

Green Dolphin 575

– a concept design for a new Handymax bulk carrier



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Developed in response to a complex and demanding market situation with low freight rates, high fuel costs and new environmental standards

The Green Dolphin 575 is the result of good long-term cooperation between SDARI and DNV GL. The new concept design builds on the success factors of the previous collaboration project, the Green Dolphin 38.

The Green Dolphin 575 is a new Handymax bulk carrier concept design. Backed up by DNV GL and SDARI's long history and experience within the bulk carrier segment, the choice of ship size is based on an extensive market analysis together with input from many ship owners and ship operators. Ship owner and ship operator input has also been considered when selecting design characteristics and design options. The main dimensions have been determined by systematic variation of different hull parameters, followed by resistance calculations using Computational Fluid Dynamics (CFD) to ensure a combination giving the lowest possible fuel consumption.

Handymax bulk carriers can take a wide range of major and minor bulk cargoes and access many ports, ensuring a

relatively stable demand for this size segment. Because of its suitable cargo lot size Handymax vessels can take market shares from the Handysize segment and compete with larger size bulk carriers. The business is driven by both the global long-haul market and regional short-to-medium-haul markets. There is a growing demand for regional transportation, particularly in Asia, and this is largely believed to benefit Handymax vessels.

DESIGN CHARACTERISTICS

The Green Dolphin 575 is a single-hull CSR Handymax bulk carrier with five cargo holds. Its design is based on currently available technologies and fulfils the four main objectives of being fuel and energy efficient, robust and reliable, operationally flexible and able to meet both current and future environmental regulations.

FUEL AND ENERGY EFFICIENT

ENVIRONMENT-FRIENDLY AND PREPARED FOR FUTURE REGULATIONS



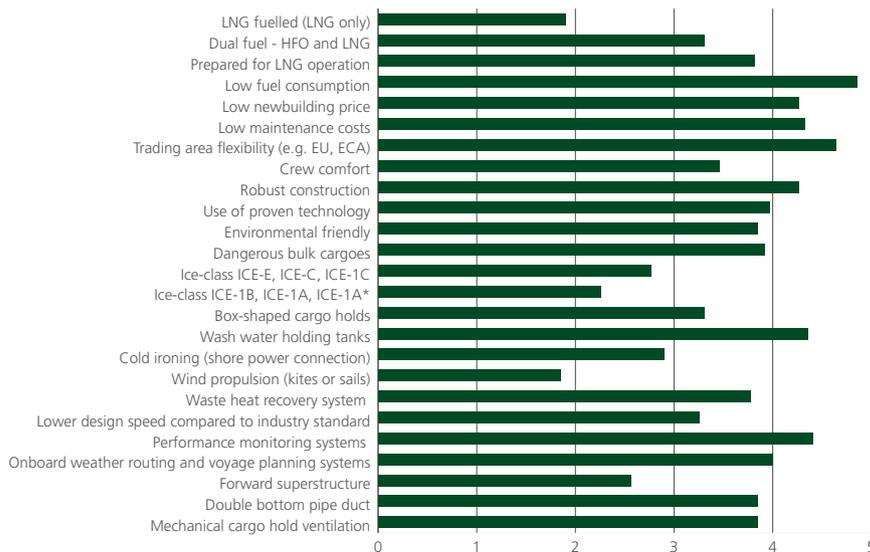
OPERATIONAL FLEXIBILITY AND MAINTENANCE FRIENDLINESS

SAFE, ROBUST AND RELIABLE

Similar to the Green Dolphin 38, the hull is designed to achieve optimal fuel efficiency without compromising on strength and operational flexibility. New for this project is that performance in waves has also been addressed - through model testing and calculations of the added resistance on a given trade route.

The engine configuration and emission-reduction technologies have been carefully evaluated. The design is fitted with an efficient Tier II long-stroke low-speed main engine.

The Green Dolphin 575 is designed to comply with current and future expected local and global emission regulations, such as those relevant for IMO Tier III, Emission Control Areas (ECAs), California and EU ports, through different alternatives: a switch to low-sulphur fuels, the installation of exhaust-gas cleaning systems or dual-fuel operation with LNG.



Design based on input from ship owners and ship operators. Illustration shows sample survey response (0-Not important, 5-Very important)

GREEN DOLPHIN 38

The first in a series of Green Dolphin bulk carriers, the Green Dolphin 38 Handysize bulk carrier concept design, was developed in 2012 by SDARI, DNV and Wärtsilä. Introduced to the market at Posidonia in Greece in June 2012, it attracted a lot of attention and interest and a number of orders have now been placed with Chinese shipyards. The Green Dolphin 38 focused on the following areas: fuel and energy efficiency; robustness and reliability; operational flexibility; and the ability to meet both current and future environmental regulations.

