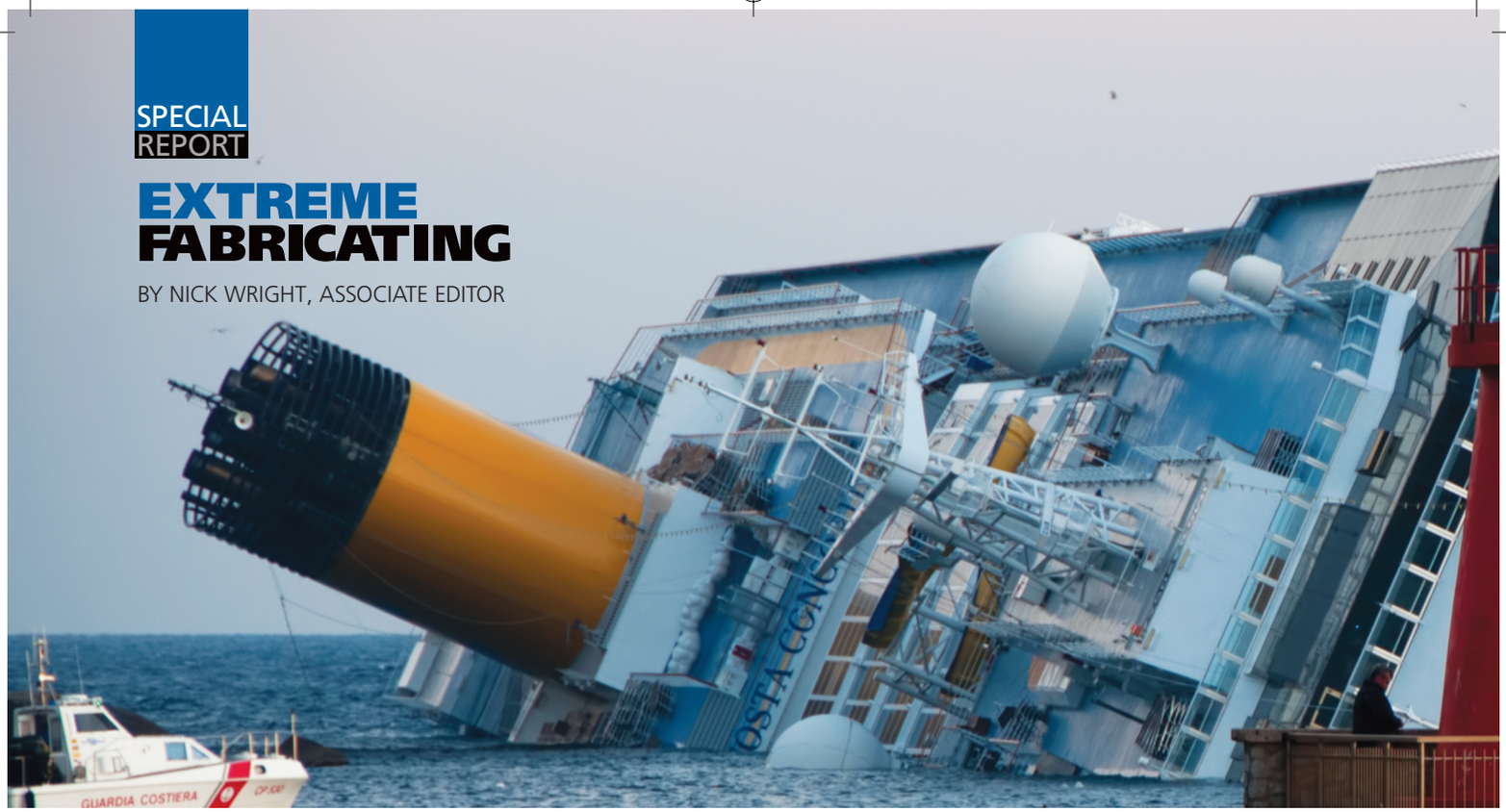
