Centro de Simulación, Investigación y Desarrollo Marítimo

SIDMAR

Autoridad del Canal de Panamá.

Marzo 17, 2004.

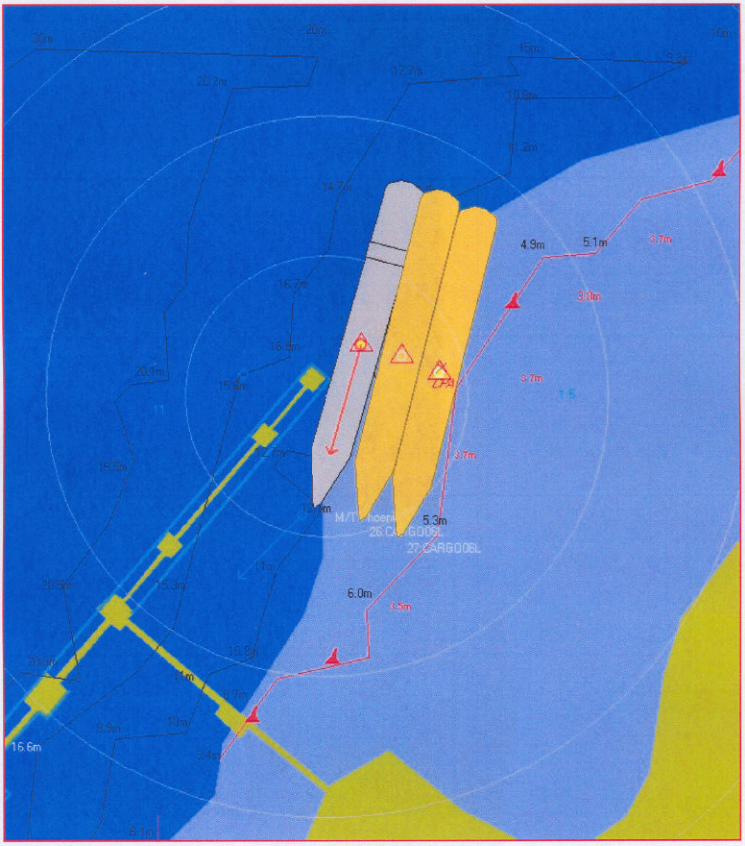
Metodología:

Ejercicios de maniobras de atraque de barcazas en diferentes escenarios en el área de la extensión, maniobras de atraque de Panamax con una barcaza atracada en la parte externa y vice-versa. Se han efectuado todos los ejercicios en condiciones de marea baja de modo a verificar puntos críticos de profundidad bajo la quilla en las aproximaciones.

Modelo de buques utilizados: (ver anexos)

- Barcaza de combustible modelo CARGO 06L (140/16,4/3,7)m (sin uso del bow thruster).
- Tanquero Panamax modelo TANK07L (228/32,2/16)m

- En la fase final de aproximación (distancia una eslora) el espacio de maniobra es reducido, la relación distancia del extremo norte del muelle a la línea isobatimetrica de 5 metros (50 metros) y la manga del buque (modelo utilizado 16,4m de manga) es de 3:1; por lo tanto el margen de error es mínimo.



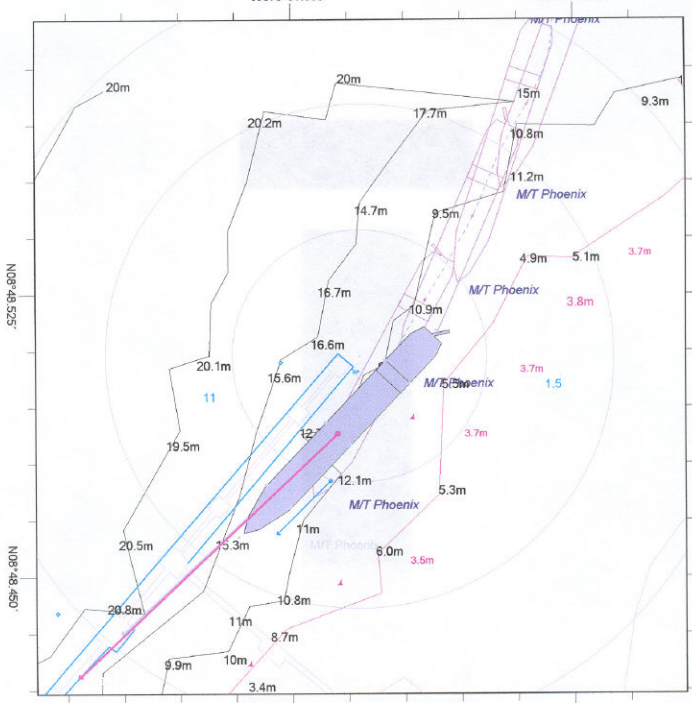
- Las maniobras de aproximación y atraque al muelle interno norte son factibles que se realicen con vientos menores de 30 nudos del cuadrante norte; maniobras con oleajes y vientos del cuadrante sur no tienen mucho impacto por la posición geográfica del terminal.
- Las maniobras de aproximación y atraque al muelle interno norte estribor al muelle (proa primero) son recomendables por la naturaleza de la dirección predominante de la corriente con rumbo oeste.
- Las maniobras de aproximación y atraque con buques tanqueros panamax (70,000 ton) es posible con la asistencia de remolcador(es) en el muelle externo con un espacio de atraque de aproximadamente de 200 metros, estando el resto del muelle ocupado por una barcaza (aprox. 80 metros), dejando un espacio entre buques de 10 metros.

Recomendaciones:

- La instalación de enfilaciones, balizas y/o boyas que proporcionen ayuda a la navegación para proporcionar referencias que faciliten el posicionamiento de la nave en la maniobra de aproximación y atraque.
- Las maniobras de aproximación y atraque al muelle interno norte es recomendable que se realicen con rumbos de aproximación entre 180 a 225 (grados).
- No es recomendable maniobras de atraque o desatraque en condiciones climatológicas de vientos mayores de 35 nudos de los cuadrantes norte y visibilidad reducida por causa de lluvia o bruma.
- Es factible el atraque, con las dimensiones del muelle modificado, de un tanquero panamax de LOA 228m y una barcaza de max. LOA 140m (parte externa), dos barcazas (interno sur y norte). Las maniobras en bajamar deben tener presente que los calados de las barcazas no debe exceder los 4 1/2 metros, dejando una relación calado profundidad de 1,10.

ANEXO DE EJERCICIO

Atraque Muelle de Taboguilla DECAL



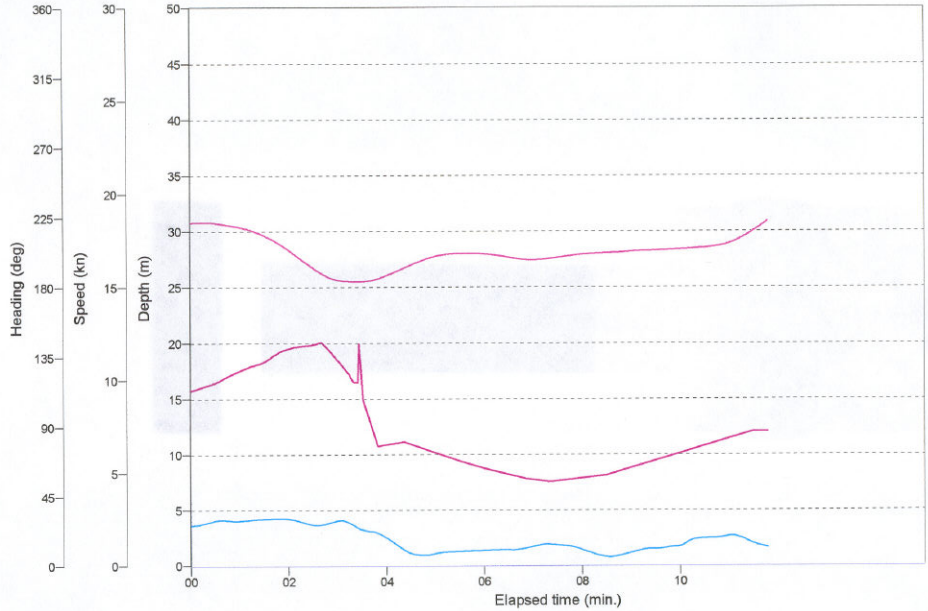
Scale 1:2104 Scale reference N08°48.508´

0.0125 0.00 0.02 0.04 0.06 0.08 n.mile

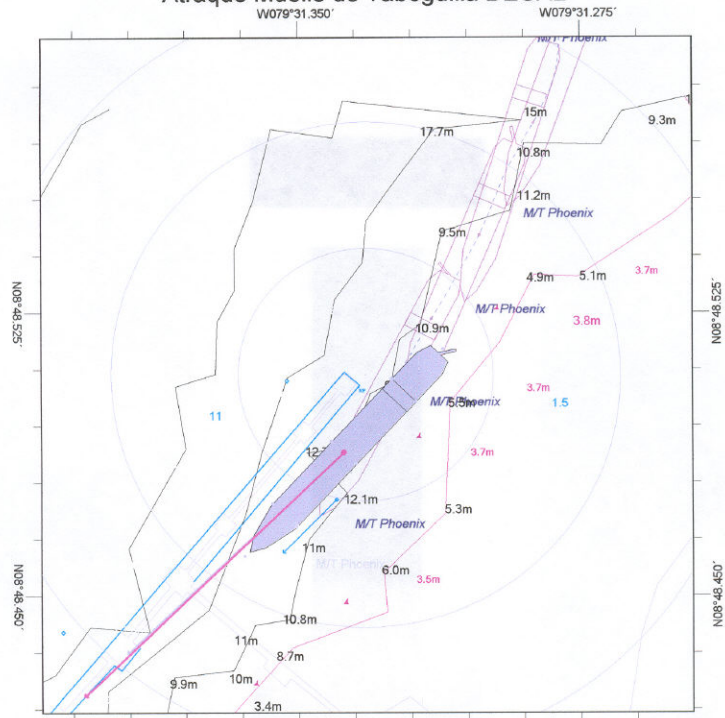
25 0 50 100 150 m

Comments: Muelle Interno modelo de buque (140/16,4/3,7) m Viento de SW=25Kn

Line sample period (s)	30
Course marker every	N/A
Heading marker period (s)	60
Shape outline every	02:00


Heading (deg)
360
315
270
225
180
135
90
45
0
Speed (kn)
30
25
20
15
10
5
0
Depth (m)
50
45
40
35
30
25
20
15
10
5
0
00
02
04
06
08
10
Elapsed time (min.)
M/T Phoenix
Heading
Speed
Depth

Atraque Muelle de Taboguilla DECAL



Scale 1:2104 Scale reference N08°48.508'

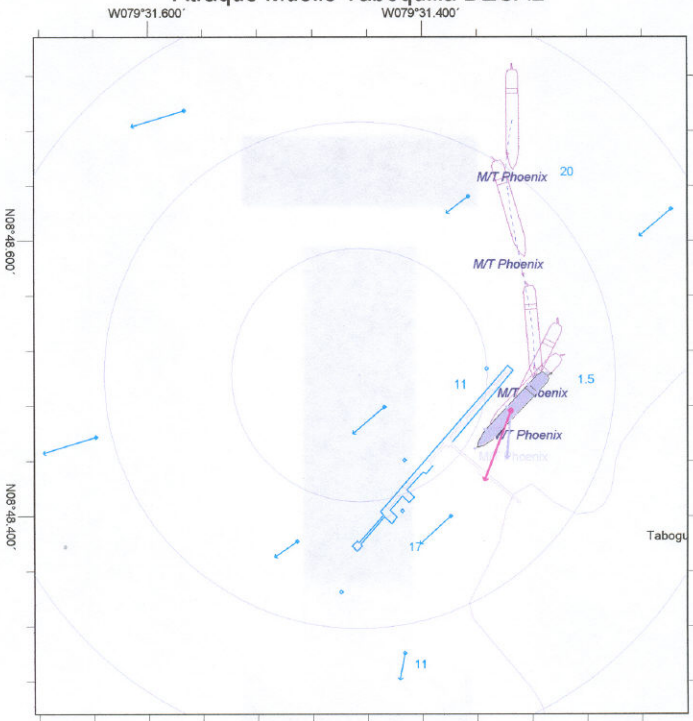
0.0125 0.00 0.02 0.04 0.06 0.08 n.mile

25 0 50 100 150 m

Comments: Muelle interno modelo de buque (140/16,4/3,7) m Viento de SW=20Kn

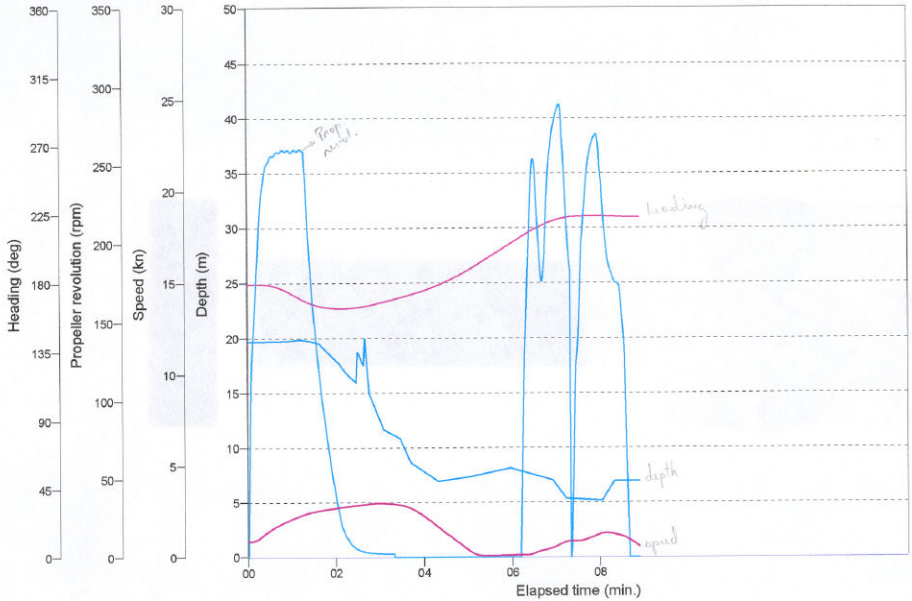
Line sample period (s)	30
Course marker every	N/A
Heading marker period (s)	60
Shape outline every	02:00

Atraque Muelle Taboquilla DECAL

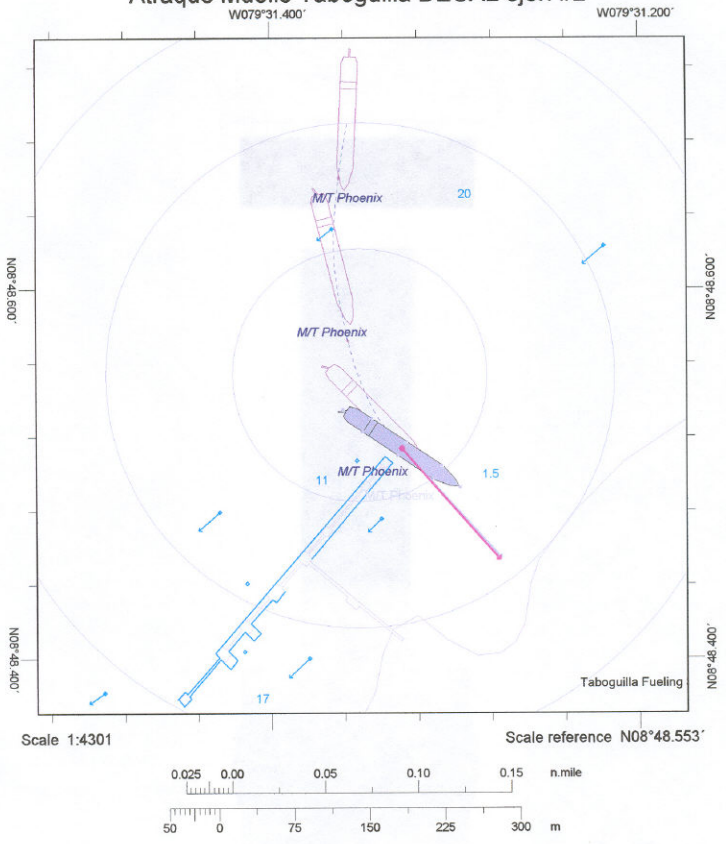


Comments: Muelle Norte Interno, modelo CARGO 06L (140/16,4/3,7)m

Line sample period (s)	30
Course marker every	N/A
Heading marker period (s)	60
Shape outline every	02:00