Main data

Length over all: 180 m
Breadth: 32.0 m
Design draught: 9.5 m
Scantling draught: 10.5 m
DWT design: 33,400 mt
DWT scantling: 38,800 mt
Service speed: 14.0 kn

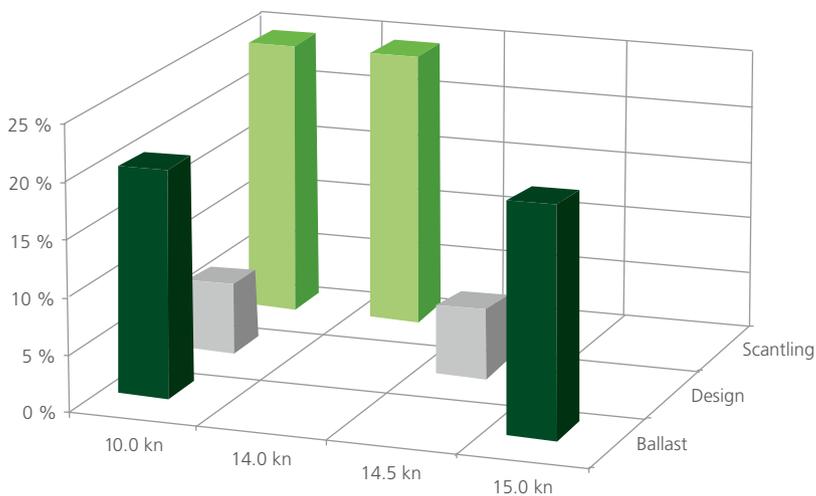


Fuel and energy efficient

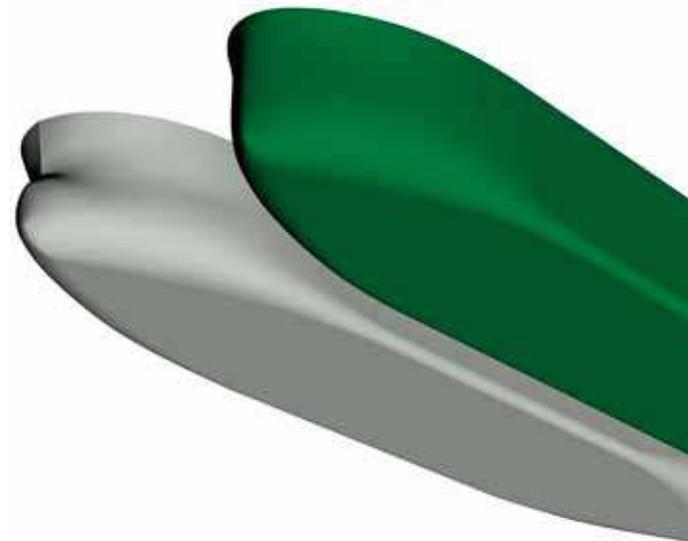
Optimal fuel efficiency in realistic conditions without compromising on strength and operational flexibility

- Main particulars (e.g. length between perpendiculars, deadweight, block-coefficient) determined by systematic variation of different hull parameters, followed by resistance calculations using Computational Fluid Dynamics (CFD) to ensure a combination giving the lowest possible fuel consumption.
- Hull lines optimised for an operating profile including ballast, design and scantling draughts and speeds in the range 10-15 kn
- Resistance calculations performed by full-scale RANS CFD simulations
- Added resistance in waves calculated numerically and compared to tank test results