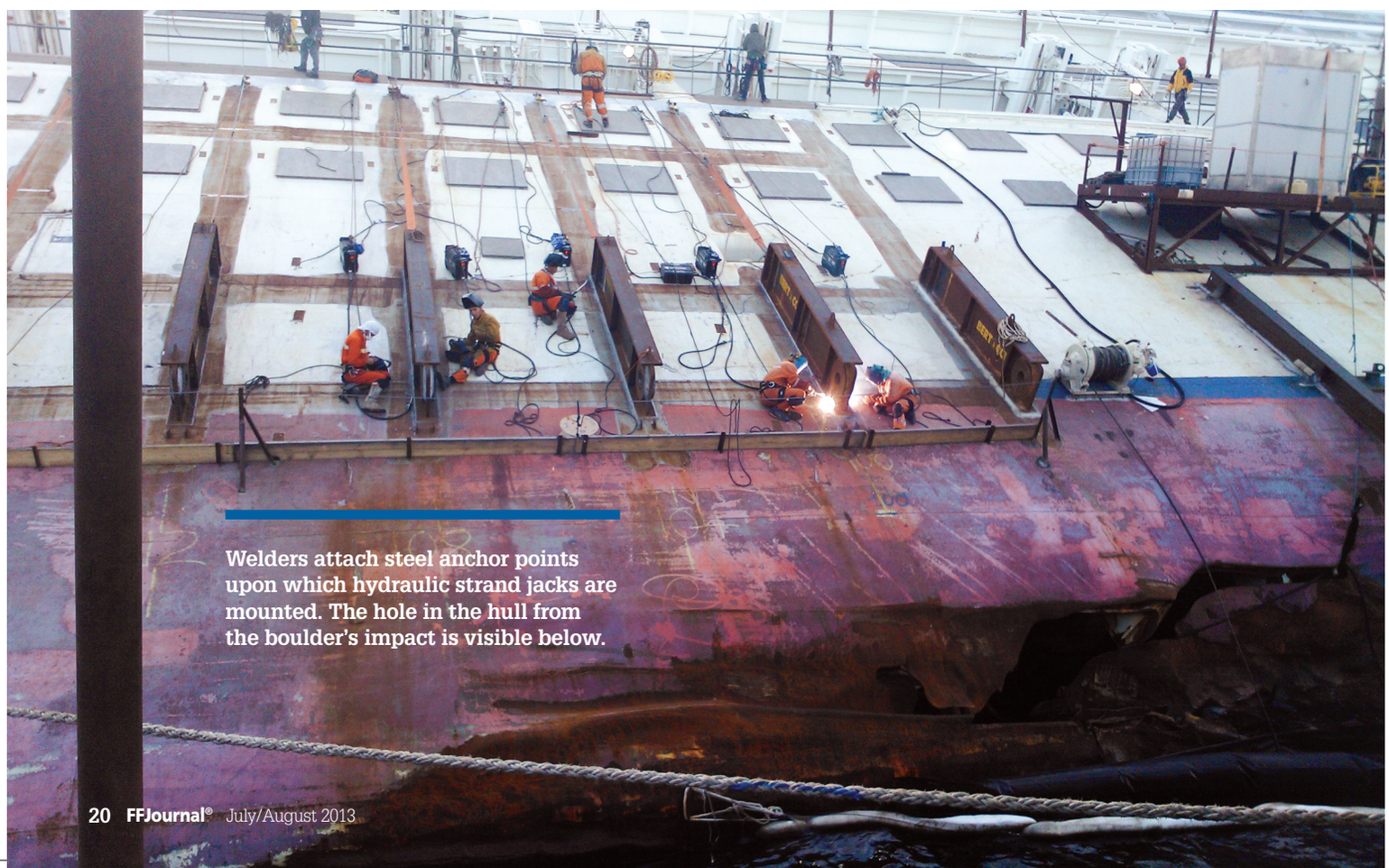
SPECIAL REPORT