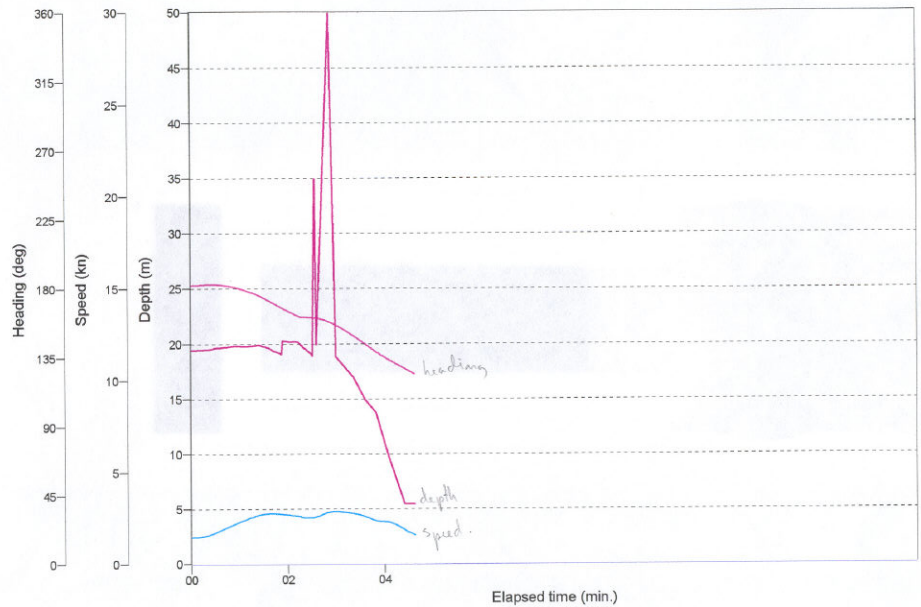

Heading (deg)
Propeller revolution (rpm)
Speed (kn)
Depth (m)
Elapsed time (min.)
heading
depth
speed
M/T Phoenix
Heading
Propeller revolution
Speed
Depth

Atraque Muelle Taboguilla DECAL ejer. #2



Line sample period (s)	30
Course marker every	N/A
Heading marker period (s)	60
Shape outline every	02:00

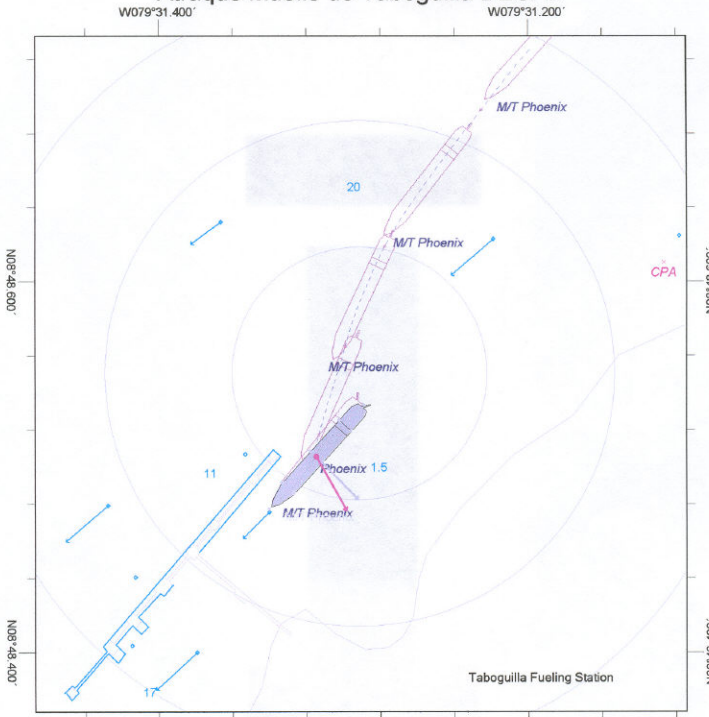
VIENTO 20° NORTE


Heading (deg)
360
315
270
225
180
135
90
45
0
Speed (kn)
30
25
20
15
10
5
0
Depth (m)
50
45
40
35
30
25
20
15
10
5
0
heading
depth
speed
00
02
04
Elapsed time (min.)
M/T Phoenix
Heading
Speed
Depth

Notas

Tabla de Contenido

Atraque Muelle de Taboguilla DECAL



Scale 1:4291 Scale reference N08°48.550´

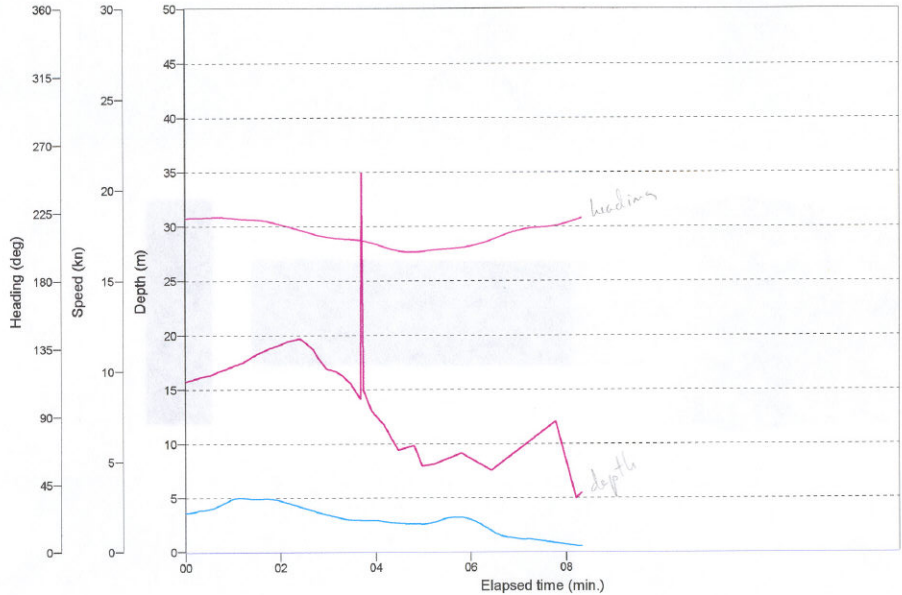
0.025 0.00 0.05 0.10 0.15 n.mile

50 0 75 150 225 300 m

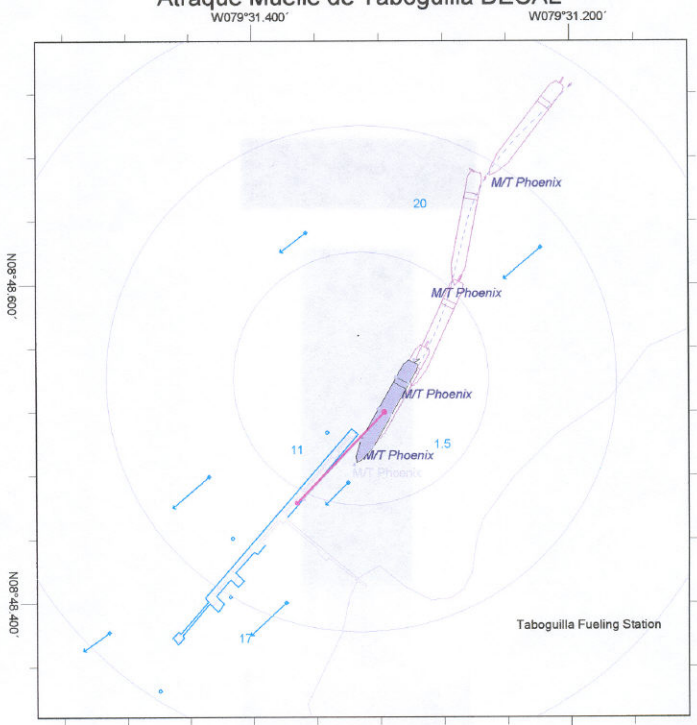
Comments: Muelle Interno modelo de buque (140/16,4/3,7) m

VIENTO 20 N

Line sample period (s)	30
Course marker every	N/A
Heading marker period (s)	60
Shape outline every	02:00


Heading (deg)
Speed (kn)
Depth (m)
Elapsed time (min.)
heading
depth
M/T Phoenix
Heading
Speed
Depth

Atraque Muelle de Taboguilla DECAL



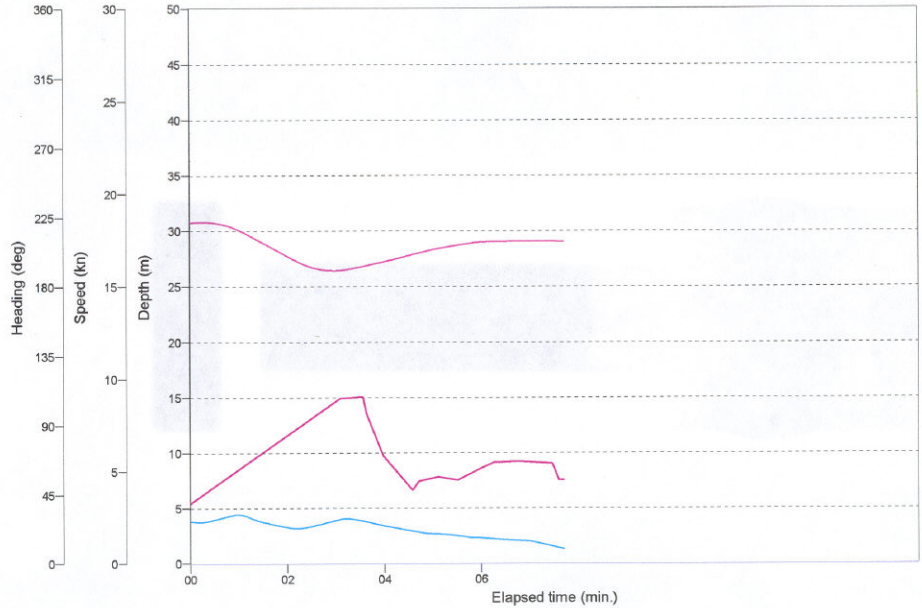
Scale 1:5000 Scale reference N08°48.540´

0.05 0.00 0.05 0.10 0.15 n.mile

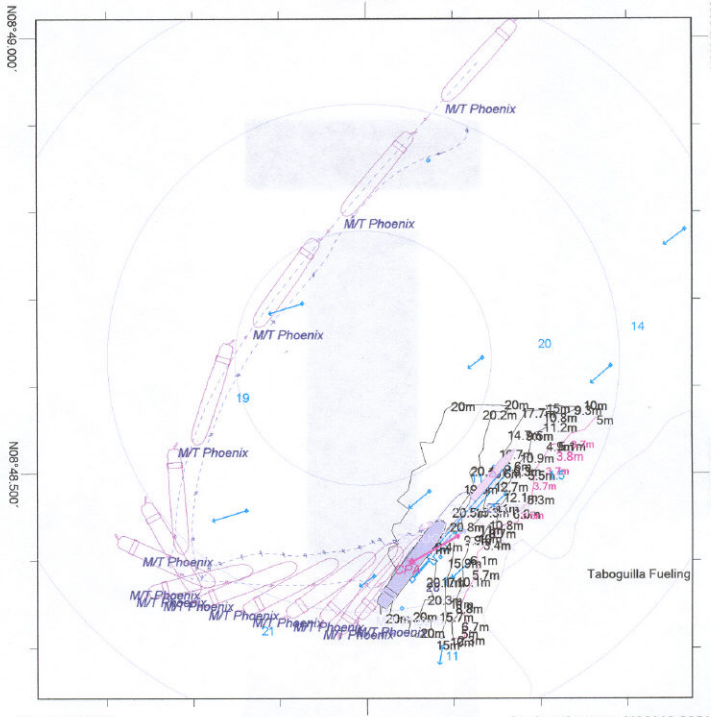
50 0 75 150 225 300 375 m

Comments: Muelle Interno modelo de buque (140/16,4/3,7) m Viento de SW=20Kn

Line sample period (s)	30
Course marker every	N/A
Heading marker period (s)	60
Shape outline every	02:00


Heading (deg)
360
315
270
225
180
135
90
45
0
Speed (kn)
30
25
20
15
10
5
0
Depth (m)
50
45
40
35
30
25
20
15
10
5
0
00
02
04
06
Elapsed time (min.)
M/T Phoenix
Heading
Speed
Depth

Atraque Panamax (228x 32.2 x 16.1)m



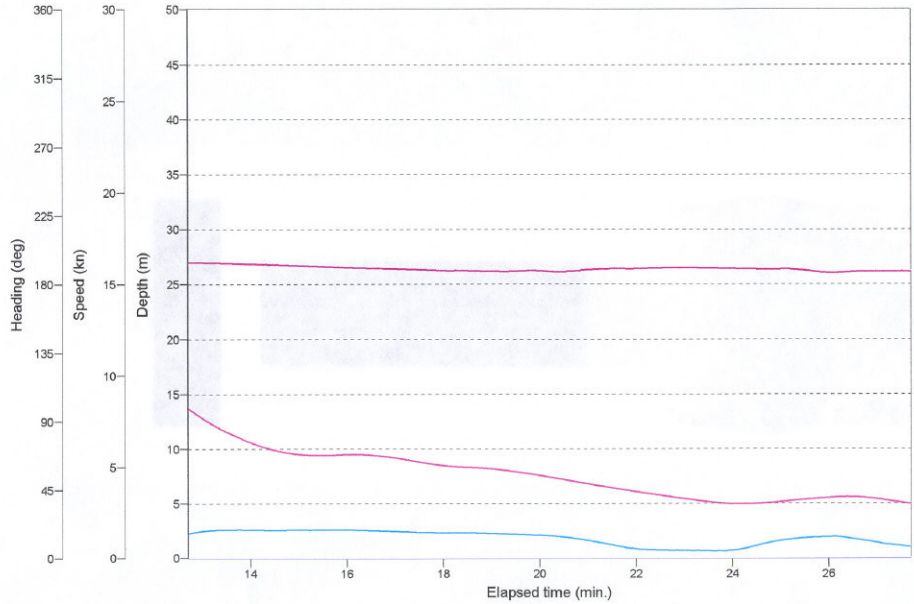
Scale 1:9179 Scale reference N08°48.632´

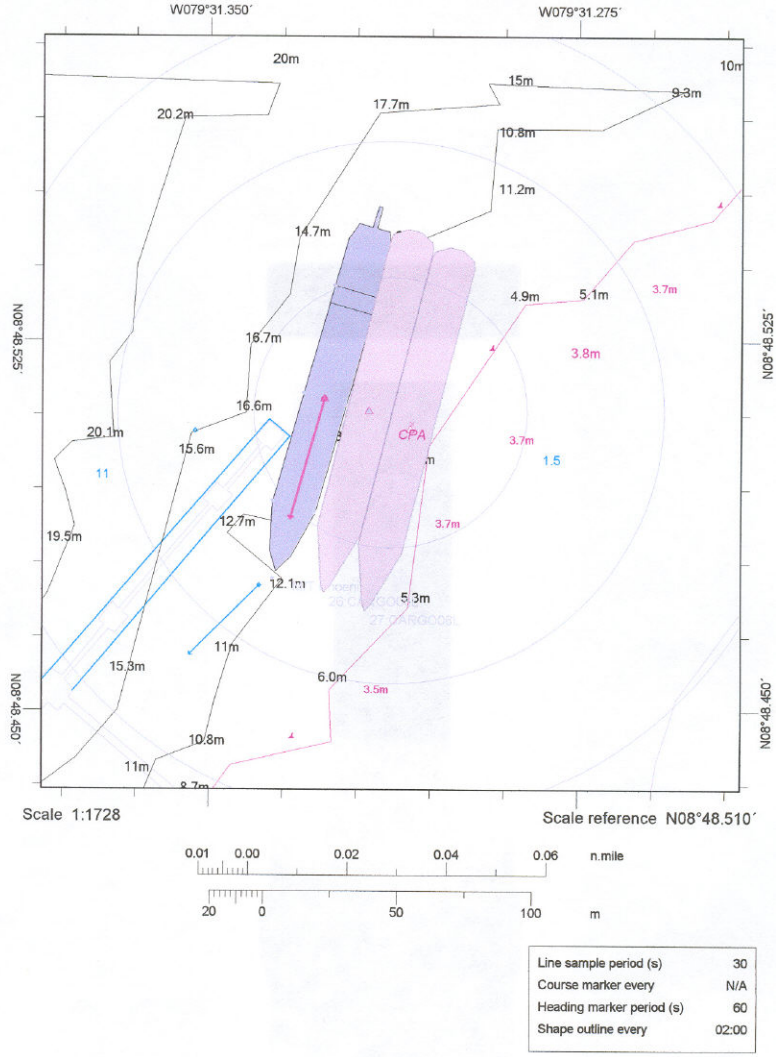
0.05 0.000 0.075 0.150 0.225 0.300 0.375 n.mile