1. Operating profile (draft-speed combinations and their relative occurrence)

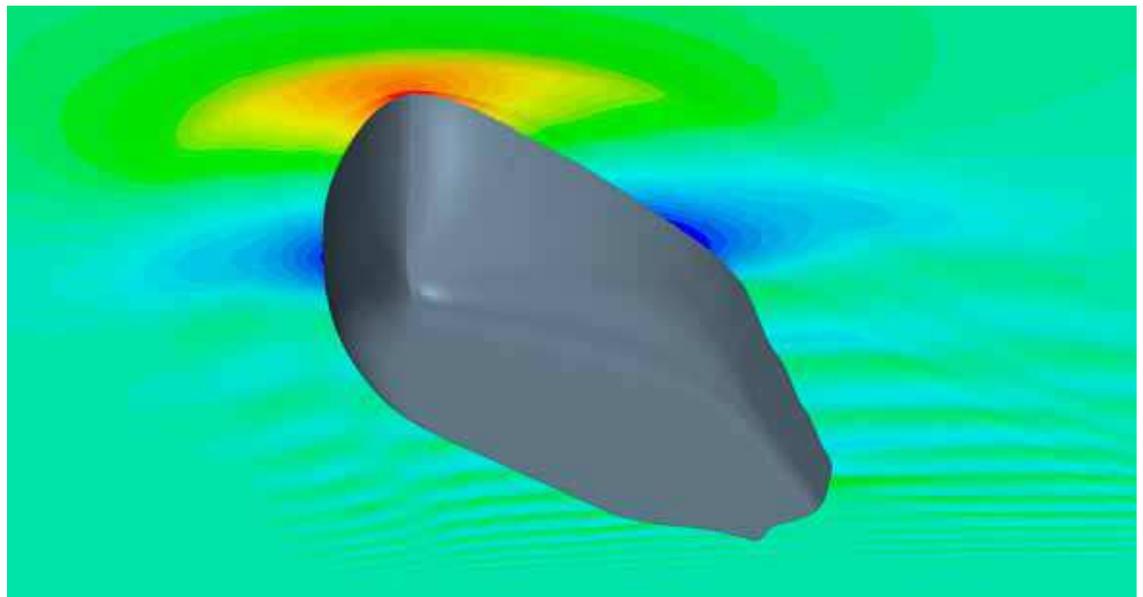


2. Hull design development illustrated by Green Dolphin 575 (green) and the existing Dolphin 57 (grey)



- No-bulb concept for a flexible design with improved overall performance, including operation in realistic sea states
- Main engine (long-stroke and low revolution) with economical fuel consumption over the entire operating range
- Large-diameter slow-rotating propeller
- Improved propulsion efficiency through energy-efficiency devices in way of the propeller, a duct in front of the propeller for improved propeller inflow and propeller cap fins to reduce the propeller hub vortex
- Main engine fuel consumption about 22.8 t/day at CSR condition with 15% sea margin
- A low Energy Efficiency Design Index (EEDI) that can fulfil the EEDI Phase 2 requirement (20% below the IMO reference line for bulk carriers)
- Prepared for shaft torque and fuel consumption monitoring systems to facilitate performance monitoring and support the implementation of SEEMP and EEOI

3. Wave pattern from hull design optimisation process using CFD tools



Performance in waves

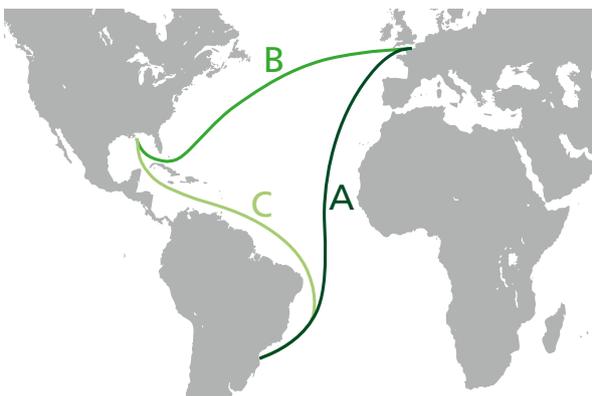
– design for seagoing conditions

A good design should account for resistance in both calm water and in waves. Ship hulls have traditionally been designed for optimal performance in calm water. In a realistic seagoing condition, however, ships will be exposed to additional forces resulting in motions and added resistance that will influence the ship speed and actual fuel consumption. For a bulk carrier of this size, the added resistance is typically up to 20% of the calm water resistance.

The Green Dolphin 575's performance in waves has been assessed through numerical added resistance calculations and corresponding tank tests in waves. The calculations have been performed using SEAROS, a time-domain higher-order DNV GL in-house code. Using this tool in the design phase allows a hull to be optimised for more realistic conditions.

During the assessment, the Green Dolphin 575 was compared to the existing SDARI Dolphin 57 hull, which has similar main dimensions. An operating profile consisting of two loading conditions and two speeds was considered - full load and ballast conditions at service and slow-steaming speeds.

The performances of the two designs were compared along a typical triangular Handymax trade route with the following legs:

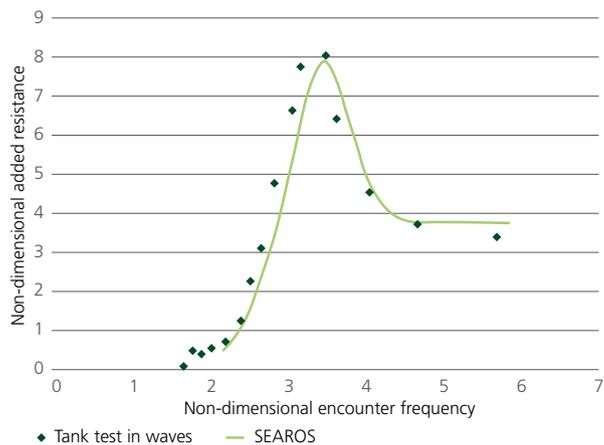


1. Trade route used for the assessment

- A. Santos (Brazil) – ARA (Amsterdam-Rotterdam-Antwerp): full load condition (e.g. with agribulk)
- B. ARA – GoM (Gulf of Mexico): full load condition (e.g. with fertilisers)
- C. GoM – Santos: ballast condition

Firstly, the mean added resistance was calculated for any possible sea state with given significant wave heights and wave periods. Thereafter, the mean added

resistance was calculated for the entire trade route by implementing tailor-made omni-directional scatter diagrams for all legs in the trade route. Each scatter diagram considers the time spent in the different environments along the leg. Oblique wave headings were considered in the assessment and the calculated mean added resistance accounts for the probability of different sea states occurring in each scatter diagram.



