## Ice Station Weddell #1

ARNOLD L. GORDON

*Lamont-Doherty Geological Observatory*
*Palisades, New York 10964*

VALERY V. LUKIN

*Arctic and Antarctic Research Institute*
*Saint Petersburg, Russia*

The Weddell Gyre is the largest of the cyclonic flowing gyres occupying the region south of the antarctic circumpolar current. Its special environmental setting makes it a key constituent of the global climate system. The coupling of the waters of the Weddell Gyre with the atmosphere across a highly variable sea-ice cover with the rather weakly stable water column (a condition forced by the regional upwelling of deep water) results in vigorous vertical fluxes of heat, salinity, dissolved gases, and nutrients. These influence the atmosphere, the ice cover, and the biology, and ventilate the ocean with cold, oxygenated water. A central product of the ventilation process is the cold antarctic bottom water, carried by the western boundary current of the Weddell Gyre into the circumpolar belt, from which it floods and chills the lower kilometer of the world ocean.

The importance of the Weddell Gyre has long been recognized, but observation has been hindered by its sea ice cover. The Weddell Gyre is nearly completely covered by sea ice in the winter, marking the greatest latitudinal range of the seasonal sea ice around Antarctica. During the 1980s a series of winter and spring expeditions (*Somov* 1981; *Polarstern* 1986 and 1989; *Fedorov* 1989) provided a more precise view of the coupling of the deep water with the winter mixed layer and its significant impact on seasonal sea-ice thickness. Along the western rim of the Weddell Gyre, the high concentration of perennial sea ice has hindered even basic exploration of this important region.

Observations from ships are essentially nonexistent in the western Weddell (west of 48° W; south of 65° S). A vast region stretching westward to the Antarctic Peninsula is largely unexplored, except by satellite-borne sensors, by recent aircraft-based geophysical observations, and by instrumented drifters placed on the ice. A range of basic questions exist that can only be addressed with detailed *in situ* observations of the environmental conditions. Fundamental questions include: Why is there an extensive all-year ice cover in the western Weddell? How climatically stable is it? How do the ocean processes along the western rim of the Weddell Gyre contribute to the formation or further modification of antarctic bottom water? Even such a basic issue as the continental slope location was not resolved. LaBrecque and Ghidella (this issue) using satellite and aircraft data place the eastern continental margin of the Antarctic Peninsula about 100 kilometers to the west of the position shown on the GEBCO map.

An effective way to gather extensive observations in the ice-cluttered western Weddell is to borrow a successful method from the Arctic: deployment of a scientific station on a drifting ice floe. In 1988, the concept for the U.S./Russian Ice Station Weddell #1 (ISW), the first ice station of the southern ocean, was initiated, with detailed planning in 1989-1991 and field deployment in 1992. The extensive experience of the former Soviet Union and the United States in ice-station operation formed a natural basis for a collaborative effort to meet the many challenges of establishing a scientific ice station in an unexplored part of the southern ocean.

In the spirit of basic exploration of an unknown region the science program spanned many disciplines. Included were measurements of full water-column thermohaline and tracer fields; current measurements; estimations of turbulent fluxes within the oceanic and atmospheric planetary boundary layers; sea-ice physical, chemical, and biological characteristics; sea-ice dynamics; and water-column biology. U.S. and Russian science programs complemented each other to yield a more complete picture of the environment. Observations were made at the ISW site, from remote instrumented drifters, from helicopter, and from the ships associated with the various phases of the work