EXTREME FABRICATING

BY NICK WRIGHT, ASSOCIATE EDITOR



Salvaging a SHIP



Welders attach steel anchor points upon which hydraulic strand jacks are mounted. The hole in the hull from the boulder's impact is visible below.

About one-third of the 952-ft. ship's hull is exposed above water. Crews plan to parbuckle the ship (roll it upright) in September.

Photo: Roberto Vongher

WRECK

In removing the *Costa Concordia*, crews take metalwork and marine salvage to a whole other league

Protruding from the Mediterranean Sea next to quiet Giglio Island, off of Italy's Tuscan coast, is a sobering reminder that today's ships are just as vulnerable as the *Titanic*. The Italian cruise liner *Costa Concordia* struck a boulder on its port side on Jan. 13, 2012, sending 4,252 passengers and crew to lifeboats and cutting vacations short. It's the largest passenger ship to have ever capsized. By comparison, the *Titanic* had a capacity of 3,327 passengers and crew, but only half the tonnage of the hulking *Costa Concordia*.

More than a year later, the 952-ft.-long vessel is still there, even though news of the wreckage has largely disappeared from headlines. But the *Costa Concordia* won't be in Giglio Island's waters for long. An army of engineers, marine specialists, divers and welders have been working around the clock since April 2012 to prepare the ship for removal. It's the largest ever marine salvage attempt of its kind.

The idea is to refloat the ship by creating more buoyancy than the weight of the ship plus the water it took on. To do this, crews are attaching giant steel boxes, called sponsons, to each of its sides, essentially welding a ship onto a ship.

As straightforward as the idea sounds, it's more complicated than simply rotating the vessel, welding steel floaties to it and towing it away. When the *Costa Concordia* capsized, it became lodged on a steep, rocky slope with little keeping it from sinking further. To stabilize the ship, crews first tied it with four submarine anchor blocks fixed to the sea bottom between the coast and the center of the wreck.

Once the 15 port side sponsons are welded on, crews plan to roll the ship upright onto a "false bottom," comprising six massive underwater steel platforms, which currently are being installed into the seabed. Rotating the ship is called parbuckling, a process that has lent itself to the salvage's official name: The Parbuckling Project. With the ship upright, 15 starboard side sponsons will be attached. After all the sponsons are emptied of their ballast, the ship is expected to be floated away to an Italian port to be scrapped.

In other situations, cutting up the ship in place or blowing it up could be an appropriate solution; however, the *Costa Concordia* is semi-submerged precariously in a national marine park. Thus, it's the project's top priority to protect the environment and the whole east coast of Giglio Island, a popular tourist destination.

The engineering, equipment and expertise involved are unprecedented in scale and scope, drawing on a consortium of companies from 18 countries. Nearly 500 personnel are on-site day and night, working from 27 different vessels, including the floating barracks *ASV Pioneer*, where workers sleep. As one can imagine, the salvage is not cheap—the estimated budget gravitates toward the $400 million mark. Despite the cost and circumstances, the disaster has made for impressive solutions not the least of which have pushed the boundaries of ex-

Photos: The Parbuckling Project, unless otherwise specified

treme metal fabrication.

Managing the salvage removal is Titan Salvage, a Pompano Beach, Fla.-based juggernaut in the marine salvage field. Titan was one of several international salvage outfits bidding for the job. The firm has partnered with Micoperi, an Italian marine contractor specializing in underwater construction and engineering.

Underwater support

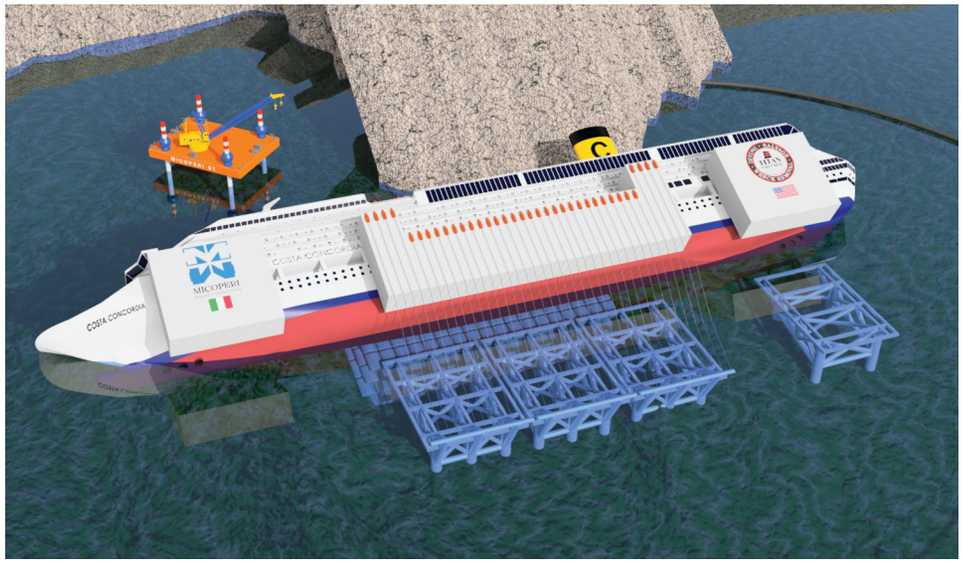
After Titan/Micoperi stabilized the ship, crews welded 12 retaining turrets to the hull. Strand jacks mounted on the turrets are attached to chains, two per turret, that pass under the hull and are connected to the port side of the ship. This holdback system will balance the ship during the parbuckling later this summer.