2. Correlation between the SEAROS calculations and tank test results (sample case shown: ballast condition at 10 kn)

**RESISTANCE IN WAVES (INCLUDING THE CALM WATER CONTRIBUTION)
Green Dolphin 575 compared to the existing Dolphin 57**

Leg	Santos-ARA (full load)	ARA-GoM (full load)	GoM-Santos (ballast)	Entire trade route (average based on time in each leg)
Speed				
Service speed, 14kn	-12 %	-12 %	-6 %	-10 %
Slow-steaming, 10kn	-6 %	-5 %	-11 %	-7 %

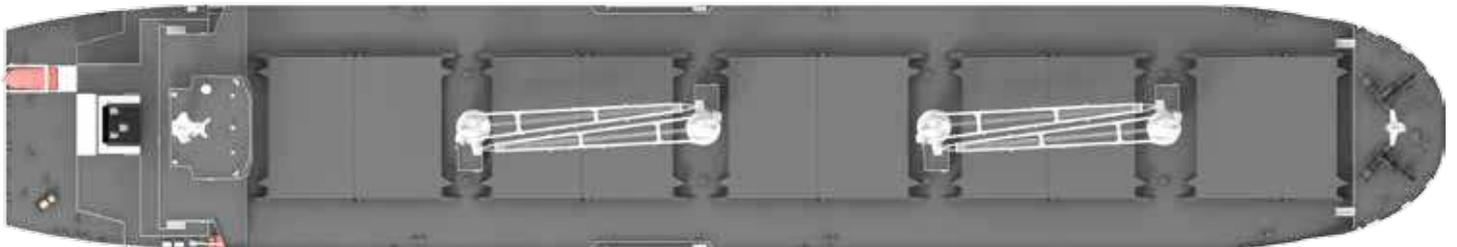
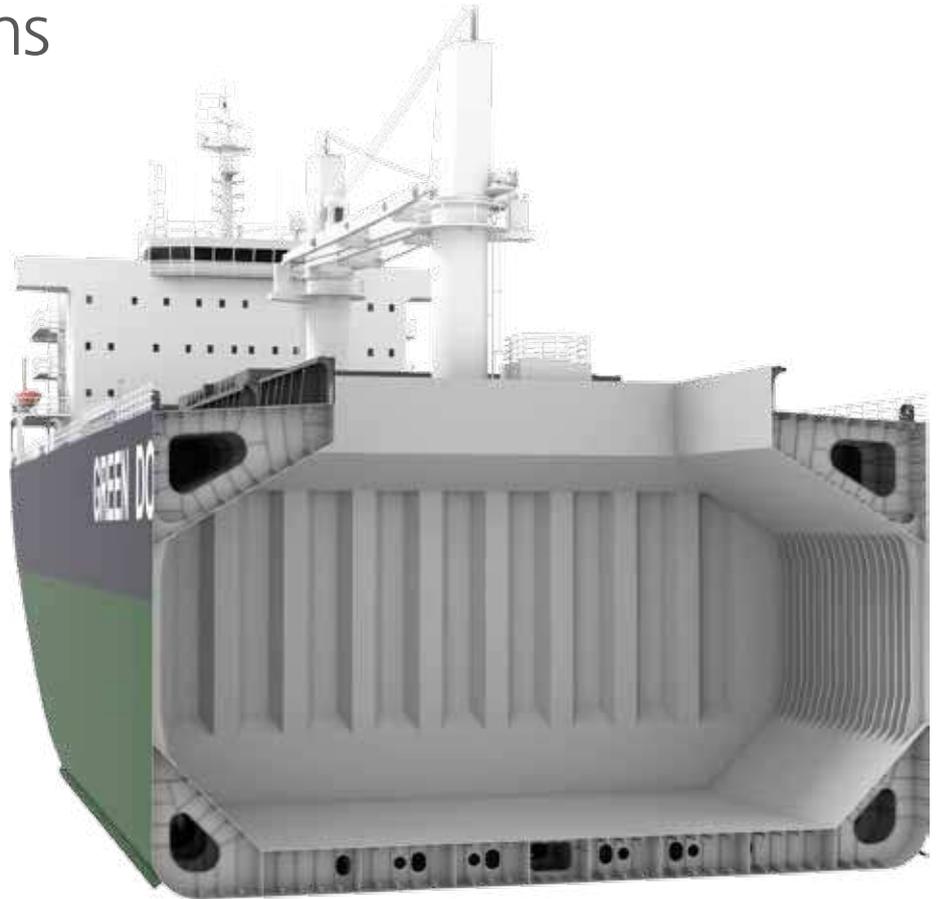
3. Calculation results - resistance in waves

Design versions

The Green Dolphin 575 is available as both a single-hull standard bulk carrier and a double-hull open-hatch bulk carrier

