Japan Plunges Into Ocean Science

Japan's Marine Science and Technology Center has some of the world's most capable research vessels. Now it wants to be a global force in ocean science, too

YOKOSUKA, JAPAN—When the experimental nuclear-powered ship *Mutsu* wandered around on the open seas a few years ago, unable to find a port willing to take it in, few would have guessed that this high-tech pariah would end up as the pride of Japan's growing scientific research fleet. But this fall, renamed *Mirai* and refitted with diesel engines, the ship will make its debut as the world's largest oceanographic research vessel. This state-of-the-art research ship is just the latest symbol of Japan's bid to become a major force in global oceanographic research.

The new ship, which will be operated by Japan's Marine Science and Technology Center (JAMSTEC), will join an impressive fleet of research vessels that includes the world's deepest diving manned submersible and the deepest diving remotely operated vehicle (see table). The ocean sciences enjoy broad-based political and popular support in Japan, reflected in JAMSTEC's budget, which has doubled in the last 5 years to $220 million. The center has also expanded its research agenda to address such high-profile issues as global climate change and life in extreme environments. It has also beefed up its scientific staff, attracting researchers from other government agencies and young scientists from around the world.

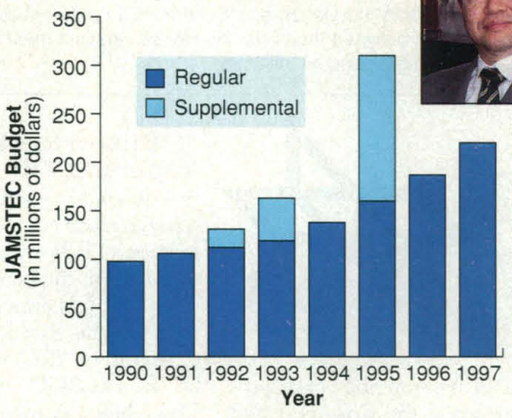
These new initiatives mark a "historical change" in JAMSTEC's mandate, says marine geologist Noriyuki Nasu. For in spite of these extraordinary facilities, Japan has been slow to make major contributions to world-class ocean science. The reason: JAMSTEC, formed in 1971, prided itself on its engineering prowess, and science took a backseat. "JAMSTEC had only been able to do engineering," says Nasu, a former head of the University of Tokyo's Ocean Research Institute and past chair of the Council for Ocean Development, which advises the prime minister. "[Now] it is able to do science as well."

Japan's bid to become a world power in ocean research still faces many obstacles, JAMSTEC officials admit. A persistent budget deficit has ushered in a period of fiscal austerity across the government that could slow the growth of some of the center's most exciting projects. Other limiting factors are a relatively small Japanese ocean science community and government-wide restrictions on hiring. The center is "very, very understaffed," says Tsuyoshi Maruyama, director of the Ocean and Earth Division of the Science and Technology Agency (STA), which oversees JAMSTEC. What's more, a historical paucity of positions has steered young scientists to other fields, resulting in a dearth of qualified oceanographers and climatologists. "We have to foster the recognition that this is an attractive research field," says JAMSTEC's president, Takuya Hirano.

Touching bottom

These new scientific aspirations have already taken JAMSTEC a long way from its roots. Uniquely among Japan's public research and development centers, JAMSTEC owes its existence to lobbying not from government officials or academe but from Japan's leading business group, the Keidanren. To this day, an association of 180 shipbuilding, steel, heavy equipment, and construction companies provides about 1% of JAMSTEC's annual budget.

No surprise, then, that the center was initially focused on work directly relevant to industry. Its first project was a pressurized chamber to prolong the time divers can spend underwater. SEATOPIA, as it was called, also became JAMSTEC's first step toward developing deep-sea vehicles, which added science to the center's agenda. Another turning point came in 1981 with the arrival of its first manned submersible, *Shinkai 2000*. For geophysicist Hiroshi Hotta, who had joined the center soon after its founding, it was a chance to carry out a long-delayed plan to explore and map the active faults in the sea trenches surrounding these earthquake-plagued islands. "My geophysical background finally proved useful," says Hotta, now JAMSTEC's executive director.



D. NORMILE

SOURCE: JAMSTEC

Money matters. Hirano has used a growing budget to beef up the center's research portfolio.