Next, crews prepared the false bottom that the ship will rest on after parbuckling. To do this, divers positioned grout bags between the two spurs of rock upon which the ship is lodged, then injected the bags with an eco-friendly cement. This effectively leveled the seabed at the base of the steel support platforms.

Because of the size of the six platforms, steel fabrication has been split among three different locations in Italy. When each is complete, it is shipped by barge to the wreck site. The largest, platform No. 1, weighs about 1,100 tons. The towering structure resembles an upper deck section of a baseball stadium without the seats. At 72 ft. tall, its platform base measures 131 ft. by 108 ft. It's supported by five, 2 m diameter pillars sunk to the granite seabed.

Platforms No. 1 and 2 were built in Ravenna, on Italy's east coast, about 950 miles from Giglio Island. The trip by barge takes about eight days, as the journey rounds Italy's "boot," then north to the site. Platform No. 3 is being fabricated in San Giorgio di Nogaro in the northwest, 970 miles away—a two-week trip. The rest were fabricated in Livorno, on the west coast, only 90 miles north of the wreck. (As this article was being written, platform No. 1 and three smaller ones near the stern had been installed.)

Crews built the platforms with EN 10025 S355 and S275 steel plate, a European structural standard similar to A572 that's used frequently in offshore structures. Other parts of the platforms include API 5L X52 seamless steel pipe in a range of sizes, from 700 mm to 1,580 mm in diameter and thicknesses of 20 mm to 65 mm. HEA 360 beams, as well as 2,000 x 30 and 800 x 50 structural tubes, support the larger beams. Below the sea floor, the platforms are supported by 2 m diameter piles that are inserted into drilled granite holes about 8 m to 10 m deep (see sidebar). Ultimately, the platform and piles are joined by grouting the annulus.



Top: After the 15 port side sponsons are welded on, strand jacks (orange) will tighten cables, rolling the Costa Concordia upright onto underwater steel platforms (blue). The process is expected to take a few days. Below: Then, 15 starboard side sponsons (not pictured) will be attached, which, when pumped full of air, should create enough buoyancy to float the ship.

Designed to hold about 175,000 tons, the platforms should have no problem supporting the *Costa Concordia*'s residual weight (minus buoyancy), and then some.

The arrangement of these stilted steel structures is just as crucial as their design. According to Pier Donato Vercellone, communications coordinator for The Parbuckling Project, the platforms have a cantilever intended for connecting the parbuckling pulling lines, and a rounded bumper against the grout bags. The grout

Above: One of six steel platforms installed into the seabed. The ship will be rolled onto these during parbuckling. Steel cables will pull on the cantilever (right side), while the steel tube (left) acts as a bumper against the grout bags. Below: The Micoperi 30 crane lowers the platforms.

SHIP STATS

A look at the *Costa Concordia* by the numbers:

Entered service: July 2006

Wrecked: Jan. 13, 2012

Wreck location: Giglio Island, Italy (pronounced JEE-lee-oh)

Tonnage: 114,147 GRT

Length: 290 m (952 ft.)

Guests: 3,000

Crew: 1,100

Cost of salvage: Approx. $400M

Fuel removed from ship: 2,100 tons

Salvage personnel on-site: 467 (as of May 2013)

Salvage vessels and structures: 27

Total weight of steel fabrications used in salvage: 21,906 tons

Source: Carnival Corp., The Parbuckling Project

bags will take some of the weight during parbuckling, but the righted ship will rest on the platforms until it's refloated.

Buoyant steel boxes

As the underwater platforms are set into place, crews follow behind them adding port side sponsons to the ship's upper hull. There are 30 total with a combined weight of about 15,817,580 kg (roughly 17,436 tons).

At first glance, the sponsons look like little more than giant white boxes. However, inside are sophisticated compressed air systems that will pump water out during refloating. When the *Costa Concordia* is eventually parbuckled, seawater will fill the sponsons' ballast tanks to act as cantilevered weight, aiding in the roll. The compressed air system is backed by an array of diesel and electric-driven compressors, controllers, air distribution and piping, and fuel storage equipment, says Vercellone.