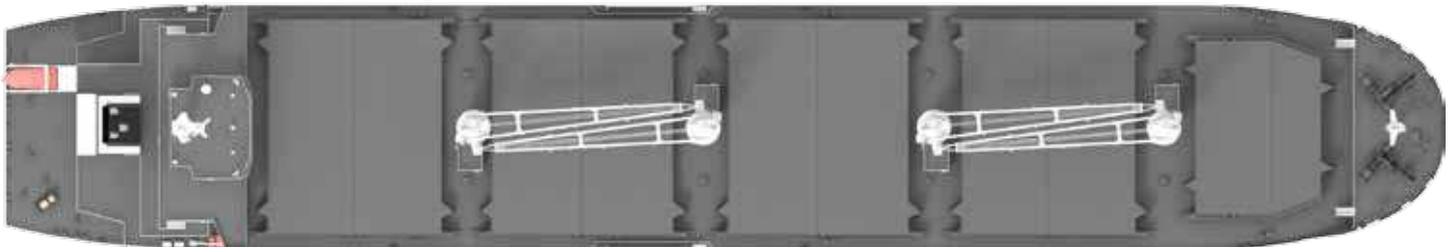
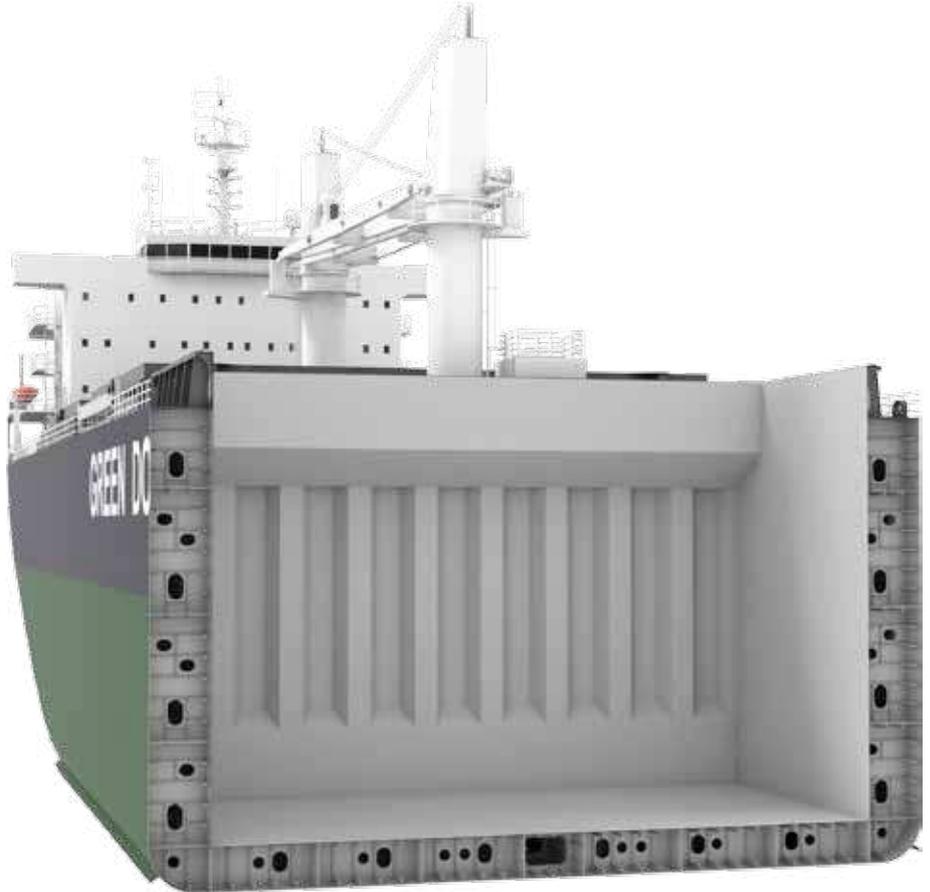
SINGLE-HULL STANDARD VERSION

- Traditional bulk carrier cross-section
- Compliant with IACS Common Structural Rules
- High cubic capacity
- Suitable for free-flowing cargoes, e.g. grain



DOUBLE-HULL OPEN-HATCH

- Double-hull construction, box-shaped cargo holds
- Wide hatch openings
- Suitable for transporting packaged goods and project cargoes
- No hopper or top wing tanks in cargo holds 2, 3 and 4 – easy stowage of project cargoes and steel coils
- Easy cargo hold cleaning
- Container loading on hatch covers, incl. lashing points
- Packaged cargo on hatch covers
- Timber cargo on hatch covers



Safe, robust and reliable

Highest structural standards for bulk carriers

- Designed in accordance with IACS Common Structural Rules (CSR) for Bulk Carriers
- Tank top designed for heavy cargoes and 20 t grabs
- Cargo hold no. 3 as heavy ballast tank
- Pipe duct in double bottom for ballast and bilge lines
- Citadel for crew protection
- A60 engine room bulkhead
- Cargo-hold CO₂ fire-fighting system
- Temperature regulation of fuel oil tanks adjacent to cargo holds no. 4 and no. 5
- Safe working environment for crew and stevedores
- Compliant with revised Code on noise levels on board ships
- Available with ICE class (ICE-1C)