100 0 200 400 600 m

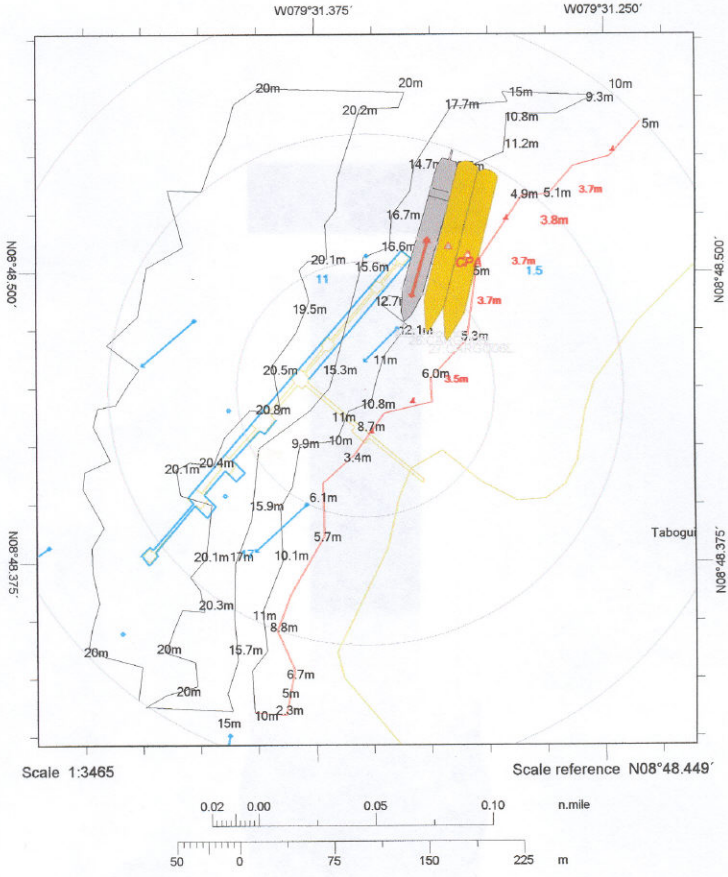
Comments: Barcaza atracada en la nueva extensión del muelle Área libre para atraque 210m

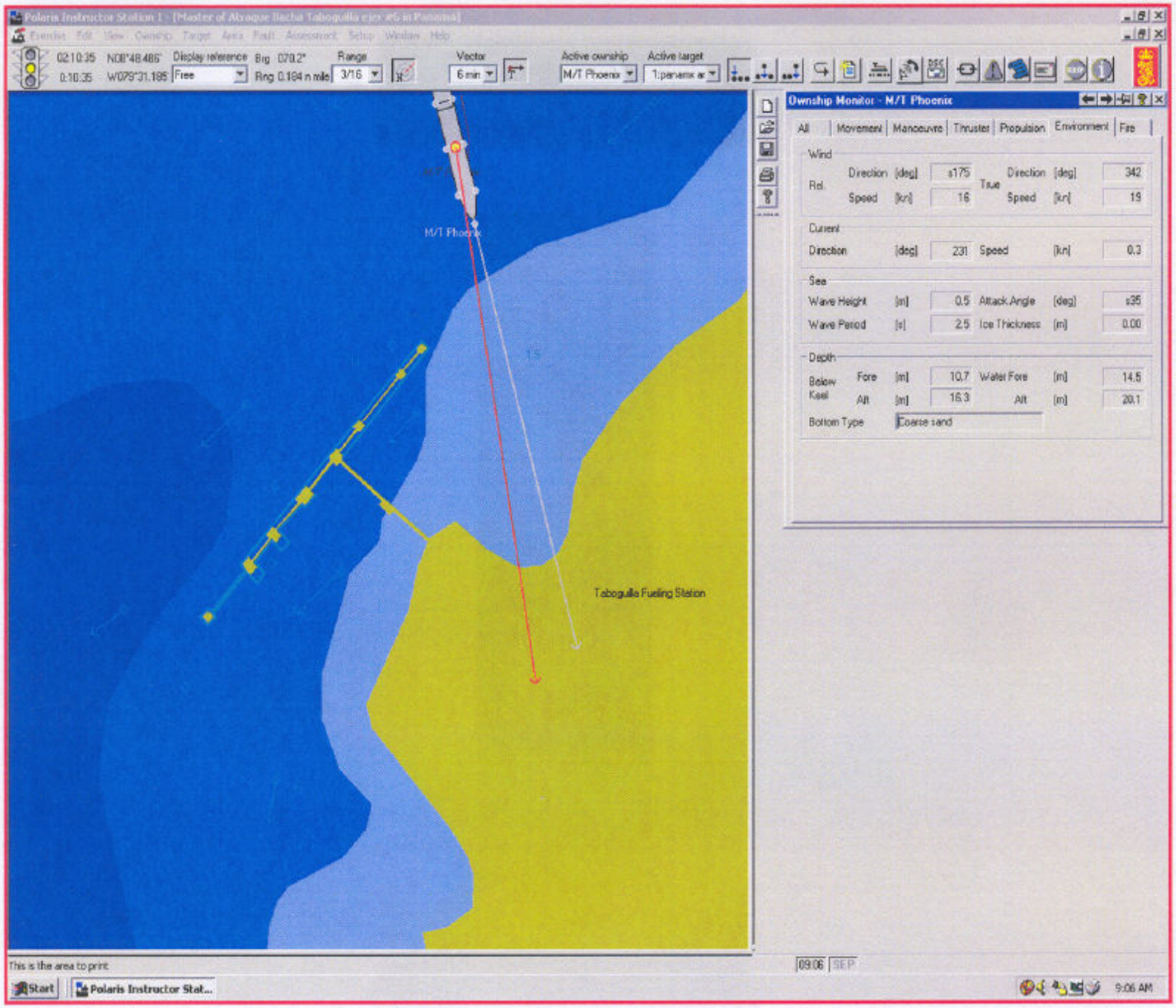
Line sample period (s)	30
Course marker every	N/A
Heading marker period (s)	60
Shape outline every	02:00

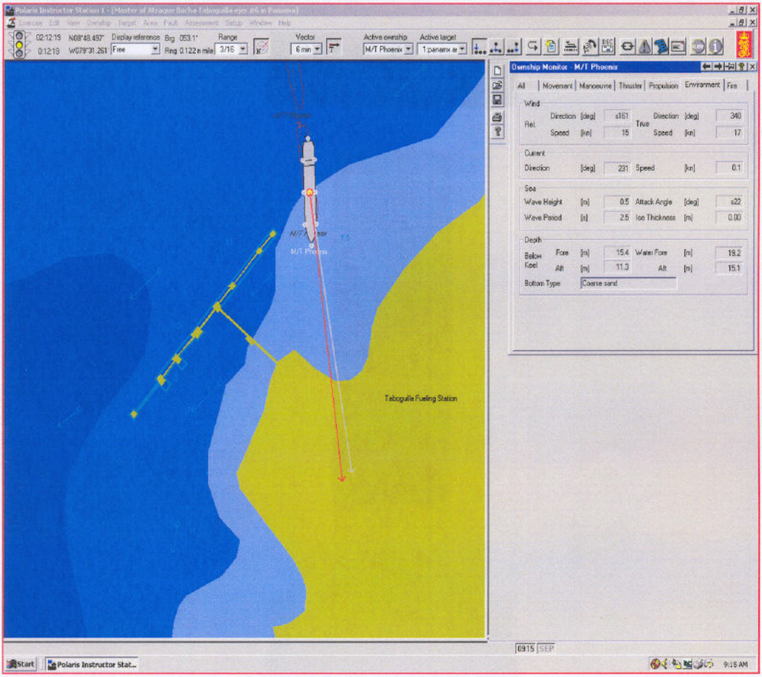

Heading (deg)
360
315
270
225
180
135
90
45
0
Speed (km)
30
25
20
15
10
5
0
Depth (m)
50
45
40
35
30
25
20
15
10
5
0
14
16
18
20
22
24
26
Elapsed time (min.)
M/T Phoenix
Heading
Speed
Depth



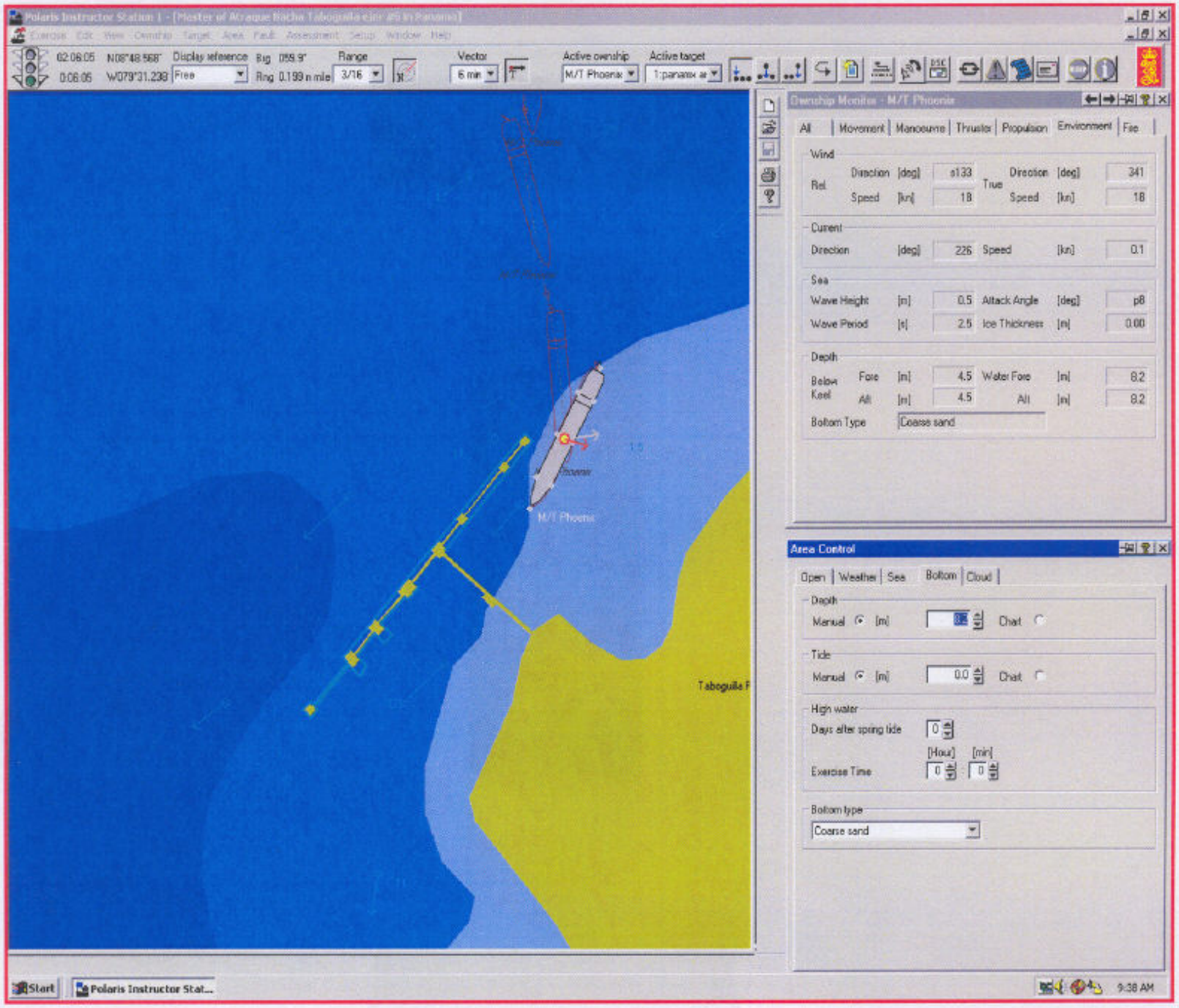
Line sample period (s)	30
Course marker every	N/A
Heading marker period (s)	60
Shape outline every	02:00

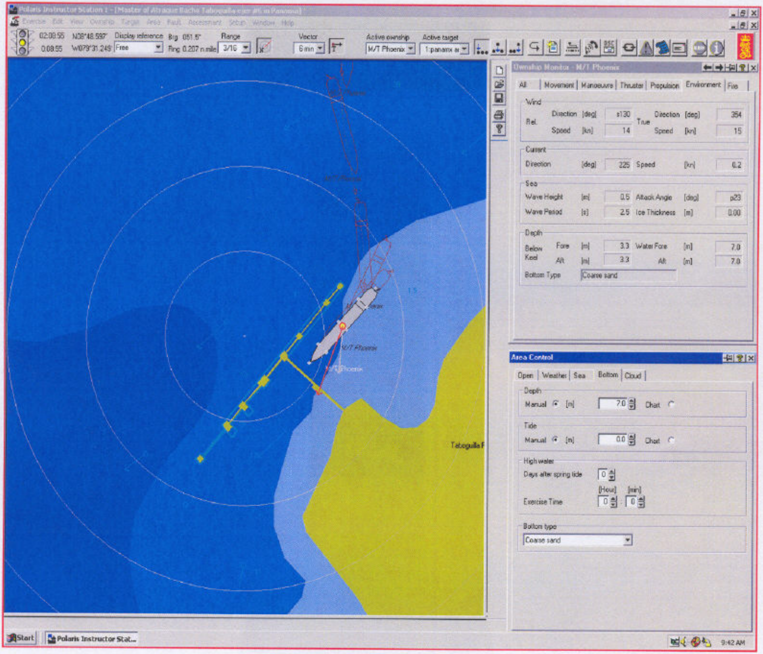

W079°31.375'
W079°31.250'
N08°48.500'
N08°48.375'
Scale 1:3465
Scale reference N08°48.449'
0.02 0.00 0.05 0.10 n.mile
50 0 75 150 225 m
Line sample period (s) 30
Course marker every N/A
Heading marker period (s) 60
Shape outline every 02:00