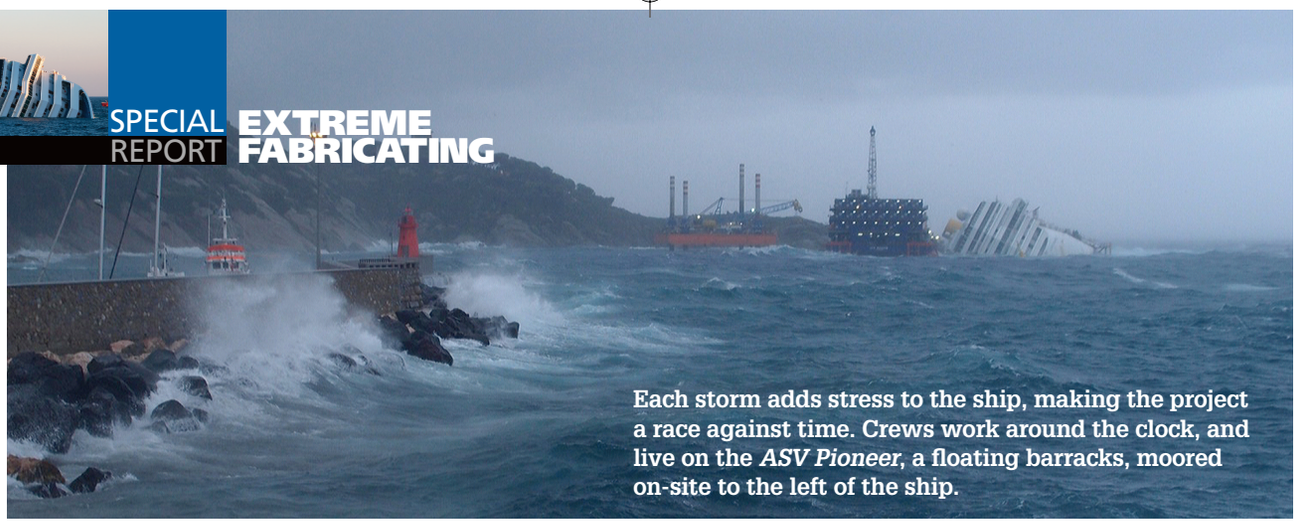
The watertight sponsons are being welded to the port side hull via grillages that are part of the sponson structure. To scale it, imagine attaching 30 apartment building-sized steel boxes to a skyscraper.

Italian shipbuilding company Fincantieri, based in Trieste, is fabricating the sponsons at multiple shipyards in Italy, following the same construction procedures it would for a vessel. Fincantieri originally built the *Costa Concordia* in 2005 for Costa Crociere, a cruise company operating under Doral, Fla.-based Carnival Corp.

Built in two sizes, the sponsons are fabricated from grade A and grade AH 36 high tensile strength steel plate in thicknesses of 12 mm to 15 mm. The 14 larger sponsons measure 10.5 m by 11.5 m, and stand 33.05 m tall, or about 10 stories. The shorter ones are 21.8 m tall, but have the same footprint.

At Fincantieri's shipyards, welders use a mix of automated welding, submerged arc welding with inert gas and flux cored arc welding. At the wreck site, welders employ semi-automatic welding, using flux cored self-shielded wire in 1.7 mm diameter, as well as manual welding with stick electrodes. Typically, 10 welders are working on-site per shift, says Vercellone.

When the ship is rolled upright and stabilized on the platforms, the starboard side sponsons won't be welded on. Instead, they'll be positioned with 3,000 m long, 133 mm diameter anchor-size chains and



Each storm adds stress to the ship, making the project a race against time. Crews work around the clock, and live on the *ASV Pioneer*, a floating barracks, moored on-site to the left of the ship.

83 mm diameter, 3,000-m-long wire ropes each anchored to a strong point on the port side, passing below the hull. While positioning and welding of the port side sponsons take about one week each, the starboard counterparts only need about four days.

Lifting the platforms and sponsons into position is the *Svenja*, a vessel built by Hamburg, Germany-based Sal Heavy Lift. It's a serious leviathan of a ship, equipped with two 2,200-ton capacity cranes meant for handling these formidable steel structures. The Micoperi 30 heavy lift crane vessel is also on-site. To illustrate how much steel is being used in the salvage, the platforms and sponsons weigh a combined 21,906 tons. In steel alone, that equates to three times the Eiffel Tower (7,300 tons), more than four times the Gateway Arch (5,199 tons) and less than one-third of the Golden Gate Bridge (83,000 tons).

Swan song

At the time of its launch in 2005, the *Costa Concordia* became Italy's largest cruise ship. Preceding the launch was the welding of a coin to the base of the mainmast—a tradition meant to bode well for a vessel. The same metalworking method has since been used to keep the sea from claiming it completely. After the accident, Italian authorities had technically designated the wreck as a crime scene, alleging negligence on the part of the captain, because the accident resulted in 32 deaths and two missing.

