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Exploring the oceans

20,000 colleagues under the sea

Fleets of robot submarines will change oceanography

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SAILING the seven seas is old hat. The latest trick is to glide them. Sea gliders are small unmanned vessels which are now cruising the briny by the hundred. They use a minuscule amount of power, so they can stay out for months. And, being submarines, they are rarely troubled by the vicissitudes of weather at the surface. Their only known enemies are sharks (several have come back covered in tooth marks) and fishing nets.

Sea gliders are propelled by buoyancy engines. These are devices that pump oil in and out of an external bladder which, because it deflates when it is empty, means that the craft's density changes as well. This causes the glider to ascend or sink accordingly, but because it has wings some of that vertical force is translated into horizontal movement. Such movement is slow (the top speed of most gliders is about half a knot), but the process is extremely efficient. That means gliders can be sent on long missions. In 2009, for example, a glider called *Scarlet Knight*, operated by Rutgers University, in New Jersey, crossed the Atlantic on a single battery charge, though it took seven months to do so.

Since that crossing, gliders have been deployed on many previously unthinkable missions. In 2010 teams from the American navy, the Scripps Institution of Oceanography and iRobot, a robot-maker based in Bedford, Massachusetts, used them to track the underwater effects of the *Deepwater Horizon* oil spill in the Gulf of Mexico. That same year a glider owned by Oregon State University watched an underwater volcano erupting in the Lau basin near Tonga. In 2011 a glider made by another firm, Teledyne Webb of East Falmouth, also in Massachusetts, tracked seaborne radiation leaked from the tsunami-damaged reactors in Fukushima, Japan. And the University of Newfoundland is planning to use gliders equipped with sonar to inspect icebergs, to work out whether they are a threat to underwater cables and other seabed infrastructure.

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Shipping under the ocean

Ten years ago there were fewer than 30 gliders in the world, all built either by academic institutions or the armed forces. Now there are at least 400, and most are made by one of three firms: iRobot, whose product is called, simply, Seaglider; Teledyne Webb, which manufactures the Slocum Glider (named after Joshua Slocum, the first man to sail solo around the world); and Bluefin Robotics (the third member of the Massachusetts sea-glider cluster, based in Quincy), which sells the Spray Glider. Broadly speaking, these machines have three sorts of application: scientific, military and commercial.

At the moment, science rules the roost. For cash-strapped oceanographers, gliders are a blessing. Their running costs are negligible and, though buying one can cost as much as \$150,000, that sum would purchase a mere three days of, say, a manned trip to the Southern Ocean.

Glider, moreover, give a continuous view of what is going on, rather than the series of snapshots yielded by equipment lowered from a vessel at the surface. Besides tracking pollution, watching volcanoes and measuring icebergs, they are following fish around, monitoring changing temperatures in different layers of seawater and mapping the abundance of algae. The Ice Dragon, a modified Seaglider operated by the Virginia Institute of Marine Science, has explored under the Antarctic ice shelf, and another modified Seaglider, the Deepglider, can plumb the depths down to 6km (20,000 feet). Teledyne Webb's Storm Glider, meanwhile, lurks in hurricane-prone areas, bobbing up to take readings during extreme weather.

Glider, are also quiet—so quiet that, as one researcher puts it, you can use them “to hear a fish fart”. This was demonstrated by a recent project run by the University of South Florida, in which a glider successfully mapped the locations of red grouper and toadfish populations on the West Florida Shelf from the noises the fish made.

Military applications are growing, too. America's navy, for example, has ordered 150 gliders from Teledyne Webb's sister company, Teledyne Brown, for what it calls its Littoral Battlespace Sensing-Glider programme. To start with, these gliders will be used individually, to measure underwater conditions that affect things like sonar. Eventually, the plan is to link them into a network that moves around in a co-ordinated manner.

Glider, are also ideal for gathering intelligence. Having no propellers and no engine noise, they are difficult to detect. They can be delivered by submarine, and can lurk unseen for as long as is necessary. Any shipping, whether on the surface or under it, which passes near a glider can be detected, identified and pinpointed without it realising it has been spotted. Indeed, the American navy is now evaluating a design called the Waveglider, made by Liquid Robotics of Sunnyvale, California, for submarine-detection work.

The third use, commerce, seems, at the moment, to be the smallest—though that may be because the companies involved are keeping quiet about what they are doing. But Joe Dyer, the chief strategy officer at iRobot, thinks oil-and-gas exploration will be a big market for the firm's gliders, because they can survey large areas of seabed in detail at low cost.

ACSA, a French glider firm, has a similar market in mind. In March it launched the SeaExplorer, a streamlined, wingless glider with a speed of one knot—twice as fast as the American competition. According to Patrice Pla, ACSA's marketing manager, SeaExplorer's lack of wings reduces the chance of its getting tangled in nets. Its payload bay, meanwhile, is designed to take interchangeable modules so that it can hold whatever equipment is required. That means customers do not have to buy different gliders for different applications.

A glide path to discovery

Nor is ACSA the only non-American in the field. A glider called Sea Wing, for example, has been developed at the Shenyang Institute of Automation, in China, by Yuan Dongliang of the country's Institute of Oceanography. It was tested last year and operated successfully in the western Pacific at depths of up to 800 metres. Meanwhile, at Tianjin University, a team of glider researchers is trying to improve the machines' endurance. They are testing fuel cells instead of batteries and are also working on the idea of powering them with a thermal engine that draws its energy from the differences in temperature between seawater at different depths.

Japanese researchers, too, are building gliders. At Osaka University, Masakazu Arima is involved in several glider projects. One is a small, low-cost version called ALEX that has

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independently movable wings. Another is a solar-powered device called SORA. Though SORA has to surface to recharge, its requirements are so modest that it does not take long to do so. It can travel underwater for months, surface for a few days, then carry on. It can therefore stay at sea indefinitely.

Dr Arima's greatest interest, though, is like America's navy's: that his gliders should collaborate. His plan is to deploy 1,000 of them in a network that surveys and measures the oceans. If it works, the single spies of sea-gliding really will have become battalions, and the ocean's fish will find themselves shadowed by shoals of mechanical counterparts.

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