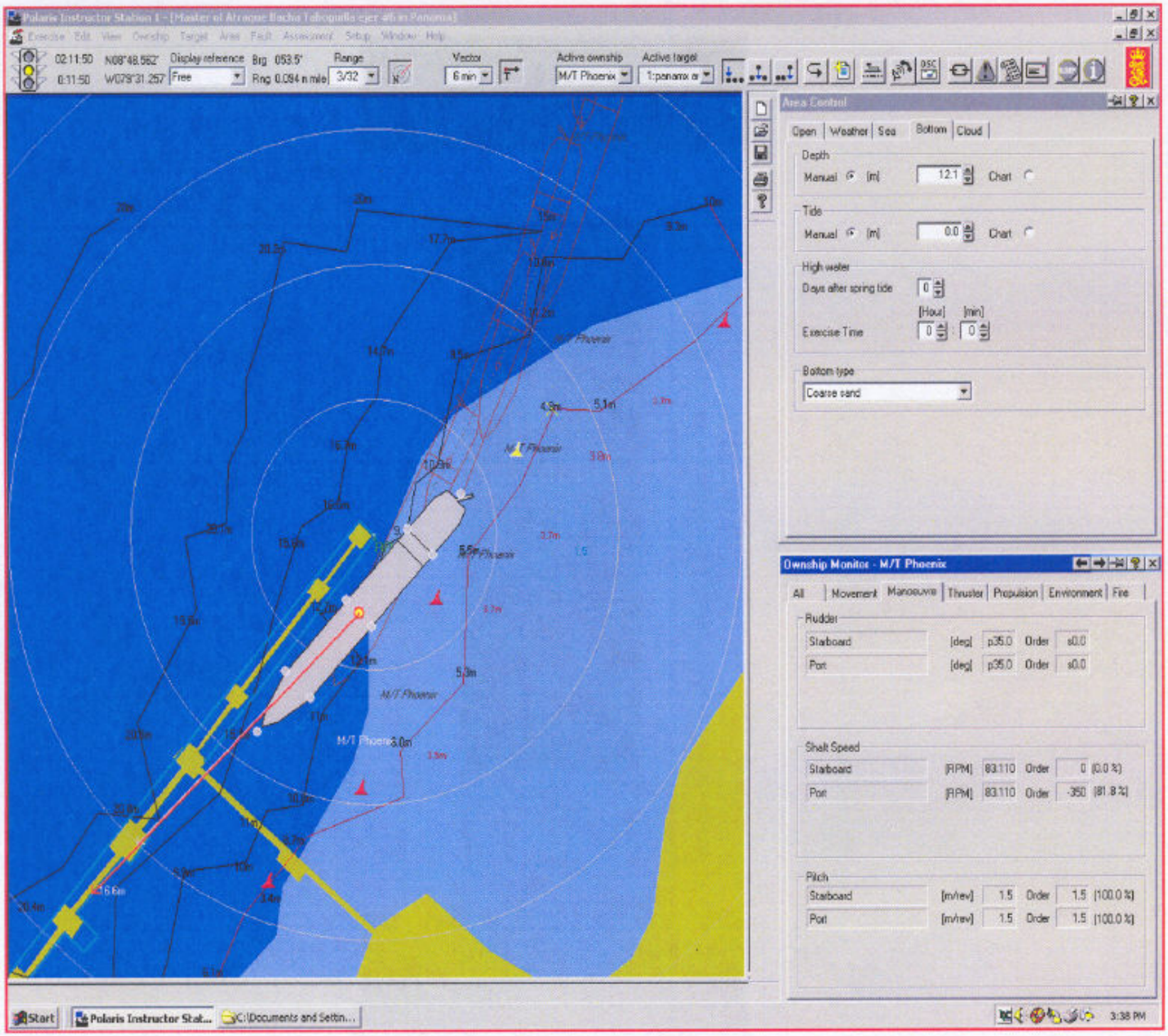

Polaris Instructor Station 1 - [Master of Abaque Bacha Taboguilla ejer. #6 in Panama]
Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help
02:10:35 N08°48.486'
0:10:35 W079°31.185'
Display reference
Free
Brg 070.2°
Rng 0.184 n mile
Range
3/16
Vector
6 min
Active ownship
M/T Phoenix
Active target
1:panamax ar
Ownship Monitor - M/T Phoenix
All
Movement
Manoeuvre
Thruster
Propulsion
Environment
Fire
Wind
Rel.
Direction [deg] s175
Speed [kn] 16
True
Direction [deg] 342
Speed [kn] 19
Current
Direction [deg] 231
Speed [kn] 0.3
Sea
Wave Height [m] 0.5
Wave Period [s] 2.5
Attack Angle [deg] s35
Ice Thickness [m] 0.00
Depth
Below Keel
Fore [m] 10.7
Aft [m] 16.3
Water Fore [m] 14.5
Aft [m] 20.1
Bottom Type
Coarse sand
M/T Phoenix
Taboguilla Fueling Station
This is the area to print
09:06
SEP
Start
Polaris Instructor Stat...
9:06 AM



02:12:19 N08°48.497' Display reference Brg 053.1° Range
0:12:19 W079°31.261' Free Rng 0.122 n mile 3/16
Vector
6 min
Active ownship
M/T Phoenix
Active target
Ownship Monitor - M/T Phoenix
All
Movement
Manoeuvre
Thruster
Propulsion
Environment
Fire
Wind
Rel.
Direction [deg] s161
Speed [kn] 15
True
Direction [deg] 340
Speed [kn] 17
Current
Direction [deg] 231 Speed [kn] 0.1
Sea
Wave Height [m] 0.5 Attack Angle [deg] s22
Wave Period [s] 2.5 Ice Thickness [m] 0.00
Depth
Below Keel
Fore [m] 15.4 Water Fore [m] 19.2
Aft [m] 11.3 Aft [m] 15.1
Bottom Type Coarse sand
M/T Phoenix
Taboguilla Fueling Station
Start
Polaris Instructor Stat...
9:16 AM


Polaris Instructor Station 1 - [Master of Acraque Bacha Taboguilla ejor #5 in Panama]
Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help
02:06:05
0:06:05
N08°48.568'
W079°31.238'
Display reference
Free
Brg 059.9°
Rng 0.199 n mile
Range
3/16
Vector
6 min
Active ownship
M/T Phoenix
Active target
1:panamax at
Ownship Monitor - M/T Phoenix
All
Movement
Manoeuvre
Thruster
Propulsion
Environment
Fire
Wind
Rel
Direction [deg] s133
Speed [kn] 18
True
Direction [deg] 341
Speed [kn] 18
Current
Direction [deg] 226
Speed [kn] 0.1
Sea
Wave Height [m] 0.5
Attack Angle [deg] p8
Wave Period [s] 2.5
Ice Thickness [m] 0.00
Depth
Below Keel
Fore [m] 4.5
Water Fore [m] 8.2
Aft [m] 4.5
Aft [m] 8.2
Bottom Type
Coarse sand
Area Control
Open
Weather
Sea
Bottom
Cloud
Depth
Manual [m]
Chart
Tide
Manual [m] 0.0
Chart
High water
Days after spring tide 0
Exercise Time
[Hour] 0
[min] 0
Bottom type
Coarse sand
M/T Phoenix
Taboguilla F
Start
Polaris Instructor Stat...
9:38 AM


Display reference
Free
Brg 051.5°
Rng 0.207 n.mile
Range
3/16
Vector
6 min
Active ownship
M/T Phoenix
Active target
M/T Phoenix
Taboguilla
Wind
Rel.
Direction [deg] s130
Speed [kn] 14
True
Direction [deg] 354
Speed [kn] 15
Current
Direction [deg] 225
Speed [kn] 0.2
Sea
Wave Height [m] 0.5
Attack Angle [deg] p23
Wave Period [s] 2.5
Ice Thickness [m] 0.00
Depth
Below Keel
Fore [m] 3.3
Aft [m] 3.3
Water Fore [m] 7.0
Aft [m] 7.0
Bottom Type
Coarse sand
Area Control
Open
Weather
Sea
Bottom
Cloud
Depth
Manual [m] 7.0
Chart
Tide
Manual [m] 0.0
Chart
High water
Days after spring tide 0
[Hour] [min]
Exercise Time 0 : 0
Bottom type
Coarse sand
Start
Polaris Instructor Stat...
9:42 AM


Area Control
Open
Weather
Sea
Bottom
Cloud
Depth
Manual
[m]
12.1
Chart
Tide
Manual
[m]
0.0
Chart
High water
Days after spring tide
Exercise Time
[Hour]
[min]
Bottom type
Coarse sand
Ownship Monitor - M/T Phoenix
All
Movement
Manoeuvre
Thruster
Propulsion
Environment
Fire
Rudder
Starboard
[deg]
Order
Port
[deg]
Order
Shaft Speed
Starboard
[RPM]
Order
Port
[RPM]
Order
Pitch
Starboard
[m/rev]
Order
Port
[m/rev]
Order
M/T Phoenix
Start
Polaris Instructor Stak...
C:\Documents and Settin...
3:38 PM

ANEXO DE VISUALE

DESCRIPCIÓN DE MODELOS DE BUQUE

Description Of Ship Model

CARGO06L
River/Sea Cargo Vessel

Version 4

Department/Author:

Sergey Zaikov

Approved by:

Trond Tveit

Proyecto Modificación (extensión) del muelle de la instalación portuaria de la Isla de Taboguilla (DECAL, Panamá)

Antecedentes:

El muelle actual de la instalación portuaria de la isla de Taboguilla dedicada al trasiego de petróleo está diseñado para la operación simultánea de un buque tanquero de aproximadamente 70,000 ton DWT en su muelle externo y una barcaza de transporte de combustible (bunker, etc.) en su muelle interno sur.

Los pronósticos de demanda de servicios de trasiego (compra, almacenamiento, venta, comercialización) de productos derivados del petróleo ofrecidos en la actual instalación está apuntando a alcanzar la máxima capacidad y utilización de las mismas a corto plazo. Por tal motivo, se está explorando la modificación del muelle con una extensión en su extremo norte de aproximadamente de 22 metros de modo a poder atracar simultáneamente barcazas de transporte de combustible en la parte interna norte y sur.

DOCUMENT STATUS

Issue No.	Date/Year	Inc. by	Issue No.	Date/Year	Inc. by
A	07-Mar-2000	SZ			
A1	26-Mar-2002	SZ			

CHANGES IN DOCUMENT

Issue No.	ECO No.	Paragraph No.	Paragraph Heading/ Description of Change
A			This document supersedes VSAWT-0008 version of 10-Apr-1995.
A1	MP-1411		Model updated to 3+3 degrees of freedom

TABLE OF CONTENTS

1. GENERAL DESCRIPTION

The River/Sea Cargo Vessel configuration can be generally described as follows:

The propulsion plant consist of
- Two diesel engines, each producing a continuous rating of 970 kW at 428 rpm
- Two propeller shafts with fixed pitch propellers, direction of rotation outwards

Top speed of the Cargo06 is 11.14 knots ahead and approximately 7.43 knots astern.

Crash stop distance is 550 m.

The River/Sea Cargo Vessel has a bow thruster. The thruster engine rates up to 135 kW. Propeller diameter is 1.1 meter, propeller revolutions are 500 rpm.

The two rudders are positioned in the slipstream of the propeller. Such a type of rudder provides the vessel with a normal turning ability. Time from the rudder port 35 degrees to starboard 35 is 20 seconds. The Vessel has no heading deviation due to pendling effect during acceleration or deceleration manoeuvres.

Zig-zag tests show the first overshoot angle 7 deg in the 10–10 deg test and 21.2 deg in the 20–20 deg test. This means that the manoeuvring ability is fairly good.

The turning ability may be judged from turning circles. The turning ability of the River/Sea Cargo Vessel is very good with an advance of 2.5 Lpp and a tactical diameter of 1.94 Lpp.

The steering ability is fairly good. The ship is course stable.

The simulation model is designed for loaded condition.

2. SHIP DATA

Identification

Model name	CARGO06L
Ship database file name	CARGO06L.sdb
Type of ship	River/Sea Cargo Vessel
Loading condition	Loaded
Ship's name	Volga-4002

General Data

Deadweight, DWT	83,890
Displacement, tonne	6,999
Length between perpendiculars, m	134
Length overall, m	140
Beam moulded, m	16.4
Draught fore, m	3.74
Draught aft, m	3.74
Block coefficient	0.831
Radius of inertia, multiples of L_{pp}	24.63
Speed ahead, knot	11.12
Speed astern, knot	7.78

Engines

Number of engines	2
Type of engine	diesel
Total shaft power, kW	1,940
Revolutions, rpm	428

Propellers

Number of propellers	2
Type of propeller	propeller in nozzle
Revolutions, rpm	428
Direction of rotation	outwards
Diameter, m	1.8
Pitch, P/D @ $0.7R$	0.817

Rudders

Number of rudders	2
Rudder type	normal
Max rudder angle, deg	35
Max rudder rate, deg/sec	3.5
Rudder area, m²	
Total rudder area, % of $L_{pp}T_{\otimes}$	

Bow Thrusters

Number of bow thrusters	1
Power, kW	135
Propeller revolutions, rpm	500
Propeller diameter, m	1.1
Propeller pitch, P/D @ $0.7R$	0.625

Stern Thrusters

Number of stern thrusters	0
Power, kW	
Propeller revolutions, rpm	
Propeller diameter, m	
Propeller pitch, P/D @ $0.7R$	

Azimuth Thrusters

Number of azimuth thrusters	0
Power, kW	
Propeller revolutions, rpm	
Propeller diameter, m	
Propeller pitch, P/D @ $0.7R$	

Bow Anchors

Number of bow anchors	2
Mass, tonne	2.5
Chain break load, tonne	500

Stern Anchors

Number of stern anchors	1
Mass, tonne	1.25
Chain break load, tonne	400

Radar Position

Longitudinal radar position, m	-43.6
Lateral radar position, m	0
Vertical radar position, m	19.5

Viewpoint Position

Longitudinal viewpoint position, m	-38.7
Lateral viewpoint position, m	0
Vertical viewpoint position, m	11.5

3. SPEED

	Machinery telegraph setting		Propeller		Speed	
			revolutions	pitch	deep $H/T = \infty$	shallow $H/T = 1.5$
			rpm	P/D	knot	knot
AHEAD	FULL (at sea)	1	427.8	0.817	11.14	10.45
AHEAD	FULL (manoeuvre)	0.8	396.1	0.817	10.33	9.83
AHEAD	HALF	0.5	340.2	0.817	8.88	8.64
AHEAD	SLOW	0.25	265.8	0.817	6.95	6.83
AHEAD	DEAD SLOW	0.125	132.9	0.817	3.46	3.43
	STOP	0	0	0.817	0	0
ASTERN	DEAD SLOW	-0.125	-43.7	0.817	-0.89	-0.88
ASTERN	SLOW	-0.25	-87.5	0.817	-1.82	-1.81
ASTERN	HALF	-0.5	-175	0.817	-3.69	-3.66
ASTERN	FULL	-1	-350	0.817	-7.43	-7.24

Table 1. Propeller revolutions and pitch and ship speed as function of machinery telegraph setting. Deep and shallow water.

4. STATISTICS

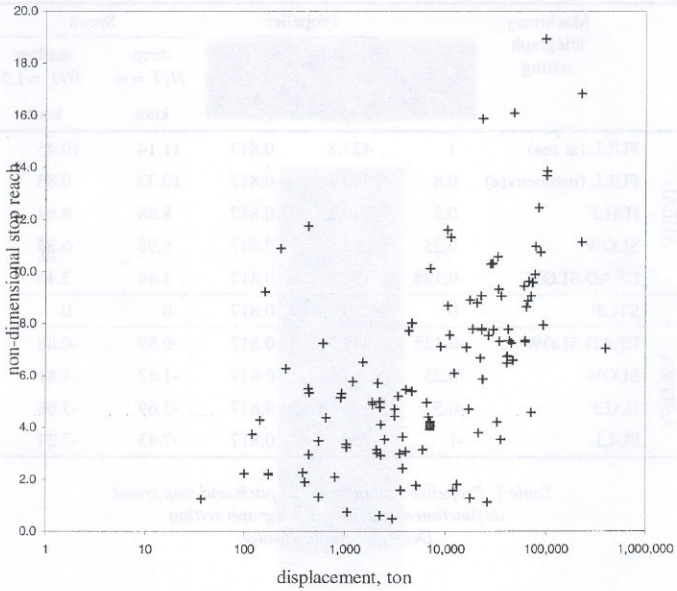


Fig. 1. Stop reach of the ship compared with other ship models.