Now, with about a third of its hull above water, streaks of rust run down the bow next to the ship's name (although rust and corrosion aren't concerns). Weather is among the biggest worries of the engineers, as each storm puts more stress on the stricken ship. On land, the residents of Giglio Island are mentally tired, as the

WATCHING THE WATER

All aspects of the *Costa Concordia* salvage are being conducted to minimize the environmental impact on Giglio Island, both on sea and land, where tourism is a big part of the economy. Immediately after the *Costa Concordia* capsized, its operator Costa Crociere installed a perimeter of booms to contain any oil leakage. One month later, a total of 20 vessels including tugboats, crane barges, tankers and oil response vessels extracted the ship's 2,100 tons of fuel. As fuel was pumped out, seawater was pumped in to maintain stability.

Marine experts from Italian universities surveyed characteristics of the water column, plankton levels, fish and coral populations, as well as acoustic emissions (noise). Divers even relocated a group of *Pinna nobilis*, a large clam native to the Mediterranean Sea, which would have been disturbed by the salvage work.

To drill for the anchor blocks that currently stabilize the ship, Italian drilling contractor Trevi brought in water-powered percussion drilling equipment, a minimally disruptive method for the protected waters in which the ship sits. Trevi sourced the DTH hammer from LKAB Wassara, a Swedish mining equipment company. Because the DTH hammer uses only high-pressure water to power its drill, there's no risk of lubricating oil polluting the 15 m (50 ft.) deep borehole.

The drilling went smoothly, "however, the tough environment with the extremely salty water and sea air resulted in a lot of wear and tear on hammer components and the pump," says Kent Bostrom, communications manager for Wassara.

For the piling foundations supporting the six platforms that will cradle the ship when it's righted, drilling firm Fugro Seacore, Falmouth, U.K., brought in an enclosed, closed-circuit drilling system to keep debris and waste from dispersing into the water.

For five years following the salvage, the waters will be monitored to address any long-term effects on the environment.

influx of activity surrounding the salvage disrupted the quiet community, says Giorgio Fanciuli, editor of *GiglioNews*, the island's online newspaper.

"Everyone would like that [the spotlight will soon be darkened]," he says. If all goes as planned, Giglio Island will return to a low profile sometime in September when the parbuckling is slated to happen. The ship's structural integrity isn't 100 percent, thus the actual rotation, a delicate and closely monitored process, will take a few days.

This is how the parbuckling should work: The already-installed strand jacks will be tied with steel cables to the underwater steel platforms, as well as the 15 port

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Above left: The *Svenja* moves the first steel sponson into position in April.

Above right: There are two sponson sizes: The left and right are 33.05 m (108 ft.) and 21.8 m (71.5 ft.) tall, respectively.

side sponsons. When the strand jacks tighten, the ship will be rolled upright, while the cables connected to the starboard turrets help balance the roll.

After the ship is righted and the 15 starboard sponsons are attached, each taking on ballast, the ship will rest on a false bottom at an approximate depth of 30 m. The compressed air system will force air into the sponson ballast tanks, gradually pushing seawater out through sea chest valves. For the open/close main air supply valves, manifolds and sea chest valves use an instrument air system, which is actuated by pneumatic and electrical signals. Ballasting operations are carried out by opening the seawater intake valve, letting water flow into the tank for level differences. This eliminates the need for pumps to manage the ballast.

The air-filled sponsons should float the ship. At this point, about 18 m of the hull will remain submerged.

Where the *Costa Concordia* will officially be scrapped has yet to be determined. Large ports in Genoa, Taranto and Palermo, all harbors where Fincantieri has a presence, are suitable candidates. However, Piombino will most likely receive the ship. It's a significantly smaller port, but it's close by, only 45 miles to the north.

Luciano Guerrieri, president of the Port of Piombino, says whether the *Costa Concordia* gets scrapped at its port is contingent on infrastructure upgrades necessary to accommodate the vessel. The upgrade deadline for the port isn't until early 2014.

In the meantime, the Tuscan Region has approved the regulatory plan of the port of Piombino, a key step in determining whether the port could be ready within the timetable laid down for the ship's removal.

Although there are no official details or proposals for dismantling the ship, the scrapping process is expected to take about two years. After the parbuckling and refloating, the underwater platforms, too, will be removed and the environment restored. **FFJ**

The Parbuckling Project, www.theparbucklingproject.com.