Although *Shinkai 2000* allowed scientists to learn more about those active faults, it couldn't reach the bottom of the subduction trenches in the western Pacific. In 1988, JAMSTEC added the 3300-meter-class remotely operated vehicle *Dolphin 3K* to its fleet, and the next year it welcomed the world's deepest diving manned submersible, *Shinkai 6500*, with a range of 6500 meters. In 1995, *Kaiko*, the world's deepest diving remotely operated vehicle, at last succeeded in touching bottom in the Marianas Trench.

But *Kaiko*'s feat has so far provided little scientific payoff. It was followed by an extended stay in dry dock, which ended only last month as it began a training cruise with its new support vessel, the *Kairei*. Kodo Matsumoto, director of JAMSTEC's Deep-Sea Technology Department, admits that the objective of the *Shinkai 6500* was to build a submersible "a little more advanced" than the 4000-meter *Alvin*, based at the Woods Hole (Massachusetts) Oceanographic Institution, and a French submersible that could descend to 6000 meters. *Kaiko*'s job was to provide a rescue vehicle for the *Shinkai 6500* and, ultimately, to operate at the very bottom of the sea. Scientific input was scarce, he says, because the research effort was limited.

That is no longer the case. The *Mirai*, which at 8600 tons will be the world's largest oceanographic research vessel, is configured to deploy instrument-laden buoys to monitor ocean temperatures and currents at varying depths as part of a broader environmental research portfolio. Its contribution will be especially valuable in the Arctic and Antarctic oceans, which now receive only sporadic instrumentation. The data are expected to refine scientific understanding of ocean currents and heat transport and improve climate modeling.

The new findings will contribute to a new program, the Frontier Research System for Global Change Prediction, that the center will launch this fall (*Science*, 16 May, p. 1025). A joint effort with the STA-affiliated National Space Development Agency, the program calls for 50 to 100 new research positions to tap into the oceanographic and at-

mospheric data gathered by NASDA's satellites and JAMSTEC's research vessels.

Further in the future is JAMSTEC's most ambitious project yet, a ship capable of drilling 3500 meters into the sea floor (*Science*, 8 March 1996, p. 1358). The Ocean Drilling in the 21st Century (OD21) program is intended to shed light on the composition of the ocean crust and the mechanism of earthquakes in subduction zones and help reconstruct a history of climate change.

Uncommon sense

This elevation of science, begun in the early 1990s, owes its success to several factors. One was a nationwide consensus that the country needed to boost spending on basic research (*Science*, 23 February 1996, p. 1046). STA's Maruyama says there was also a sense that the center had focused too narrowly on deep-sea projects, neglecting other aspects of oceanography. JAMSTEC and STA officials also realized that, while the submersibles gave them something to brag about, they had yielded little data. "Even now, you can't see much in terms of results" in major publications, admits Hajimu Kinoshita, JAMSTEC's director of deep-sea research.

One response has been to attract researchers with proven track records. Kinoshita, for example, was lured away in 1995 from a comfortable position at the University of Tokyo's Earthquake Research Institute by the opportunity to develop research programs in marine seismology, his specialty, and related fields. "It would have been Japanese common sense to stay at Tokyo and retire as a prestigious professor emeritus," he says. "But my common sense is a bit different."

In another case, JAMSTEC recruited an entire research team facing the end of its funding. Molecular biologist Koki Horikoshi was leading a group at the Institute of Physical and Chemical Research (RIKEN) near Tokyo studying how microorganisms cope with extremes in temperature, pressure, and alkalinity. The work was done under STA's ERATO program, which provides generous funding for 5 years—but no more—to tackle ambitious research themes. In 1990, when the grant was finished, Horikoshi and the core of his team relocated to JAMSTEC and switched their focus to deep-sea microorganisms.

The center's submersibles make it possible to retrieve such microorganisms in sea-floor sediment samples, while the center's novel onshore lab facilities, including pressurized containers for handling the organisms, allow replication of deep-sea conditions for experimental purposes. Over the past several years, the team has isolated organisms tolerant of high pressure and high solvent concentrations and identified the proteins responsible.

The program, dubbed Deep Star, also pioneered the idea of outside scientific scrutiny. External reviews are a part of the ERATO projects, and Horikoshi carried this practice over to the Deep Star program. In 1995, Deep Star was reviewed by a international panel chaired by Harlyn Halvorson, former director of the Marine Biological Laboratory at Woods Hole, which concluded that JAMSTEC is "the premier center in the world for such research."