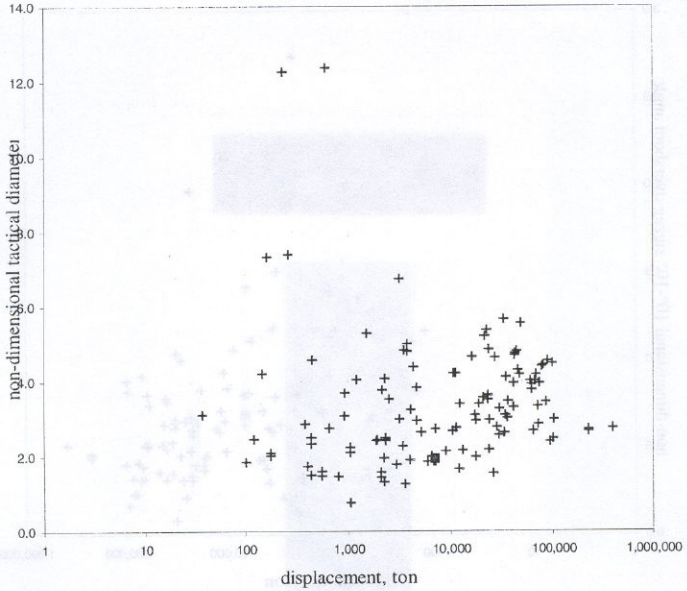


Fig. 2. Tactical diameter of the ship compared with other ship models.

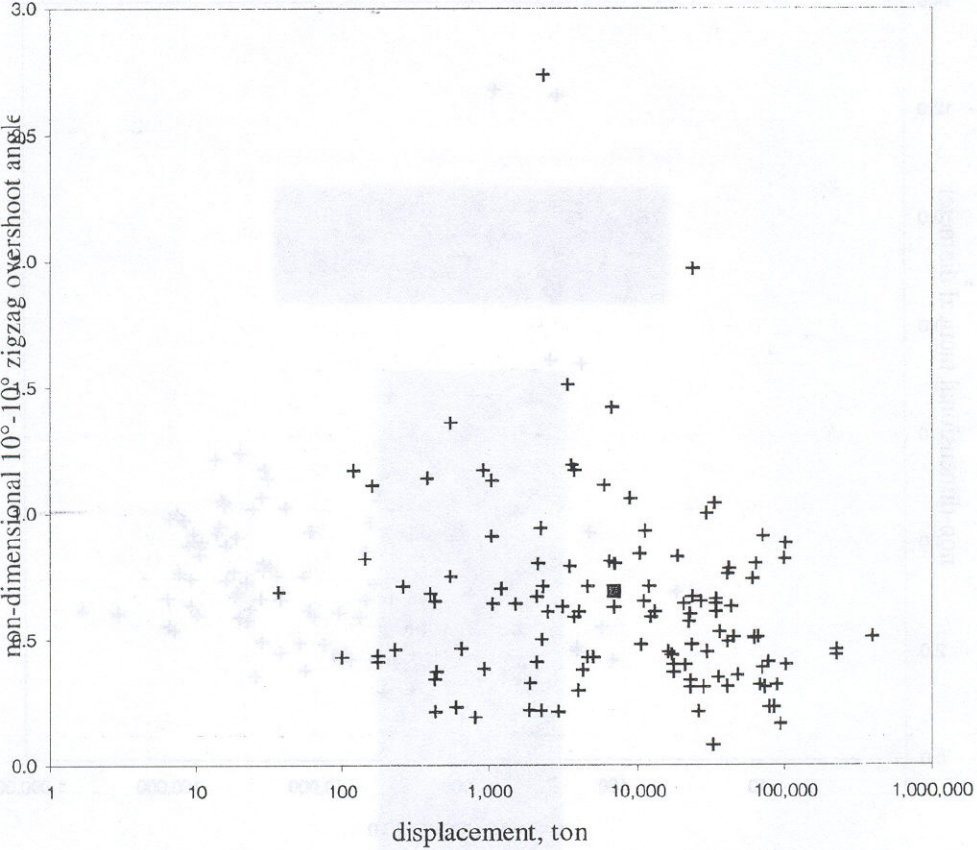


Fig. 3. Zig-zag overshoot angle of the ship compared with other ship models.

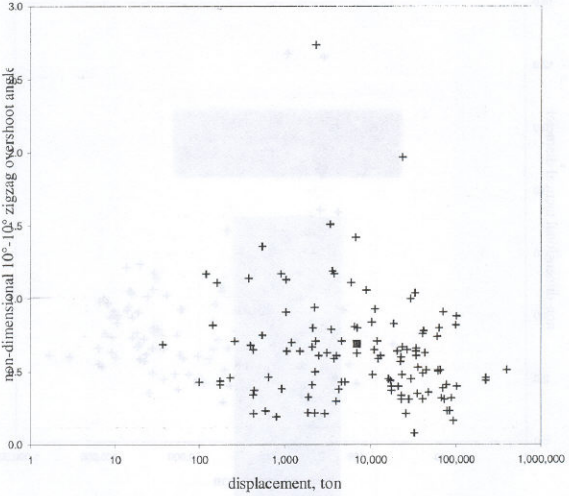


Fig. 3. Zig-zag overshoot angle of the ship compared with other ship models.

La posibilidad de atraque de un tanquero Panamax (+/- 228m eslora) y una barcaza de aproximadamente 60m de eslora en la parte externa del muelle.

La administración de la instalación portuaria ha solicitado al **Centro SIDMAR** llevar a cabo el diseño de tal modificación y realización de ejercicios en diferentes escenarios en su sistema de simuladores, de modo a poder analizar los resultados obtenidos y asistir en la toma de decisiones de la factibilidad del proyecto.

5. ACCELERATION

Environment

Water depth, H/T ..... ∞
Wind speed 0
Water current speed 0

Controls

Machinery telegraph setting
from 0
to 1
Rudder, deg 0

time s	propeller rpm	pitch ratio P/D	speed knot	distance m
00:00:00	0	0.817	0.0	0
00:00:20	291	0.817	0.5	2
00:00:40	361	0.817	1.9	14
00:01:00	377	0.817	3.5	42
00:01:20	385	0.817	5.0	86
00:01:40	393	0.817	6.3	145
00:02:00	401	0.817	7.4	216
00:02:20	409	0.817	8.3	297
00:02:40	416	0.817	9.1	387
00:03:00	422	0.817	9.6	483
00:03:20	427	0.817	10.1	585
00:03:40	428	0.817	10.4	691
00:04:00	428	0.817	10.7	800
00:04:20	428	0.817	10.8	910
00:04:40	428	0.817	10.9	1,022
00:05:00	428	0.817	11.0	1,135

Table 2. Acceleration.

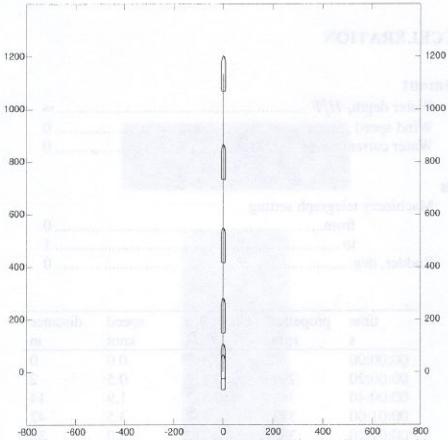


Fig. 4. Acceleration. Ship position plot.

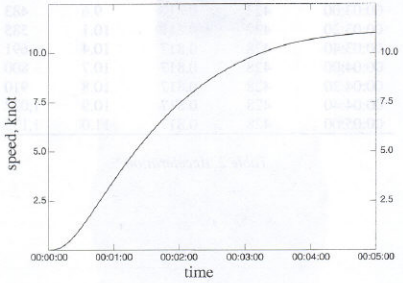


Fig. 5. Acceleration. Speed plot.

6. CRASH STOP

Environment

Water depth, H/T ..... ∞
Wind speed 0
Water current speed 0

Controls

Machinery telegraph setting
from..... 1
to ..... -1
Rudder, deg..... 0

Performance

Stop time, s 00:03:05
Advance at stop time, m 545
Transfer at stop time, m..... 0
Heading at stop time, deg s0.0

time s	propeller rpm	propeller P/D	speed knot	distance m	Heading deg
00:00:00	428	0.817	11.1	0	000.0
00:00:15	167	0.817	10.7	85	000.0
00:00:30	-123	0.817	9.9	164	000.0
00:00:45	-232	0.817	9.0	237	000.0
00:01:00	-306	0.817	8.0	302	000.0
00:01:15	-345	0.817	6.9	360	000.0
00:01:30	-350	0.817	5.8	409	000.0
00:01:45	-350	0.817	4.8	450	000.0
00:02:00	-351	0.817	3.8	483	000.0
00:02:15	-350	0.817	2.9	509	000.0
00:02:30	-350	0.817	2.0	527	000.0
00:02:45	-350	0.817	1.1	539	000.0
00:03:00	-350	0.817	0.3	545	000.0

Table 3. Crash stop test.

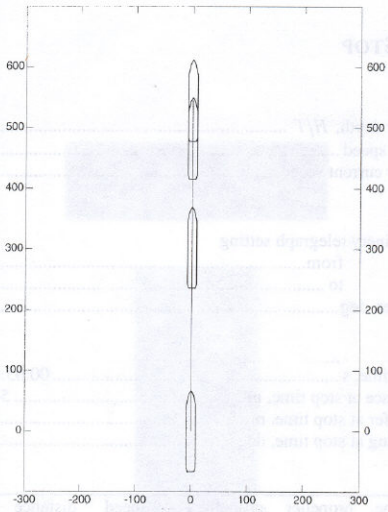


Fig. 6. Crash stop test. Ship position plot.

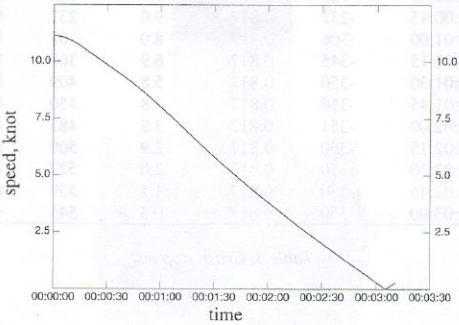


Fig. 7. Crash stop test. Speed plot.

7. COASTING STOP

Environment

Water depth, H/T ..... ∞
Wind speed 0
Water current speed 0

Controls

Machinery telegraph setting
from 1
to 0
Rudder, deg 0

time s	propeller rpm	propeller P/D	speed knot	distance m	heading deg
00:00:00	428	0.817	11.1	0	000.0
00:00:40	157	0.817	9.6	215	000.0
00:01:20	82	0.817	8.1	396	000.0
00:02:00	36	0.817	7.0	551	000.0
00:02:40	15	0.817	6.1	685	000.0
00:03:20	11	0.817	5.5	804	000.0
00:04:00	9	0.817	4.9	911	000.0
00:04:40	7	0.817	4.5	1,008	000.0
00:05:20	6	0.817	4.1	1,096	000.0
00:06:00	5	0.817	3.8	1,177	000.0
00:06:40	4	0.817	3.5	1,252	000.0
00:07:20	4	0.817	3.3	1,322	000.0
00:08:00	3	0.817	3.1	1,387	000.0
00:08:40	3	0.817	2.9	1,449	000.0
00:09:20	3	0.817	2.7	1,507	000.0
00:10:00	2	0.817	2.6	1,562	000.0

Table 4. Coasting stop test.

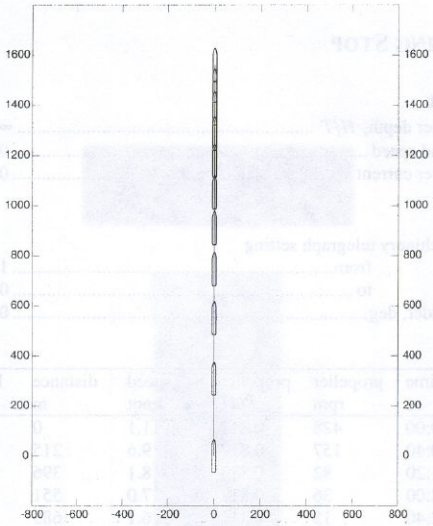


Fig. 8. Coasting stop test. Ship position plot.

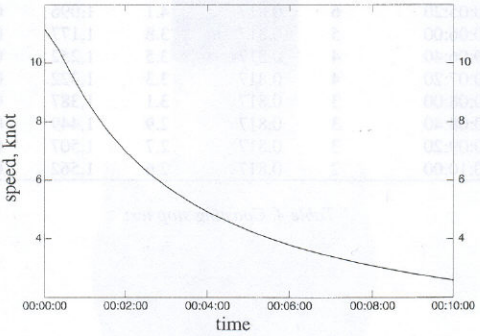


Fig. 9. Coasting stop test. Speed plot.

8. Turning Circle 35° Starboard, Deep Water

Environment

Water depth, H/T ..... ∞
Wind speed 0
Water current speed 0

Controls

Machinery telegraph setting 0.8
Rudder command
from, deg 0
to, deg s35

Performance

Time 90°, s 00:01:20
Advance, m 333
Transfer, m 128

Time 180°, s 00:02:09
Tactical diameter, m 259

Circulation diameter, m 202
Turn rate, deg/min s102.3
Speed loss, % 43

time s	speed knot	heading deg	turn rate deg/min	Drift angle deg
00:00:00	10.3	000.0	s0.0	s0.0
00:00:15	10.3	002.5	s23.5	s2.2
00:00:30	10.2	011.9	s52.5	s5.6
00:00:45	9.6	029.2	s85.9	s8.6
00:01:00	8.7	053.5	s105.4	s9.9
00:01:15	7.9	080.8	s111.7	s10.6
00:01:30	7.3	108.9	s112.2	s11.0
00:01:45	6.8	136.8	s110.7	s11.2
00:02:00	6.5	164.2	s108.7	s11.3
00:02:15	6.3	191.2	s106.9	s11.3
00:02:30	6.1	217.7	s105.5	s11.4
00:02:45	6.0	243.9	s104.4	s11.4
00:03:00	6.0	269.9	s103.6	s11.4
00:03:15	5.9	295.8	s103.1	s11.4
00:03:30	5.9	321.5	s102.7	s11.4
00:03:45	5.9	347.1	s102.4	s11.4

Table 5. Turning circle 35° starboard, deep water.

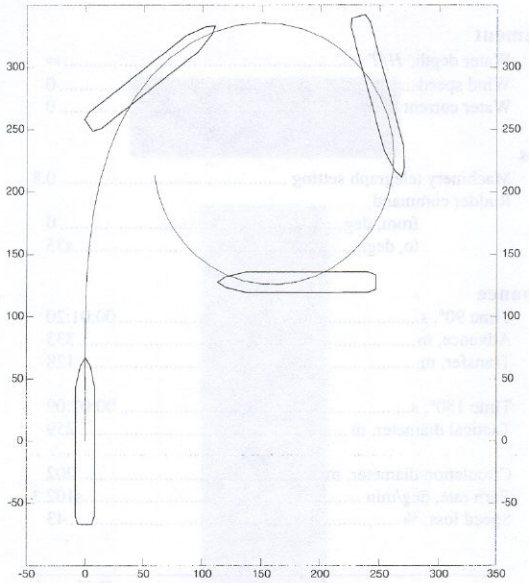


Fig. 10. Turning circle 35° starboard, deep water. Ship position plot.

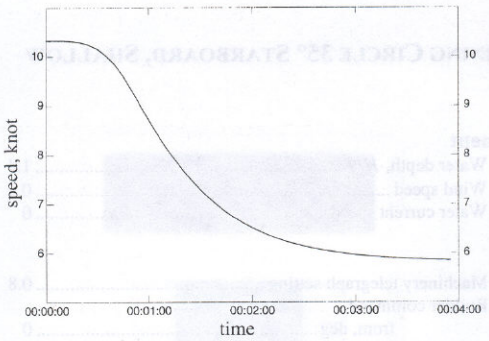


Fig. 11. Turning circle 35° starboard, deep water. Speed plot.