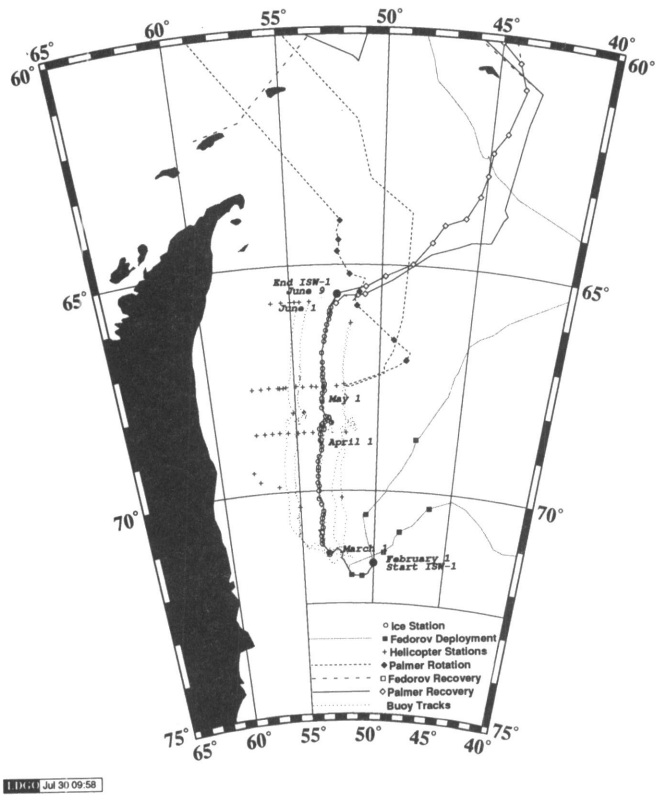



**Figure 1. Map of activities of Ice Station Weddell #1.**

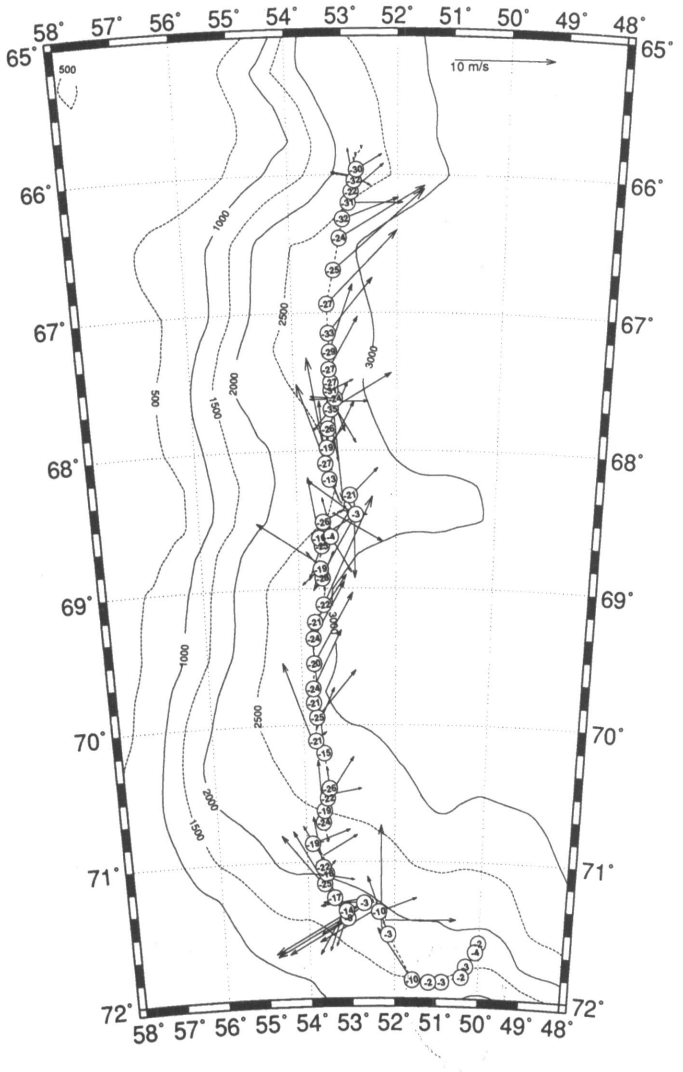



**Figure 2. Drift track, with noon wind-vector and air-temperature values.**

(figure 1). The ISW drifted roughly along 53° W at a northward drift rate of 6.2 kilometers per day between 71.4° S and 65.8° S, experiencing temperatures mostly about -25 °C, but getting as low as -36 °C (figure 2).

The U.S.-Russian ISW may best be summarized by quoting the closing statement from V. V. Lukin, chairman of the Soviet Antarctic Expedition, and Arnold L. Gordon, chief scientist for Ice Station Weddell #1:

"Tuesday 9 June 1992 at 65.63° S and 52.41° W aboard R/V *Akademik Federov* and R/V *Nathaniel B. Palmer*

"The United States Antarctic Program of the National Science Foundation and the Soviet Antarctic Expedition state that on 9 June 1992 the experimental phase of the joint U.S.-Russian project entitled Ice Station Weddell #1 has been successfully completed.