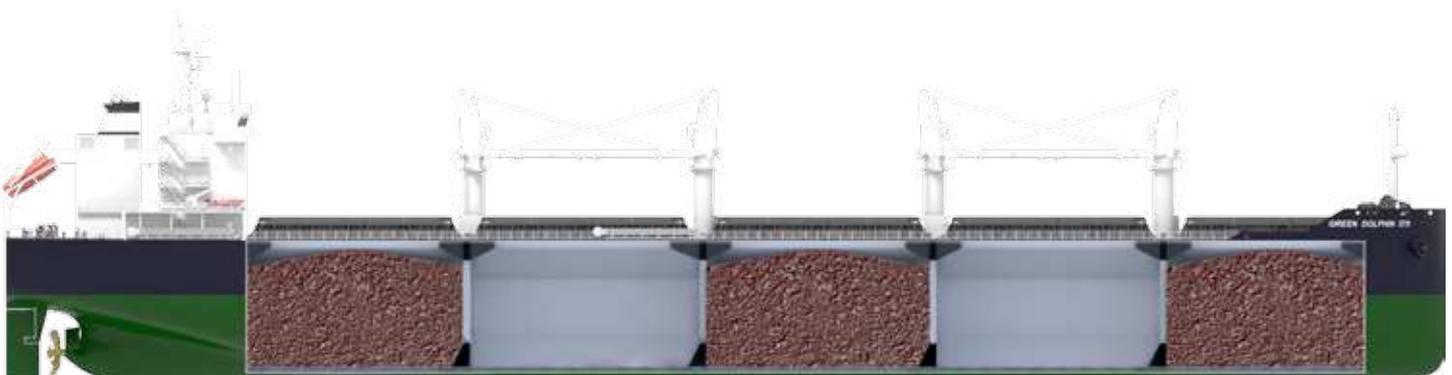


Operational flexibility and maintenance friendliness

Designed to ensure efficient cargo handling and easy cargo-hold cleaning

- Five cargo holds
- Designed for a wide range of minor and major bulk cargoes
- Main dimensions allowing operation in many ports
- Cargo holds designed for the loading of heavy cargo, holds no. 2 and no. 4 may be empty
- Cargo holds equipped with a supply of compressed air, power and wash water at tank top level for portable cleaning systems
- Permanent bilge and wash water supply and return lines
- Ballast stripping lines for efficient de-ballasting to allow higher loading rates
- Fresh water storage tanks for cargo hold cleaning and wash water holding tanks
- GRP pipes for ballast and bilge lines
- High tank top load capacity, fitted for steel coil loading
- Energy-efficient electric deck cranes with variable-frequency drive
- Electric windlass and mooring winches
- Prepared for cold ironing, e.g. for crane operations in port

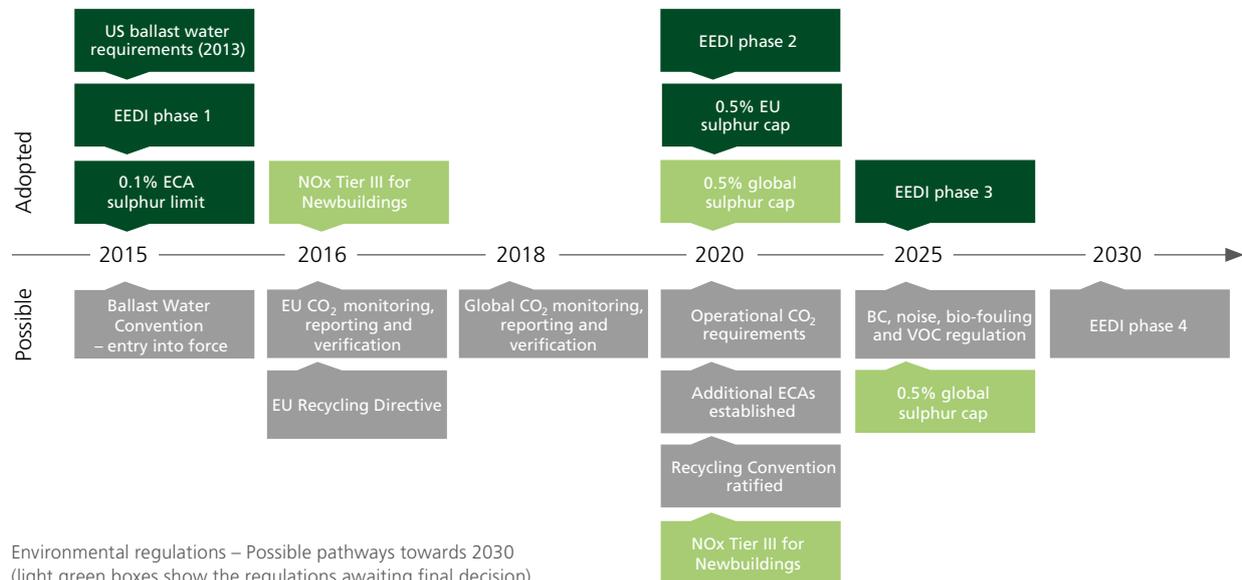
Alternate loading – holds no. 2 and no. 4 empty



