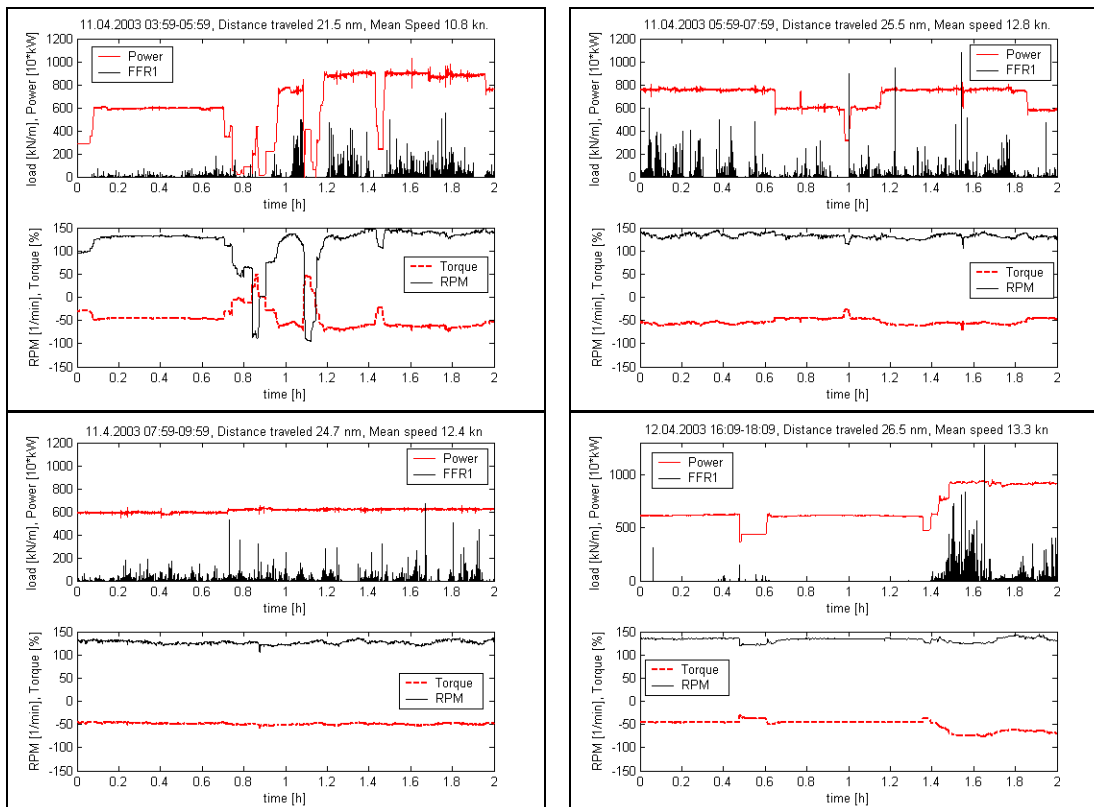


Figure 17. The distance travelled as a function of date/time and as a function of time in ice.

In Figures 18 and 19 the propulsion data and ice-induced loads in the bow frame are presented. From the Gulf of Finland six hours period (11-Apr, 03:59-09:59) is selected. It can be seen that the ship got stuck in ice for one time in the Gulf of Finland. That was when she hit an ice ridge with moderate low propulsion power. In Gulf of Finland the ship used 9 MW propulsion power for half an hour. The largest ice load, 1000 kN/m, was observed in ridged ice field with propulsion power of 7 MW and speed of 13 kn. From the Bothnian Bay 10 hours time period is selected (Figure 18). The ship used 9 MW power for 1.5 hours and full power 10 MW for 2 hours. She got stuck in ice for 5 times in one difficult location and she needed icebreaker assistance in order to carry on. The highest ice load 1300 kN/m was observed just before open water in rafted and ridged ice. The speed was 13 knots and the propulsion power was 9 MW. In Figure 19 the data between Oulu and Kemi is presented. The ship operated in old consolidated ice channel using 6 MW power and speed was 10 kn. One large ice load value was observed. Possible reason is contact with edge of the ice channel.