Fiscal squalls ahead

As it takes these steps, JAMSTEC must contend with a government-wide fiscal crisis. A governmental committee earlier this summer recommended the delay of "big-science projects" and a 5% cap on growth in a category that includes funding for JAMSTEC. While JAMSTEC's budget is not expected to shrink, says Shizuo Hoshiba, JAMSTEC's planning director on loan from STA, the goal is to maintain steady increases and to start design work on the OD21 ship. But he worries that a delay could hamper efforts to build international support for the project and to assemble a research staff that can put the center's engineering wonders to full use.

One ongoing problem is hiring restrictions intended to reduce overall levels of government employment. Maruyama notes that JAMSTEC's permanent research staff of 125 is small in proportion to the center's $220 million budget and that scientists must work with virtually no technicians or assistants. For comparison, Woods Hole supports 135 scientists and 120 technicians on an annual budget of $87 million. The discrepancy widens when purchasing power is factored into the equation. What's more, Kinoshita says that JAMSTEC's permanent staff is so burdened with planning and administrative chores that "the time they have for thinking solely about research is limited."

JAMSTEC has used contracts to escape some of the restrictions on permanent staff. Virtually all of the Deep Star researchers are on contract, for example, and the entire program has a fixed life of 15 years, although it may be extended. Similar conditions will apply to the global change program and its research positions.

But there is still a paucity of scientists in relevant fields. "There are really only small numbers of earth and ocean research scientists [in Japan]," says Hirano. The shortage is a legacy of limited employment opportunities, and Hirano hopes that a growing interest in environmental issues and the expanding job opportunities will gradually attract more young scientists. In the meantime, Kinoshita says, the best way to maximize the fleet's potential is more international collaborations.

Global cooperation is the norm in a field that relies on expensive equipment and travel to out-of-the-way parts of the world, and JAMSTEC is no stranger to the practice, beginning with a 1988 agreement with Woods Hole. Investigations along the mid-Atlantic Ridge in 1994 in which scientists from JAMSTEC and Woods Hole jointly used JAMSTEC's *Shinkai 6500* manned submersible and its support ship "really provided a lot of detail on [the region's] geological processes," says Richard Von Herzon, a Woods Hole marine geophysicist. Bruce Robison, a deep-sea ecologist at the Monterey Bay Aquarium Research Institute (MBARI) in California, says joint work with JAMSTEC has produced valuable comparative studies of the

JAMSTEC'S WORLD-CLASS FLEET

Vessel	Features	Crew	Began service
Shinkai 2000	Manned submersible Dives to 2000 meters	3 (1 scientist)	1983
Natsushima	Support vessel for *Shinkai 2000*	55	1983
Kaiyo	Research vessel 61 meters long	69	1985
Dolphin 3K	Remotely operated vehicle Dives to 3300 meters	unmanned	1988
Shinkai 6500	Manned submersible Dives to 6500 meters	3 (1 scientist)	1989
Yokosuka	Support vessel for *Shinkai 6500*	57	1988
Kaiko	Remotely operated vehicle Dives to 11,000 meters	unmanned	1995
Kairei	Support vessel for *Kaiko*	60	1997
Mirai	Research vessel 130 meters long	80	1997

SOURCE: JAMSTEC

PHOTOS: JAMSTEC

Superlatives. JAMSTEC can boast of the deepest diving submersible and remotely operated vessel and the largest research ship.

marine ecology of Monterey Bay and Japan's Sagami Bay. "We really are learning more by being able to look at two systems," he says.

The OD21 program would mark a new level of international cooperation. Although Japan plans to shoulder most of the estimated $500 million cost of building the ship, it is seeking contributions for equipment, instrumentation, and the $100 million in annual operating expenses. So far, those would-be partners say they are impressed. "[JAMSTEC] has shown an incredible understanding of what it takes to make an international program work," says Michael Purdy, head of the U.S. National Science Foundation's division of ocean sciences.

In a model now under review, Japan's OD21 ship and a second ocean drill ship, intended for shallower holes and supplied by the United States, would operate under the direction of international scientific committees. The program would be similar to the current Ocean Drilling Program, which expires in 2003. The shallower drill ship would be particularly useful for extracting records of climate change, while the deeper drill ship would be more important for geological studies. The key question is whether the international community can support two ships.

Another form of cooperation involves welcoming more foreign scientists to JAMSTEC. One likely recruit is James Hunt, now at JAMSTEC on an STA fellowship. After studying midwater biology at MBARI, Hunt came to JAMSTEC for comparative studies of Monterey and Sagami bays and says he would like to join the JAMSTEC staff when his fellowship ends this fall. "I feel like I'm getting in on the ground floor with midwater research at JAMSTEC," he says. "To me, that's a great opportunity."