Environmentally friendly and prepared for future regulations

Designed to comply with current and future expected local and global emission regulations

- Efficient main engine with low fuel consumption and emission levels, IMO Tier II compliant
- Fuel tanks for different grades of fuel (HFO, MDO and low-sulphur fuels/distillates)
- Fuel tanks in protected location
- Prepared for the installation of an SCR or EGR system for IMO Tier III compliance
- Prepared for the installation of a scrubber for ECA compliance
- Prepared for dual-fuel operation with LNG for ECA compliance
- Ballast water treatment system
- Sewage water treatment system
- Integrated bilge water treatment system (IBTS)
- Waste management system
- Air-seal system for stern tubes
- Class notations CLEAN and Recyclable





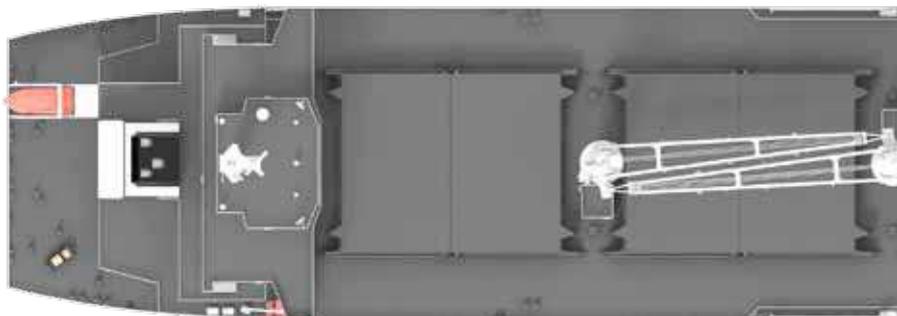
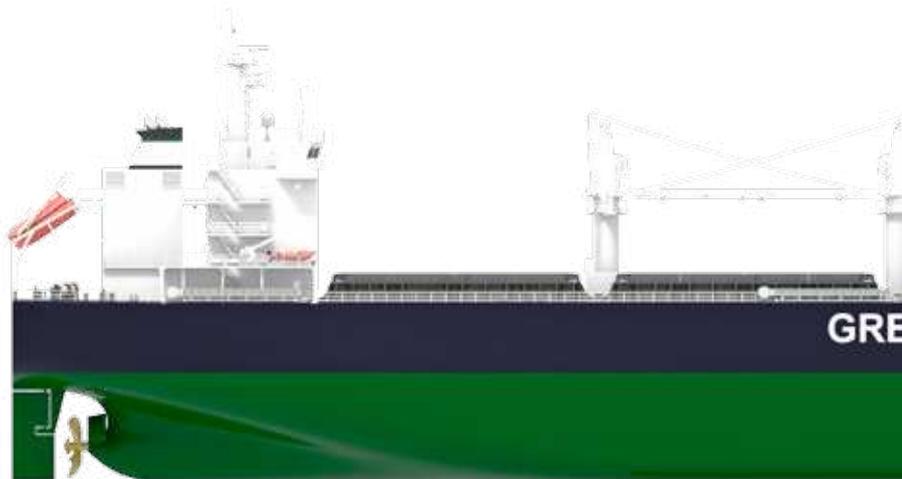
Prepared for LNG tank installation



Prepared for SCR/EGR and scrubber installation

EMISSIONS	REGULATIONS	SOLUTIONS
SO _x	1 January 2015 – 0.1% S in ECA; 1 January 2020 – 0.5% S in EU; 1 January 2020 or 2025 – 0.5% S globally	Low sulphur fuels/ distillates or Scrubber system or LNG
NO _x	1 January 2016 or 2021 – NO _x Tier III in ECA	Selective Catalytic Reduction (SCR) and Exhaust Gas Recirculation (EGR) systems or LNG
CO ₂	1 January 2013 – EEDI; Market Based Measures	Energy efficient design development and operations

GREEN DOLPHIN 575 design solutions
for compliance with emission regulations



Main particulars

Length over all: 189.9 m
 Length between perpendiculars: 186.5 m
 Breadth: 32.26 m
 Depth: 18.5 m
 Draught, scantling: 13.0 m
 Draught, design: 11.3 m
 Endurance: 18,000 nm
 Freeboard: B-60
 Complement: 26 + 6 Suez canal crew

Deadweight and cargo hold capacity

Deadweight, scantling: 57,500 mt
 Deadweight, design: 47,500 mt
 Cubic capacity (grain): 72,000 m³

- Hold no. 1: 12,200 m³
- Hold no. 2: 15,600 m³
- Hold no. 3: 14,800 m³
- Hold no. 4: 15,600 m³
- Hold no. 5: 13,800 m³

Hatch openings

No.1 hold: 18.0 x 18.3 m
 No. 2-5 holds: 21.3 x 18.3 m

Capacities

Heavy fuel oil: 1,500 m³
 Marine diesel oil, marine gas oil: 300 m³
 Fresh water: 250 m³
 Ballast water: 16,300 m³
 Cargo hold wash water: 400 m³

Cargo list

Solid bulk cargoes, e.g. ore, grain; IMSBC Code cargoes (including dangerous solid bulk cargoes), all Group A and C cargoes, e.g. cement, distillers dried grains with solubles (DDGS); Group B cargoes, e.g. coal, DRI(A), fertiliser, seedcake(a), sulphur, wood products.