9. Turning Circle 35° Starboard, Shallow Water

Environment

Water depth, H/T 1.5
Wind speed 0
Water current speed 0

Controls

Machinery telegraph setting 0.8
Rudder command
from, deg 0
to, deg s35

Performance

Time 90°, s 00:01:42
Advance, m 399
Transfer, m 194

Time 180°, s 00:02:44
Tactical diameter, m 367

Circulation diameter, m 286
Turn rate, deg/min s86.4
Speed loss, % 32

Metodología:

Ejercicios de maniobras de atraque de barcazas en diferentes escenarios en el área de la extensión, maniobras de atraque de Panamax con una barcaza atracada en la parte externa y vice-versa. Se han efectuado todos los ejercicios en condiciones de marea baja de modo a verificar puntos críticos de profundidad bajo la quilla en las aproximaciones.

Modelo de buques utilizados: (ver anexos)

- Barcaza de combustible modelo CARGO 06L (140/16,4/3,7)m (sin uso del bow thruster).
- Tanquero Panamax modelo TANK07L (228/32,2/16)m

time s	speed knot	heading deg	turn rate deg/min	drift angle deg
00:00:00	10.3	000.0	s0.0	s0.0
00:00:20	10.1	003.7	s25.2	s2.0
00:00:40	9.7	016.3	s49.2	s3.9
00:01:00	9.2	035.6	s65.8	s4.9
00:01:20	8.7	059.8	s78.3	s5.6
00:01:40	8.1	087.2	s85.0	s5.8
00:02:00	7.7	115.9	s87.0	s6.1
00:02:20	7.5	145.0	s87.4	s6.3
00:02:40	7.3	174.1	s87.3	s6.4
00:03:00	7.2	203.2	s87.2	s6.5
00:03:20	7.1	232.2	s86.9	s6.5
00:03:40	7.1	261.2	s86.8	s6.5
00:04:00	7.0	290.1	s86.6	s6.6
00:04:20	7.0	318.9	s86.5	s6.6
00:04:40	7.0	347.8	s86.4	s6.6

Table 6. Turning circle 35° starboard, shallow water.

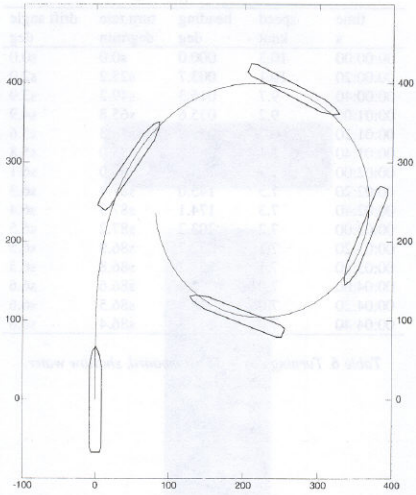


Fig. 12. Turning circle 35° starboard, shallow water. Ship position plot.

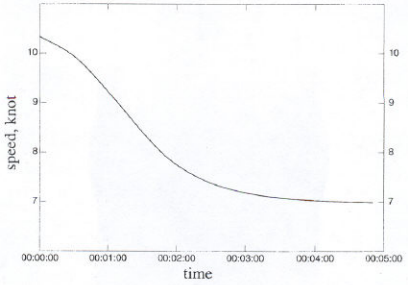


Fig. 13. Turning circle 35° starboard, shallow water. Speed plot.

10. Turning Circle 35° Port, Deep Water

Environment

Water depth, H/T ..... ∞
Wind speed 0
Water current speed 0

Controls

Machinery telegraph setting 0.8
Rudder command
from, deg 0
to, deg p35

Performance

Time 90°, s 00:01:20
Advance, m 335
Transfer, m 129

Time 180°, s 00:02:09
Tactical diameter, m 261

Circulation diameter, m 204
Turn rate, deg/min p101.9
Speed loss, % 43

time s	speed knot	heading deg	turn rate deg/min	drift angle deg
00:00:00	10.3	000.0	s0.0	s0.0
00:00:15	10.3	357.6	p23.3	p2.1
00:00:30	10.2	348.3	p51.9	p5.5
00:00:45	9.6	331.2	p85.0	p8.6
00:01:00	8.7	307.0	p104.7	p9.8
00:01:15	7.9	279.9	p111.1	p10.5
00:01:30	7.3	252.0	p111.7	p10.9
00:01:45	6.9	224.2	p110.2	p11.1
00:02:00	6.5	196.9	p108.3	p11.2
00:02:15	6.3	170.1	p106.5	p11.3
00:02:30	6.2	143.6	p105.1	p11.3
00:02:45	6.1	117.5	p104.0	p11.4
00:03:00	6.0	091.6	p103.2	p11.4
00:03:15	5.9	065.9	p102.7	p11.4
00:03:30	5.9	040.2	p102.3	p11.4
00:03:45	5.9	014.7	p102.0	p11.4

Table 7. Turning circle 35° port, deep water.

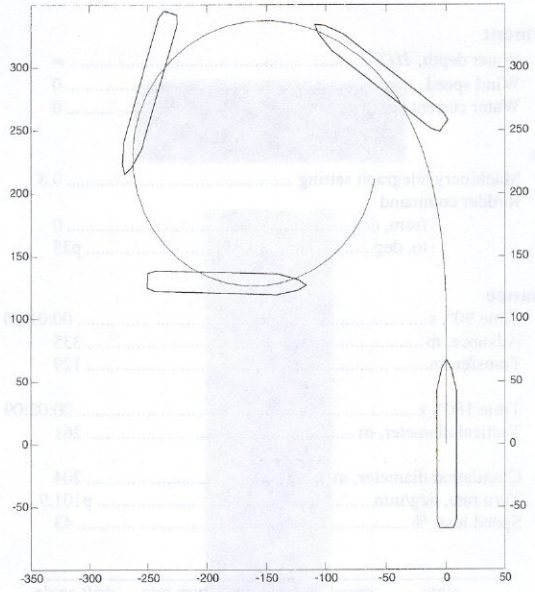


Fig. 14. Turning circle 35° port, deep water. Ship position plot.

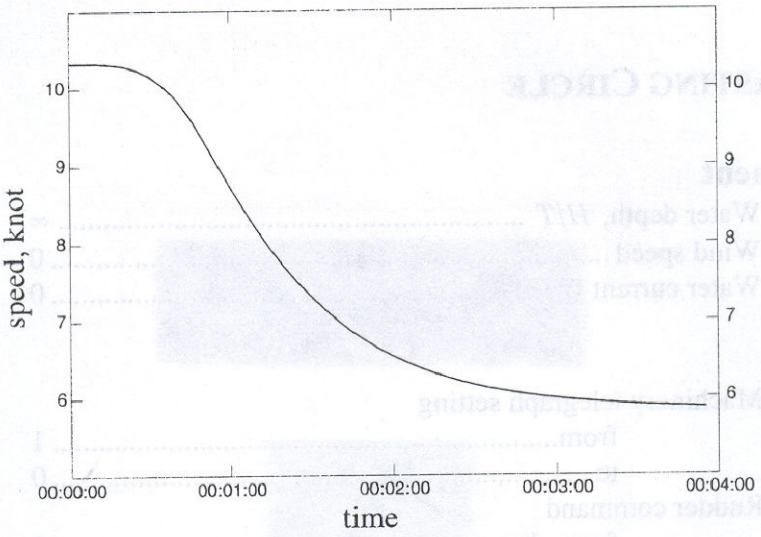


Fig. 15. Turning circle 35° port, deep water. Speed plot.

11. COASTING CIRCLE

Environment

Water depth, H/T ..... ∞
Wind speed 0
Water current speed 0

Controls

Machinery telegraph setting
from..... 1
to 0
Rudder command
from, deg..... 0
to, deg.....s35

time s	speed knot	heading deg	turn rate deg/min	drift angle deg
00:00:00	11.1	000.0	s0.0	s0.0
00:00:40	9.4	013.4	s37.5	s4.9
00:01:20	6.9	048.7	s65.3	s9.1
00:02:00	4.8	092.2	s62.2	s10.3
00:02:40	3.5	130.2	s51.6	s10.9
00:03:20	2.7	161.4	s42.6	s11.2
00:04:00	2.2	187.4	s35.7	s11.4
00:04:40	1.8	209.4	s30.5	s11.5
00:05:20	1.5	228.4	s26.5	s11.6
00:06:00	1.3	245.0	s23.4	s11.7
00:06:40	1.2	259.7	s20.9	s11.7
00:07:20	1.0	272.9	s18.8	s11.8
00:08:00	0.9	284.9	s17.1	s11.8
00:08:40	0.8	295.8	s15.7	s11.9
00:09:20	0.8	305.9	s14.5	s11.9
00:10:00	0.7	315.2	s13.4	s11.9

Table 8. Coasting Circle.

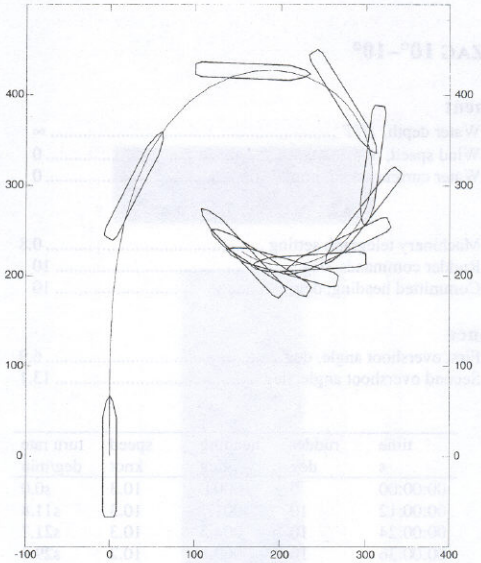


Fig. 16. Coasting Circle. Ship position plot.

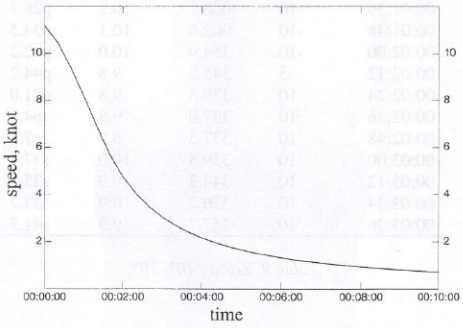


Fig. 17. Coasting Circle. Speed plot

12. ZIGZAG 10°–10°

Environment

Water depth, H/T ..... ∞
Wind speed, m/s 0
Water current speed, knot 0

Controls

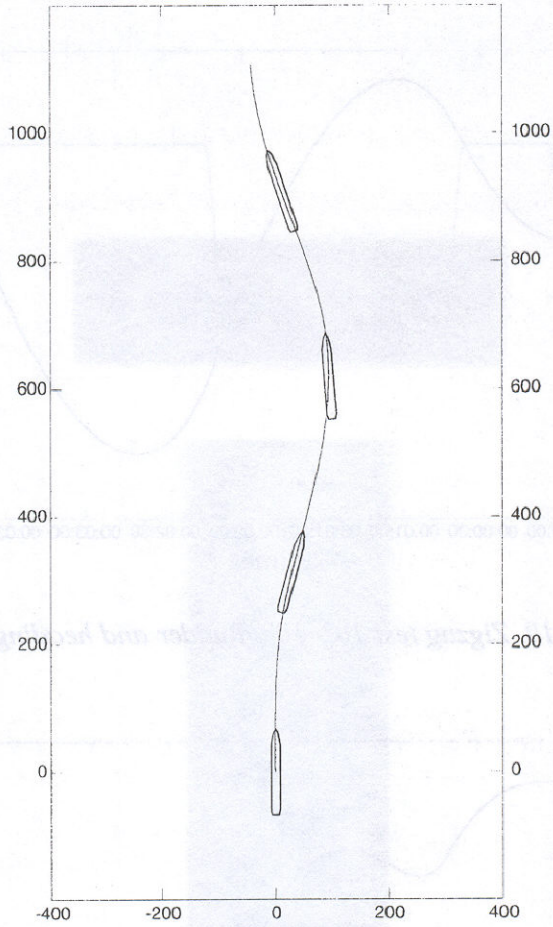
Machinery telegraph setting 0.8
Rudder commands, deg 10
Committed heading, deg 10

Performance

First overshoot angle, deg 6.9
Second overshoot angle, deg 13.1

time s	rudder deg	heading deg	speed knot	turn rate deg/min
00:00:00	0	000.0	10.3	s0.0
00:00:12	10	001.1	10.3	s11.8
00:00:24	10	004.5	10.3	s21.7
00:00:36	10	009.6	10.2	s29.6
00:00:48	-10	015.0	10.2	s17.6
00:01:00	-10	016.8	10.2	s2.3
00:01:12	-10	016.1	10.2	p9.1
00:01:24	-10	013.3	10.2	p18.6
00:01:36	-10	008.7	10.2	p26.7
00:01:48	-10	002.6	10.1	p34.5
00:02:00	-10	354.9	10.0	p42.2
00:02:12	5	345.9	9.8	p44.2
00:02:24	10	339.5	9.8	p21.0
00:02:36	10	337.0	9.8	p4.8
00:02:48	10	337.3	9.9	s7.3
00:03:00	10	339.8	10.0	s17.4
00:03:12	10	344.2	10.0	s25.8
00:03:24	10	350.2	10.0	s33.7
00:03:36	10	357.7	9.9	s41.7

Table 9. Zigzag 10°–10°.


1000
800
600
400
200
0
-400
-200
0
200
400

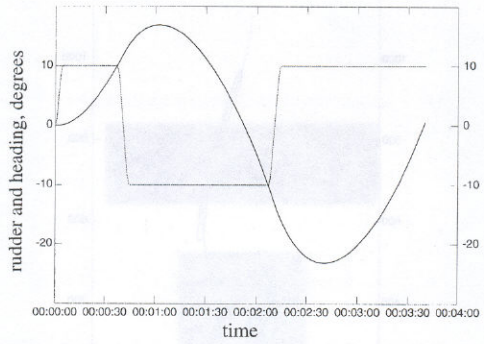


Fig. 19. Zigzag test 10°–10°. Rudder and heading plot.

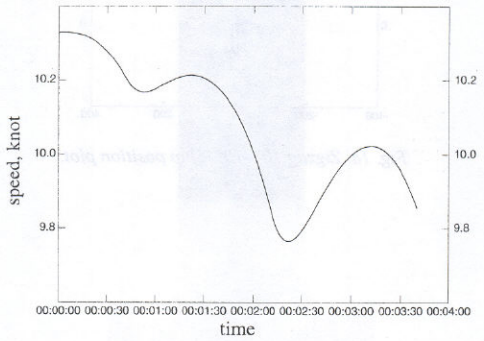
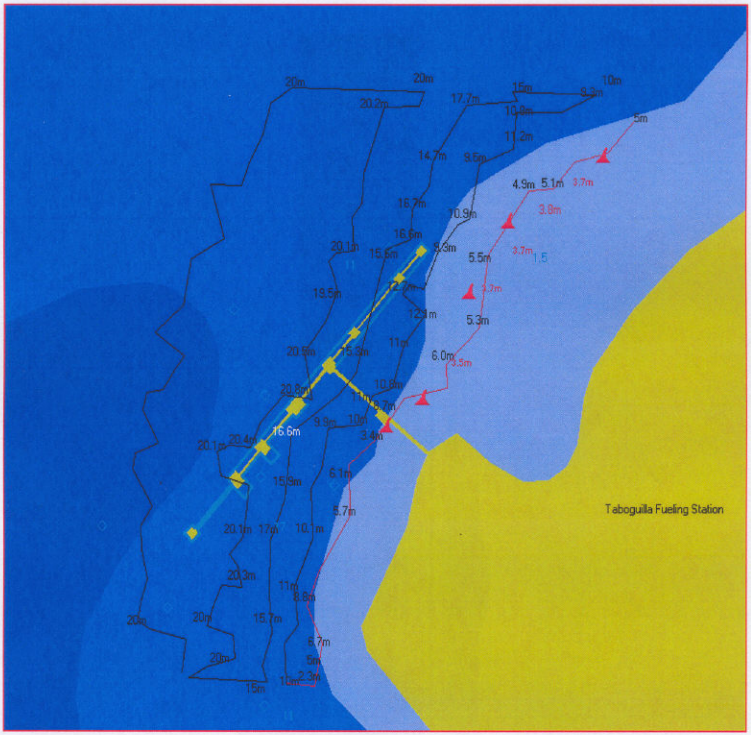


Fig. 20. Zigzag test 10°–10°. Speed plot.