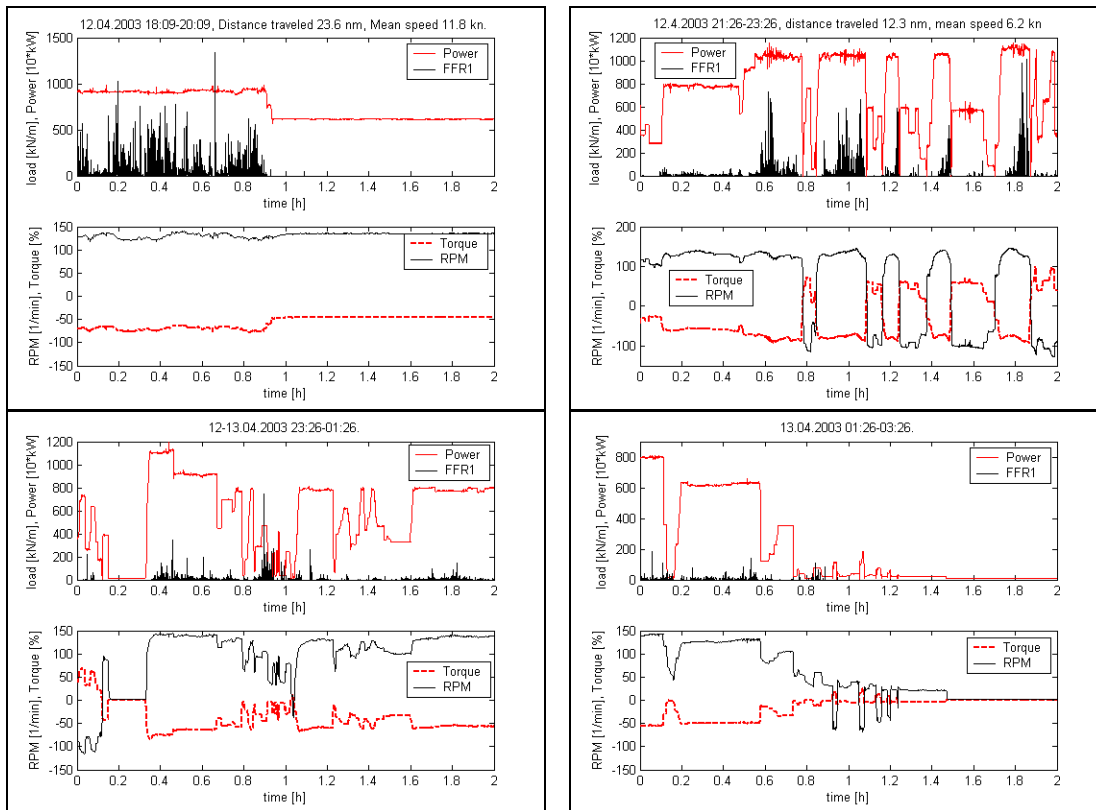


Figure 18. Machinery data and ice induced loads during 11-12-Apr-03 from Porvoo to Oulu harbour.