Most scientists agree that JAMSTEC is well positioned to make significant contributions to marine science. Woods Hole marine geologist Henry Dick, who is involved in planning a joint 1998 cruise, predicts the center will soon become a "first-rate research organization." For JAMSTEC officials, keeping up with their first-class fleet will be good enough.

–Dennis Normile

SCIENTIFIC MISCONDUCT

Allegations Prompt Debate in Germany

BERLIN—When a scandal involving allegations of falsified data in biomedical research broke this spring, Germany's scientific establishment was caught off guard: The revelations exposed possible flaws in the mechanisms for monitoring research and investigating claims of fraud. Now, Germany's main granting agency—the Deutsche Forschungsgemeinschaft (DFG)—has decided to establish an international commission of scientific experts to discuss research standards and the procedures for scientific oversight in Germany and internationally.

"The complexity and the growing international competitive pressure in many scientific fields may be increasing the temptation to use deception and falsification" in research, said the DFG's president, Wolfgang Frühwald. He will ask the panel of seven to 10 prominent scientists to discuss safeguards against research fraud, as well as wider issues such as controls on co-authorship of papers. Many leading German scientists, however, have already spoken out against creating a national oversight body like the U.S. Office of Research Integrity (ORI).

The DFG commission is the latest in a series of panels formed in the wake of allegations that at least one researcher manipulated data while working at Berlin's Max Delbrück Center for Molecular Medicine in the mid-1990s, and possibly at other laboratories before and afterward. The alleged falsifications include data in an autoradiogram that was part of a 1995 paper, published in *The Journal of Experimental Medicine*, about transcription factors induced by tumor necrosis factor in human fibroblasts.

Marion Brach, a former group leader in a Max Delbrück research team under the general supervision of Friedhelm Herrmann—a hematologist and a leading genetic therapy researcher—has said she manipulated data in at least two research papers with Herrmann's knowledge. But Herrmann denies knowing of any data falsification until the matter was brought to his attention earlier this year. He describes himself as "primarily a clinician" who mainly set the direction for the research groups in his Max Delbrück team. Pending the outcome of the investigations, Herrmann has been suspended from his current position as a professor at Ulm University. Brach recently resigned as a professor at Lübeck University, and research grants to both scientists' laboratories have been frozen.

"If science does not [come up with solutions], then politicians must."

—Klaus von Trotha

Guido Adler, dean of Ulm's medical school and chair of the university's investigatory panel, says three other "witnesses" have also come forward in the case. The Ulm group is one of several panels—including those at Max Delbrück, Lübeck, and Freiburg University (where both Herrmann and Brach had worked before moving to Berlin in 1992)—that are reporting their findings to a national investigatory commission, headed by Wolfgang Gerok, a professor of internal medicine at Freiburg. Gerok, whose commission will present its own report this month, told *Science* that the current scandal is "clearly the most serious such case in Germany" in many years.

Meanwhile, the DFG's international panel, whose members are expected to be named soon, will be asked to discuss why the peer-review system did not detect the alleged data manipulation earlier; why supervising scientists who have limited knowledge of the research are sometimes listed as co-authors of papers; whether cooperating groups are under sufficient supervision; and whether fast-moving developments in certain fields are making it difficult for reviewers to verify the quality of new publications.

The panel is expected to issue its report by next spring, and its findings and recommendations are likely to intensify the ongoing debate about research oversight. Both Frühwald and Hubert Markl, president of the Max Planck Society—Germany's premier scientific research organization—argue that Germany should avoid setting up a government agency to monitor research integrity. "We have to bite the bullet" and squarely face the potential problem of manipulated research data, said Markl. "But it would be a bad idea to try to imitate [ORI]"—partly because its centralized powers would clash with the German system, in which individual states have jurisdiction over universities. Markl said Max Planck is developing new guidelines and procedures for detecting, assessing, and punishing research fraud. Its plans are to be presented this fall to Max Planck's board.

"It is important that we rethink the system," said Detlev Ganten, director of the Max Delbrück Center and a member of the national investigative panel. But while scientists including Adler believe that "peer review remains the most effective instrument" for evaluating research, some officials are concerned that science may not be effectively policing itself. Says Klaus von Trotha, science minister for the German state that includes Ulm: "I have appealed to science to make a systematic inquiry and come up with solutions. If science does not do so, then politicians must."

–Robert Koenig

Robert Koenig is a writer in Berlin.