Resultados (ver anexos ejercicios/visuales):

- Las maniobras de aproximación y atraque al muelle interno norte tienen un grado alto de dificultad por la falta de señalización (enfilaciones, boyas limites, etc.) que dificultan la localización de la isobatimetrica de 5 metros y por tanto, el posible encalle de la nave. En circunstancias de visibilidad reducida (lluvia, etc.) no es recomendable la maniobra.



13. ZIGZAG 20°–20°

Environment

Water depth, H/T ..... ∞
Wind speed 0
Water current speed 0

Controls

Machinery telegraph setting 0.8
Rudder commands, deg 20
Committed heading, deg 20

Performance

First overshoot angle, deg 20.7
Second overshoot angle, deg 28.9

time s	rudder deg	heading deg	speed knot	turn rate deg/min
00:00:00	0	000.0	10.3	s0.0
00:00:14	20	002.0	10.3	s20.1
00:00:28	20	009.1	10.2	s40.0
00:00:42	20	020.8	10.0	s60.0
00:00:56	-20	034.2	9.6	s43.3
00:01:10	-20	040.2	9.6	s10.4
00:01:24	-20	039.8	9.7	p12.4
00:01:38	-20	034.8	9.8	p30.8
00:01:52	-20	025.3	9.8	p50.3
00:02:06	-20	011.3	9.4	p69.0
00:02:20	-20	353.4	8.9	p82.5
00:02:34	-9	333.6	8.4	p85.2
00:02:48	20	318.0	8.2	p45.6
00:03:02	20	311.6	8.5	p11.3
00:03:16	20	311.8	8.9	s11.7
00:03:30	20	316.8	9.1	s30.1
00:03:44	20	326.1	9.2	s49.5
00:03:58	20	339.8	9.0	s68.3
00:04:12	20	357.5	8.6	s81.3

Table 10. Zigzag 20°–20°.

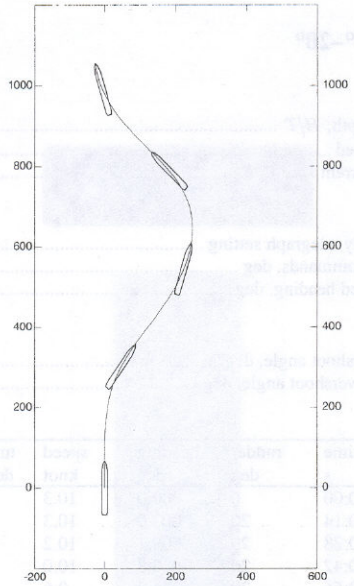


Fig. 21. Zigzag 20°–20°. Ship position plot.

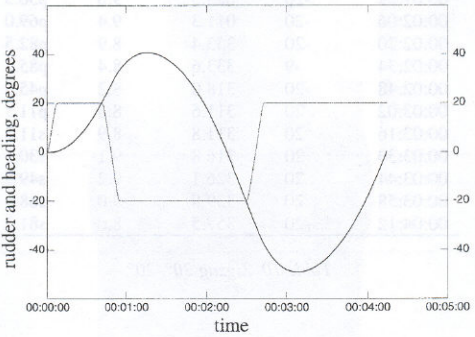


Fig. 22. Zigzag test 20°–20°. Rudder and heading plot.

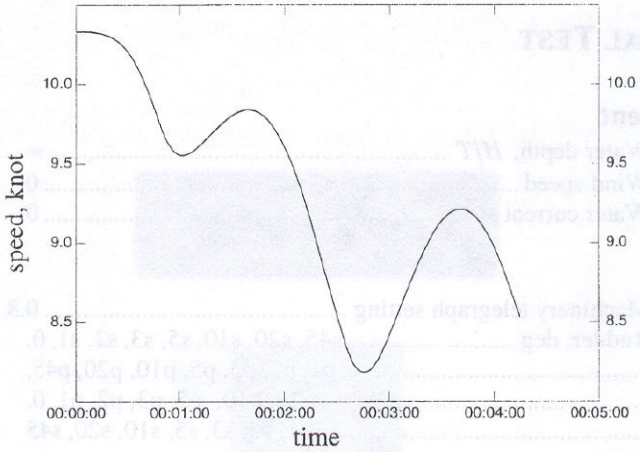


Fig. 23. Zigzag test 20°–20°. Speed plot.

14. SPIRAL TEST

Environment

Water depth, H/T ..... ∞
Wind speed 0
Water current speed 0

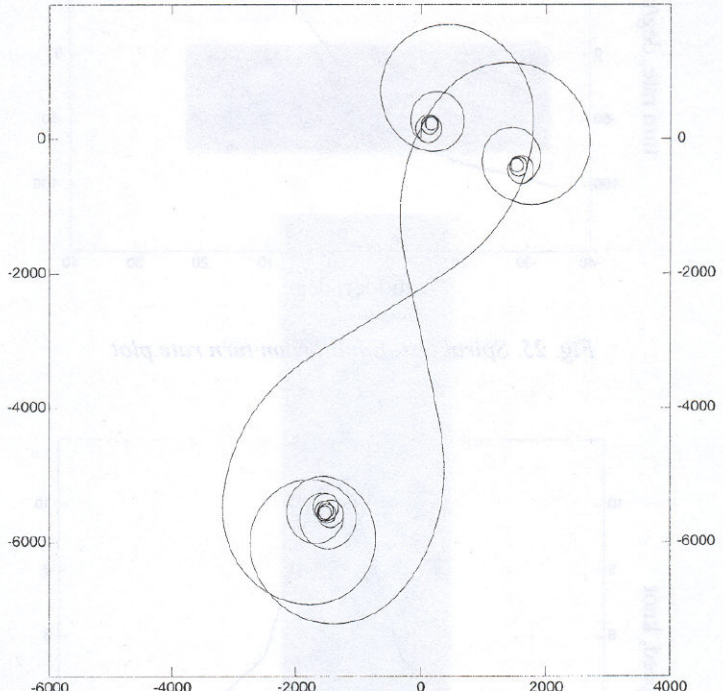
Controls

Machinery telegraph setting 0.8
Rudder, deg s45, s20, s10, s5, s3, s2, s1, 0,
..... p1, p2, p3, p5, p10, p20, p45,
..... p20, p10, p5, p3, p2, p1, 0,
..... s1, s2, s3, s5, s10, s20, s45

time s	rudder deg	speed knot	turn rate deg/min
00:00:00	s0.0	10.3	s0.0
00:08:20	s35.0	5.8	s101.8
00:16:40	s20.0	6.7	s84.0
00:25:00	s10.0	7.7	s65.4
00:33:20	s5.0	9.4	s37.5
00:41:40	s3.0	10.1	s19.0
00:50:00	s2.0	10.2	s13.2
00:58:20	s1.0	10.3	s6.8
01:06:40	s0.0	10.3	p0.0
01:15:00	p1.0	10.3	p6.7
01:23:20	p2.0	10.2	p12.9
01:31:40	p3.0	10.1	p18.7
01:40:00	p5.0	9.4	p36.9
01:48:20	p10.0	7.7	p65.5
01:56:40	p20.0	6.8	p82.7
02:05:00	p35.0	5.8	p101.4
02:13:20	p20.0	6.8	p82.8
02:21:40	p10.0	7.7	p65.6
02:30:00	p5.0	9.4	p37.1
02:38:20	p3.0	10.1	p18.8
02:46:40	p2.0	10.2	p12.9
02:55:00	p1.0	10.3	p6.7
03:03:20	s0.0	10.3	s0.0
03:11:40	s1.0	10.3	s6.9
03:20:00	s2.0	10.2	s13.2
03:28:20	s3.0	10.1	s19.0
03:36:40	s5.0	9.4	s37.4
03:45:00	s10.0	7.7	s65.2
03:53:20	s20.0	6.7	s83.9

04:01:40	s35.0	5.8	s101.8

Table 11. Spiral test.



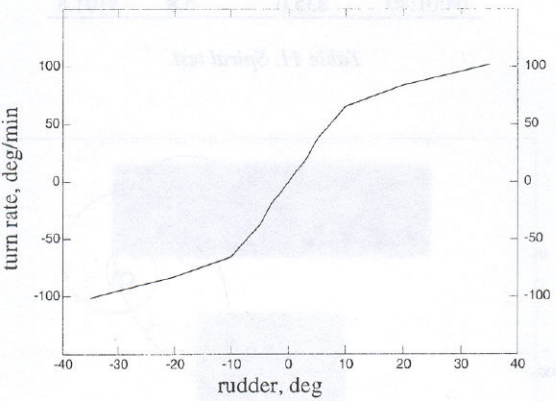
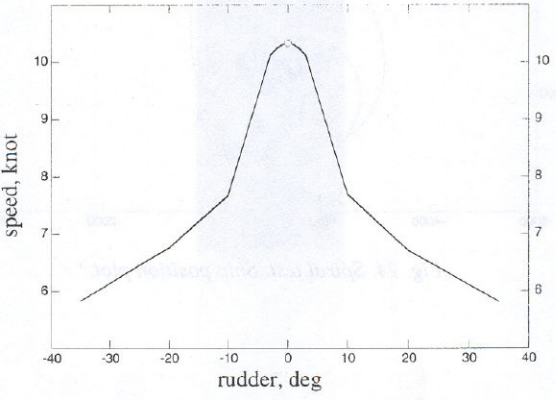


Fig. 25. Spiral test. Equilibrium turn rate plot



15. WIND EFFECT—STOPPED

Environment

Water depth, H/T ..... ∞
Wind speed, m/s 20
Wind direction "from", deg 090.0
Water current speed 0

Controls

Machinery telegraph setting 0
Rudder, deg 0

time s	speed knot	heading deg	drift angle deg
00:00:00	0.0	000.0	s0.0
00:00:20	0.8	000.4	s90.4
00:00:40	1.1	001.1	s91.2
00:01:00	1.2	001.5	s92.0
00:01:20	1.2	001.6	s92.7
00:01:40	1.2	001.5	s93.1
00:02:00	1.2	001.3	s93.4
00:02:20	1.2	001.0	s93.6
00:02:40	1.2	000.7	s93.7
00:03:00	1.2	000.5	s93.9
00:03:20	1.2	000.3	s94.1
00:03:40	1.2	000.2	s94.3
00:04:00	1.2	000.1	s94.5
00:04:20	1.2	000.0	s94.8
00:04:40	1.2	360.0	s95.0
00:05:00	1.2	359.9	s95.2

Table 12. Wind effect—stopped.

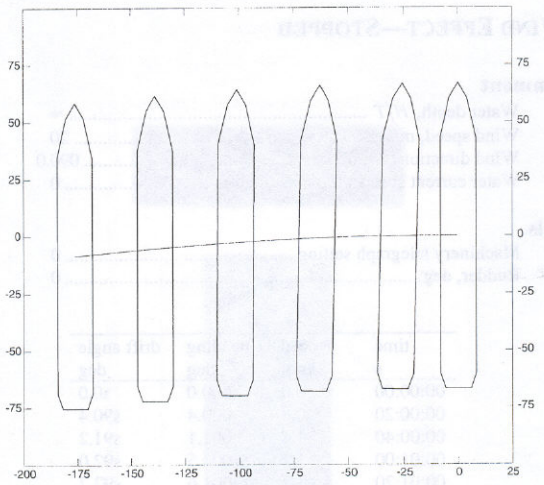


Fig. 27. Wind effect—stopped. Ship position plot.

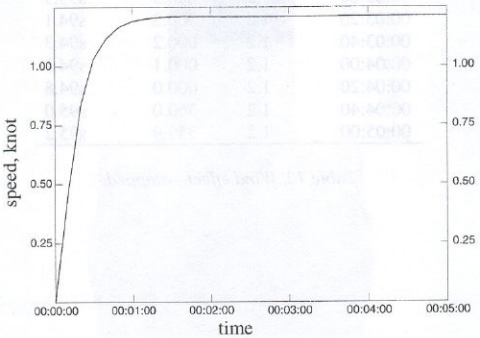


Fig. 28. Wind effect—stopped. Speed plot.

16. WIND EFFECT—UNDER WAY

Environment

Water depth, H/T ..... ∞
Wind speed, m/s 20
Wind direction "from", deg 090.0
Water current speed 0

Controls

Machinery telegraph setting 1
Rudder, deg 0

time s	speed knot	heading deg	drift angle deg
00:00:00	11.1	000.0	s0.0
00:00:20	11.1	001.2	s3.2
00:00:40	11.0	006.4	s5.0
00:01:00	10.9	014.3	s6.0
00:01:20	10.7	023.3	s6.4
00:01:40	10.5	032.4	s6.5
00:02:00	10.4	040.7	s6.2
00:02:20	10.3	048.1	s5.7
00:02:40	10.3	054.5	s5.1
00:03:00	10.3	059.9	s4.5
00:03:20	10.3	064.3	s3.9
00:03:40	10.4	067.9	s3.3
00:04:00	10.4	070.8	s2.8
00:04:20	10.5	073.3	s2.4
00:04:40	10.5	075.4	s2.1
00:05:00	10.5	077.2	s1.8

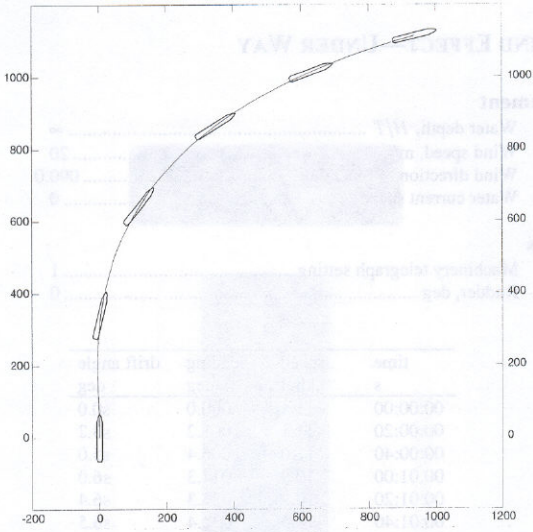


Fig. 29. Wind effect— under way. Ship position plot.

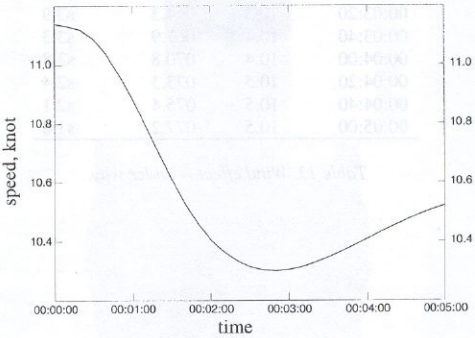
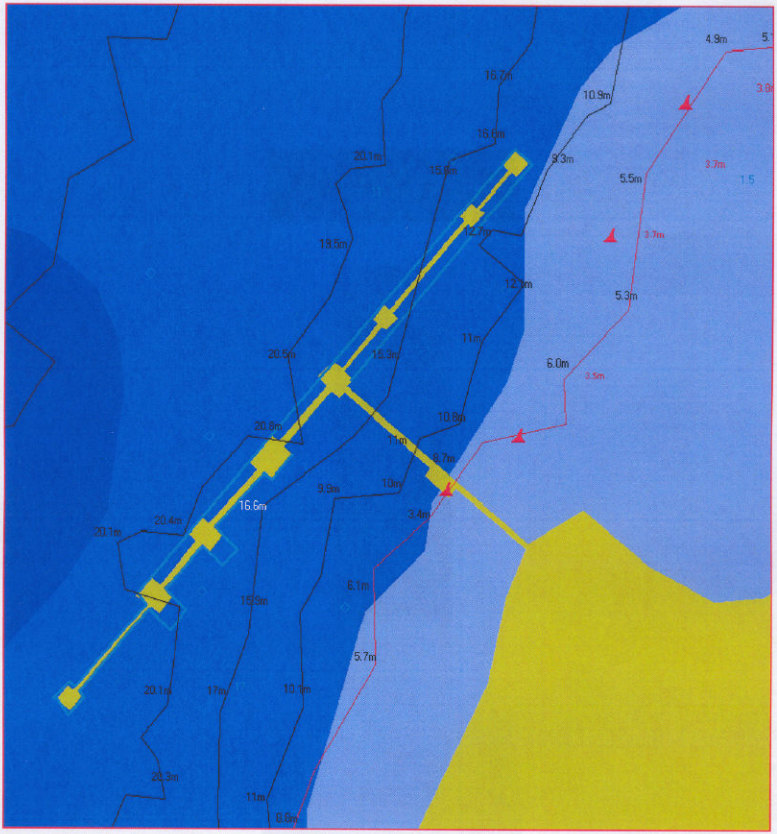


Fig. 30. Wind effect—under way. Speed plot.