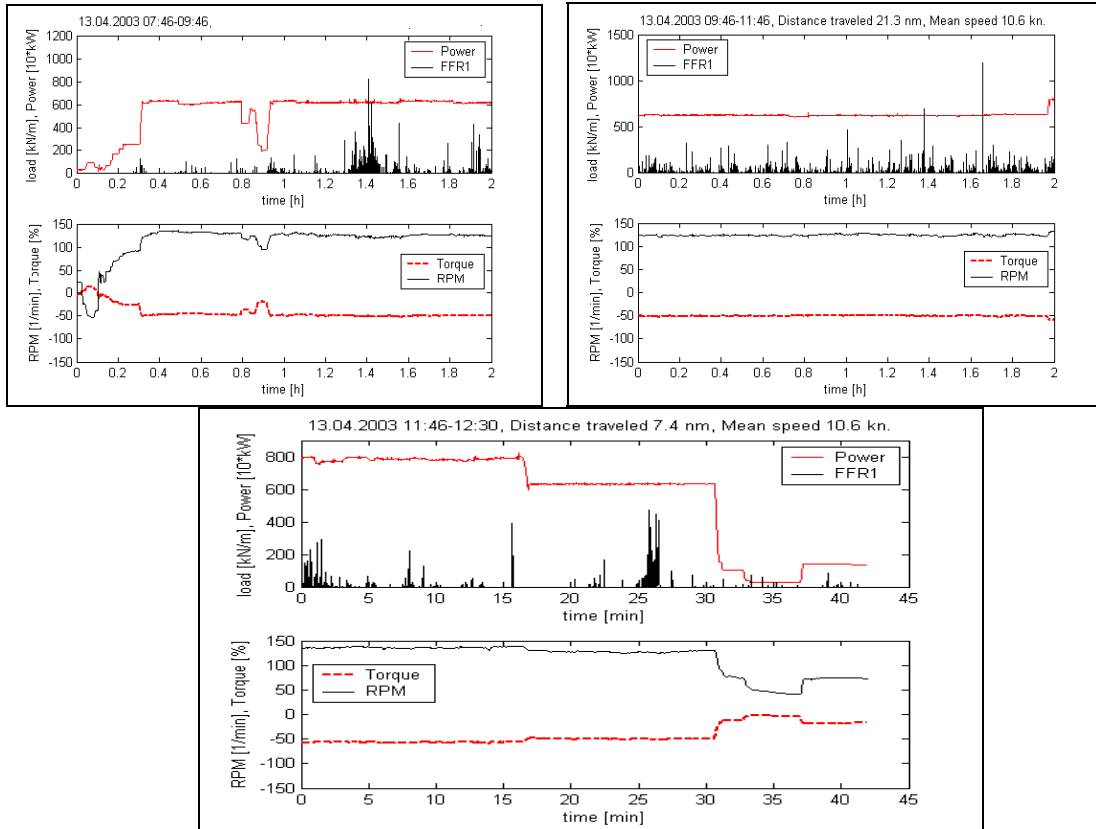


Figure 19. Machinery data and ice induced loads during 13-Apr-03 from Oulu to Kemi harbour.

4. CONCLUSIONS

In this paper description of manned voyages onboard MT Uikku during winter 2003 was given. The measured data gives an opportunity to study relationships between ship navigation, ice conditions and ice-induced loads. Machinery data and ice loads were collected automatically throughout the winter from 31-Jan-2003 to 30-Apr-2003. This data and ship log can be used for suchlike analysis to cover whole winter navigation of MT Uikku.

MT Uikku is a powerful ship and well suited for ice navigation. She needs icebreaker assistance quite seldom and she can maintain moderately high speed in ice. During the manned voyages the ship ice-going speed was normally 12 knots and open water speed 16 knots. In ice-going situation the speed varies greatly and in heavy ice she had to use full propulsion power 10.5 MW. Normally she used 7 MW in ice. The ship route and speed was compared with ice thickness map. The speed was kept 12.5-15 kn in thin ice and 10-12.5 kn in thicker ice. The speed seemed to vary quite a lot in intermediate area between thicker and thinner ice. In those areas there might be more ridged and rafted ice. The propulsion power was increased when the ship entered to thicker ice field. Ice thickness maps can be used in route optimisation, to avoid heavy ice and to minimize time needed between two winter harbours. However, information of ridged ice is also needed. The ship got stuck in ice couple of times. Some of these happened in rafted and ridged ice field. Icebreaker assistance was needed three times. Two times near Oulu and one time in the Gulf of Finland. It seemed that ship had a bit more difficulty to manage in heavy ice in ballast condition than in cargo condition (Voyage I).

During these three manned voyages 2200 nm were travelled of which about 1100 nm were ice navigation. 130 hours of data were gathered of which about 100 hours were ice operations. The voyages distance travelled as a function of time in ice are presented in Figure 20. The voyages were made between January and April 2003. The ship moved both in ice channels and natural ice fields.

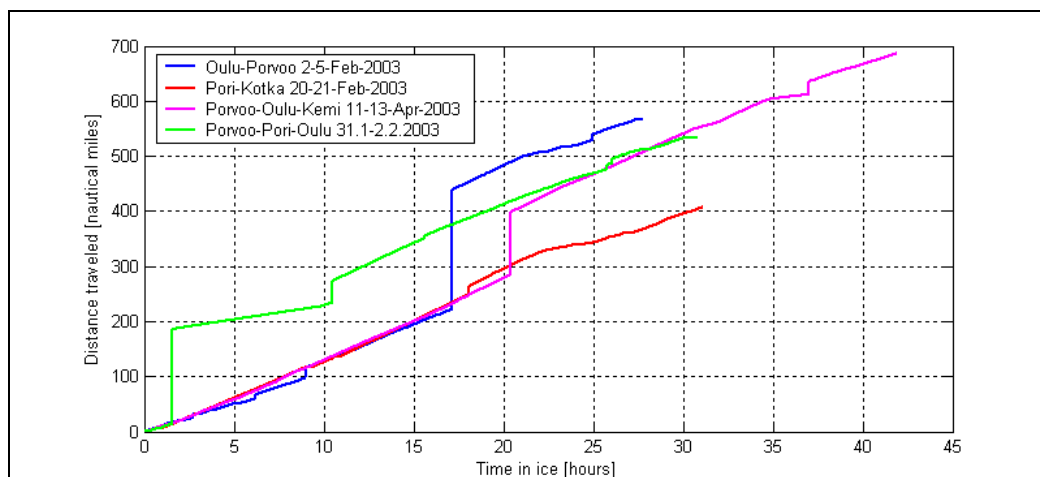


Figure 20. The distances travelled as a function of time in ice.



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