Steel coil loading: 2 tiers of 25 t/coil

Machinery

Main engine options:
 Wärtsilä W5X62

- CMCR: 7,950 kW x 77.0 r/min
- CSR: 6,161 kW x 70.7 r/min

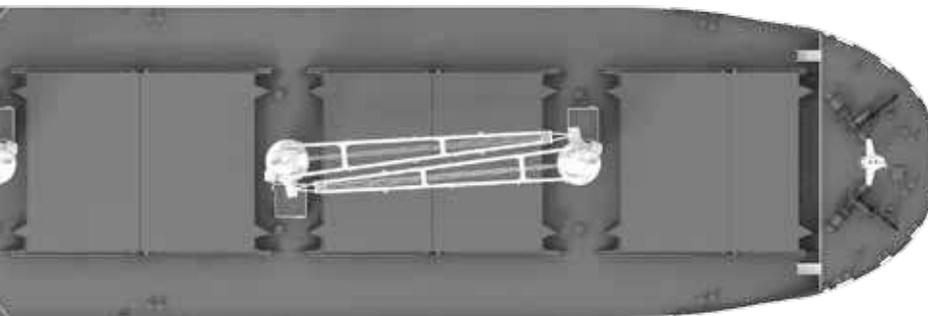
MAN 5G60ME-C9.2

- CMCR: 8,500 kW x 77.0 r/min
- CSR: 6,163 kW x 69.2 r/min

Auxiliary engines: 3 x 650 kW
 Emergency generator: 120 kW
 Ballast pumps: 2 x 800 m³/h
 Ballast water treatment plant: 2 x 800 m³/h

Optional:

- Exhaust Gas Scrubber for main and auxiliary engines – SOx reduction
- Selective Catalyst Reducer (SCR) or Exhaust Gas Recirculation (EGR) for main and auxiliary engines – NOx reduction (Tier III)
- Dual-fuel configuration – SOx, NOx and



CO₂ reduction:

- Low-speed dual-fuel main engine
- Medium-speed dual fuel auxiliary engines
- Double-wall vacuum-insulated IMO Type C LNG tank (about 550 m³) and gas supply system
- Endurance on LNG: 3,500 nm

Speed and fuel consumption

Service speed at CSR with 15% sea margin:
 Design draught: 14.5 kn
 Scantling draught: 14.0 kn
 Daily main engine fuel consumption at CSR with 15% sea margin: 22.8 t (equivalent for both main engine options) (ISO Ambient Conditions, LCV=42,700 kJ/kg, no engine tolerance included)

EEDI

Attained index 4.1/4.3 gCO₂/tonne nm (Wärtsilä/MAN main engine)

Equipment

Electric variable frequency drive deck cranes: 4 x 30 t SWL, 28 m max. outreach
 Hatch covers: 5 x steel foldable, double-skin, integrated grain feeder and cement openings
 Cargo hold CO₂ firefighting system
 Cargo hold compressed air, power and wash water supply
 Cargo hold natural ventilation system
 Sewage water treatment system
 Integrated bilge water treatment system (IBTS)
 Waste management system
 Remotely operated valves and tank readings
 Optional: Shaft torque and fuel consumption monitoring systems

Design and Classification

Design: Shanghai Merchant Ship Design & Research Institute

Classification society: Det Norske Veritas or Germanischer Lloyd

DNV class notations: +1A1 Bulk Carrier ESP, CSR, BC-A (Holds 2,4 may be empty), GRAB[20], DG-B, BIS, TMON, BWM-T, CLEAN, E0, Recyclable, ICE-1C (optional notation), Gas Fuelled (optional notation)

GL class notations: +100A5 Bulk Carrier ESP, CSR, BC-A, {hold 2, 4 may be empty}, GRAB[20], DBC, DG, BWM(d2), IW, EP-D, +MC, AUT, CM-PS, GF (optional notation)



SDARI is a ship design consultant under China State Shipbuilding Corporation (CSSC) with more than 600 employees. SDARI is the market leader in merchant ship design and development in China. Each year more than 100 new developments are promoted to the market, more than 30 new ships are designed for shipyards and more than 200 vessels are delivered to ship owners. In the bulk carrier segment SDARI has very good experience and expertise with more than 1000 deliveries in the past decades.

<http://sdari.cssc.net.cn/>
Contact: rnd@sdari.com.cn



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Phase 1
Concept design by
SDARI and DNV GL

Phase 2
Basic and detailed
design by SDARI

Approval in principle by
DNV GL

Development process for the Green Dolphin 575