4.9m
18.7m
10.9m
16.6m
20.1m
15.9m
9.3m
5.5m
3.7m
18.7m
12.7m
12.3m
5.3m
11m
20.5m
16.3m
6.0m
3.5m
10.8m
20.9m
9.7m
9.9m
10m
16.6m
3.4m
20.1m
20.4m
8.1m
15.9m
5.7m
20.1m
17m
10.1m
20.3m
11m
8.9m

17. FREE OSCILLATIONS

Environment

Water depth, H/T ..... ∞
Wind speed 0
Water current speed 0
Wave height 0

Controls

Machinery telegraph setting 1
Rudder, deg 0

Initial Inclination

Roll, deg 5
Pitch, deg 2.5
Heave, m 0

time s	roll deg	pitch deg	heave m
0	5.0	2.5	0.00
1	4.5	0.7	-0.01
2	3.2	-1.5	0.00
3	1.4	-1.3	0.01
4	-0.4	0.6	0.01
5	-2.0	1.2	0.00
6	-3.1	0.2	-0.01
7	-3.5	-0.9	0.00
8	-3.2	-0.5	0.01
9	-2.3	0.4	0.00
10	-1.1	0.6	-0.01
11	0.2	0.0	-0.01
12	1.4	-0.5	0.00
13	2.2	-0.2	0.01
14	2.5	0.3	0.00
15	2.3	0.3	0.00
16	1.7	-0.1	-0.01
17	0.9	-0.2	0.00
18	-0.1	-0.1	0.00
19	-0.9	0.1	0.00
20	-1.5	0.1	0.00
21	-1.8	-0.1	0.00
22	-1.7	-0.1	0.00
23	-1.3	0.0	0.00
24	-0.7	0.1	0.00
25	0.0	0.1	0.00

26	0.6	0.0	0.00
27	1.0	-0.1	0.00
28	1.2	0.0	0.00
29	1.2	0.0	0.00
30	0.9	0.0	0.00
31	0.5	0.0	0.00
32	0.0	0.0	0.00
33	-0.4	0.0	0.00
34	-0.7	0.0	0.00
35	-0.9	0.0	0.00
36	-0.9	0.0	0.00
37	-0.7	0.0	0.00
38	-0.4	0.0	0.00
39	-0.1	0.0	0.00
40	0.3	0.0	0.00
41	0.5	0.0	0.00
42	0.6	0.0	0.00
43	0.6	0.0	0.00
44	0.5	0.0	0.00
45	0.3	0.0	0.00
46	0.1	0.0	0.00
47	-0.2	0.0	0.00
48	-0.4	0.0	0.00
49	-0.5	0.0	0.00
50	-0.5	0.0	0.00
51	-0.4	0.0	0.00
52	-0.2	0.0	0.00
53	-0.1	0.0	0.00
54	0.1	0.0	0.00
55	0.2	0.0	0.00
56	0.3	0.0	0.00
57	0.3	0.0	0.00
58	0.3	0.0	0.00
59	0.2	0.0	0.00
60	0.1	0.0	0.00
61	-0.1	0.0	0.00
62	-0.2	0.0	0.00
63	-0.2	0.0	0.00
64	-0.2	0.0	0.00
65	-0.2	0.0	0.00
66	-0.1	0.0	0.00
67	0.0	0.0	0.00

Table 14. Free Oscillations.

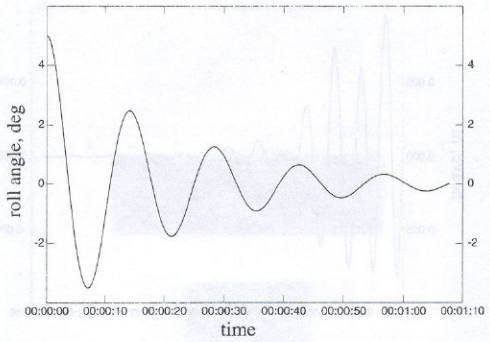


Fig. 31. Free Oscillations. Roll plot.

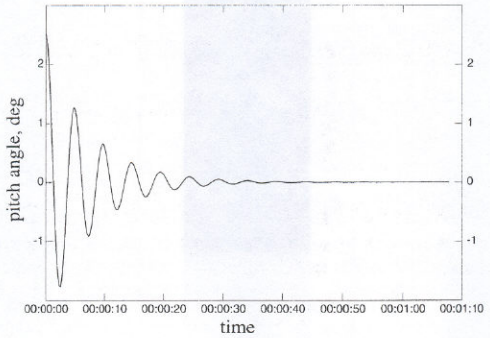


Fig. 32. Free Oscillations. Pitch plot.

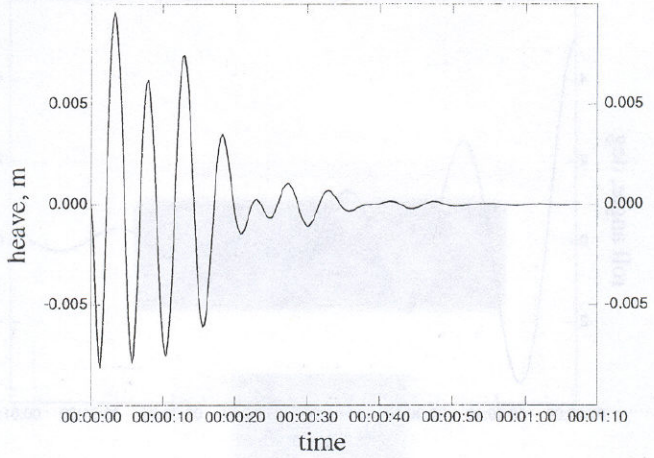


Fig. 33. Free Oscillations. Heave plot.

18. WAVES—STOPPED

Environment

Water depth, H/T	∞
Wind speed	0
Water current speed	0
Wave height, m	2.6
Wave length, m	52.4
Wave period, s	5.8
Wave direction, deg	45
Wave spectrum	Pierson-Moskowitz

Controls

Machinery telegraph setting	0
Rudder, deg	0

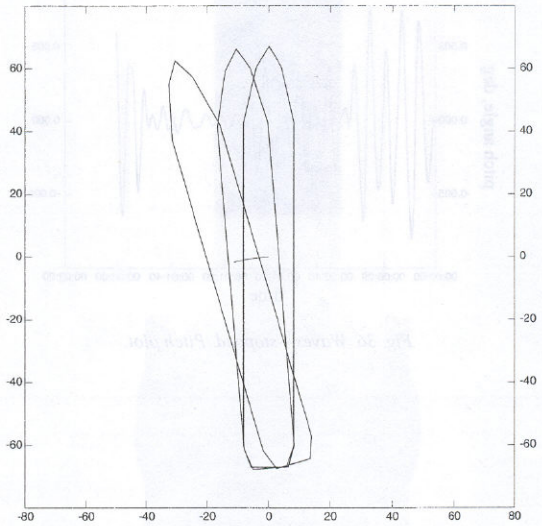


Fig. 34. Waves. Ship position plot.

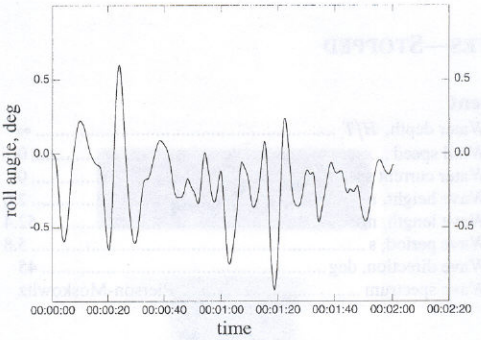


Fig. 35. Waves—stopped. Roll plot.

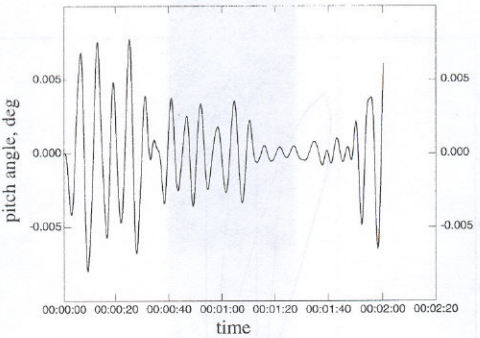


Fig. 36. Waves—stopped. Pitch plot.

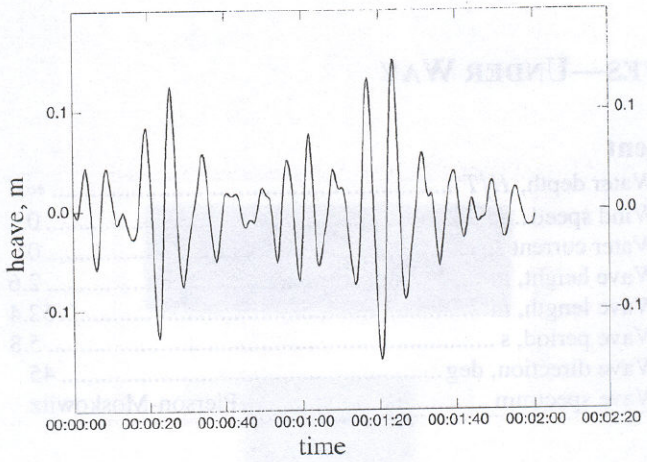


Fig. 37. Waves—stopped. Heave plot.

19. Waves—Under Way

Environment

Water depth, H/T ..... ∞
Wind speed 0
Water current speed 0
Wave height, m 2.6
Wave length, m 52.4
Wave period, s 5.8
Wave direction, deg 45
Wave spectrum ..... Pierson-Moskowitz

Controls

Machinery telegraph setting 1
Rudder, deg 0

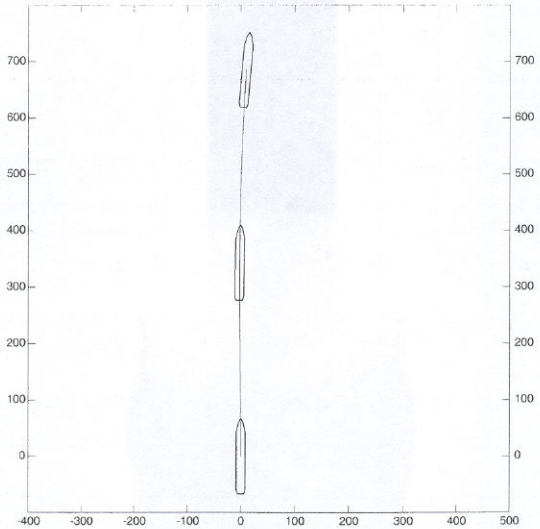


Fig. 38. Waves—under way. Ship position plot.

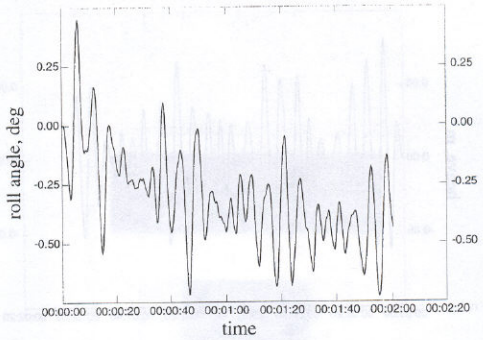


Fig. 39. Waves—under way. Roll plot.

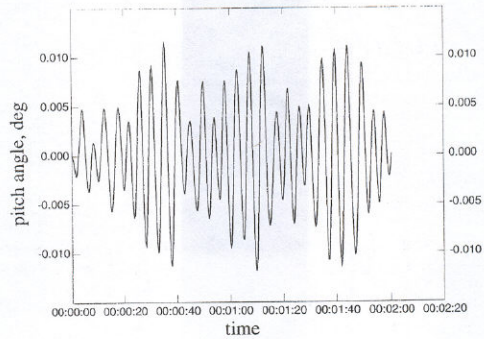


Fig. 40. Waves—under way. Pitch plot.

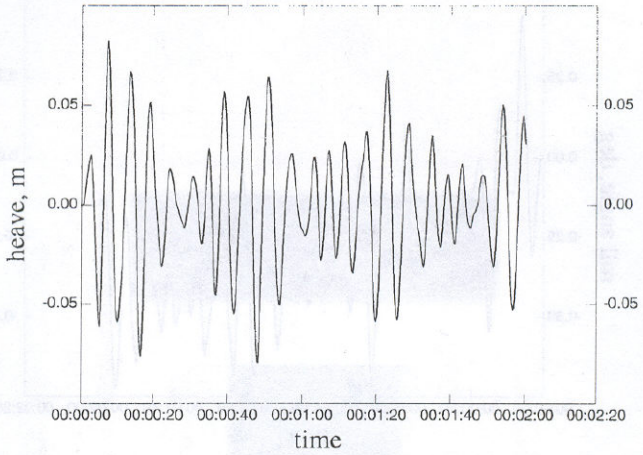
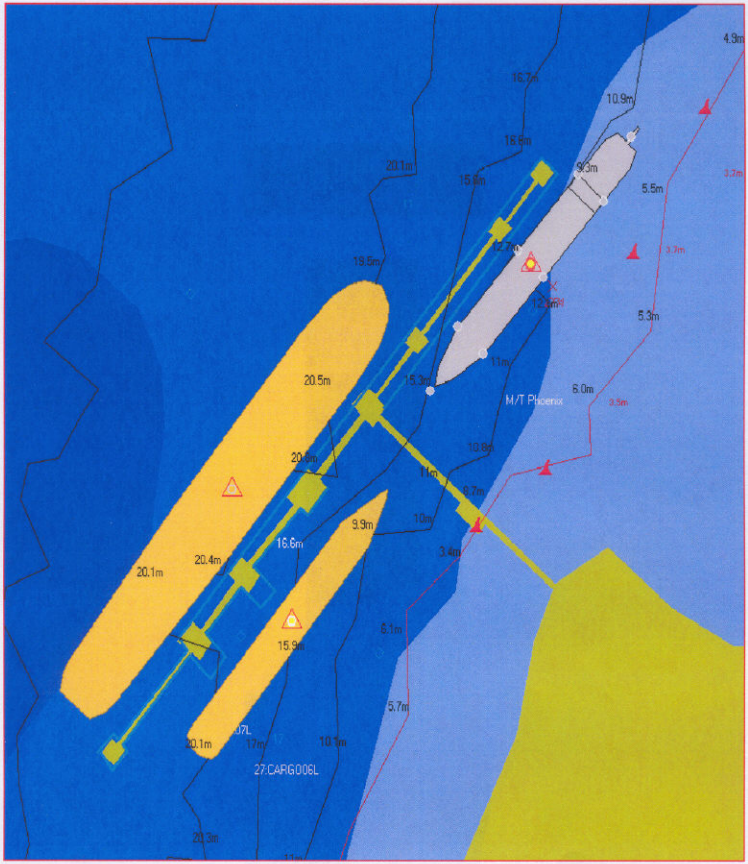


Fig. 41. Waves—under way. Heave plot.


4.9m
16.7m
10.9m
18.6m
20.1m
15.8m
9.3m
5.5m
19.5m
12.2m
5.3m
20.5m
15.3m
11m
6.0m
M/T Phoenix
20.4m
10.8m
11m
9.7m
9.9m
10m
16.6m
20.1m
20.4m
3.4m
6.1m
15.9m
5.7m
20.1m
17m
10.3m
27:CARG006L
20.3m