"The difficult environmental conditions of the western Weddell Sea have previously prohibited data collection in this segment of the southern ocean. Only now in the closing decade of the twentieth century has this region been thoroughly observed through this joint effort (figures 1 and 2). Ice Station Weddell #1, the first drift station of the southern ocean, becomes an important part of the history of antarctic exploration, filling a large gap in our view of this remote part of the global ocean.

**Participants of Ice Station Weddell #1**

| | |
|---|---|
| ADCP/Oceanic Microstructure: | |
| Laurence Padman | OSU |
| Atmospheric physics: | |
| Edgar Andreas | CRREL |
| Kerry Claffey | CRREL |
| Boris Ivanov | AARI |
| Aleksandr Makshtas | AARI |
| Biology: | |
| Chris Fritsen | USC |
| Ignor Melnikov | |
| Calvin Mordy | USC |
| Chief of ice station: | |
| Valery Lukin | AARI |
| Cooks: | |
| Dave Cotter | ASA |
| Evgeny Novokhatsky | AARI |
| CTD/Tracer: | |
| Jay Ardai | LDGO |
| Nikolai Dmitriev | AARI |
| Amy Field | LDGO |
| Raul Guerrero | INIDEP |
| Hartmut Hellmer | LDGO |
| Valery Karpiy | AARI |
| Guy Mathieu | LDGO |
| Suzanne O'Hara | LDGO |
| Ralph Weppernig | LDGO |
| Current observations: | |
| Mark Morehead | SAIC |
| Helicopter: | |
| Andy Campbell | |
| Tom Duncan | |
| Jim Innes | |
| Mike Rugg | |
| Brent Snyder | |
| Logistics/Mechanic: | |
| Mike Darrah | ASA |
| Sergey Kasjanov | AARI |
| Kirk Kiyota | ASA |
| Sergei Labinsky | AARI |
| Physician: | |
| Dmitri Kirjunichev | AARI |
| Sea ice: | |
| Steve Ackley | CRREL |
| David Bell | NOARL |
| Vladimir Churun | AARI |
| Bruce Elder | CRREL |
| Vladimir Grischenko | AARI |
| Vlad Korostelev | AARI |
| Vicky Lytle | CRREL |
| Nikolai Sukhorukov | AARI |
| Technical coordinator: | |
| Jose Ardai | LDGO |
| Upper ocean physics: | |
| Roger Andersen | APL |

"Ice Station Weddell #1 began operation on 11 February 1992 at 71°48' S 51°43' W, with the support of the R/V *Akademik Federov*. Seventeen American and 15 Russian polar scientists successfully fulfilled the scientific program on the drifting ice floe.The scientific program consists of physical oceanography, meteorology, sea-ice physics, and marine biology. In March and April 1992 part of the U.S. team were rotated with U.S. aircraft (mid-March) and with the U.S. icebreaker R/V *Nathaniel B. Palmer* (late April). In May and June 1992 Ice Station Weddell #1 was recovered by cooperative cruise of the Aboard R/V *Aakademik Federov* and R/V *Nathaniel B. Palmer*. The official closing ceremony was held on 9 June 1992 at 65.63° S and 52.41° W.

"The successful performance of this project was made possible by the significant polar experience both of the American and Russian teams. The success of Ice Station Weddell #1 forms the basis for future collaboration between the U.S. and Russia for both polar regions."

The articles following this overview report on the nature of each of the component programs of ISW, the associated ship work, and whenever possible, provide a few of the preliminary findings (also see LaBrecque and Ghidella in this issue of *Antarctic Journal* concerning regional bathymetry of the western Weddell). Because of the proximity of the recovery of ISW to the deadline for this issue of *Antarctic Journal* it was not possible to more fully coordinate the reporting of the U.S. and Russian science programs.

Many people contributed to the historic achievement of Ice Station Weddell #1 (see participants list). The support of Office of Polar Programs of the National Science Foundation (Peter Wilkniss, Bernard Lettau, and Al Sutherland) is greatly appreciated. John Evans of ASA had the most difficult task of procuring and shipping all of the material required for ISW life—and science—support systems. Jay Ardai's remarkable talent of getting things to work under the most adverse conditions was essential to the ISW success. The superhuman effort of the Russians to come through with most of their part of the effort even as the USSR was dissolving, was phenomenal.

### References

LaBrecque, J. L. and M. E. Ghidella. 1992. Estimates of bathymetry, depth to magnetic basement, and sediment thickness for the western Weddell Basin. *Antarctic Journal of the U.S.*, this issue.

---

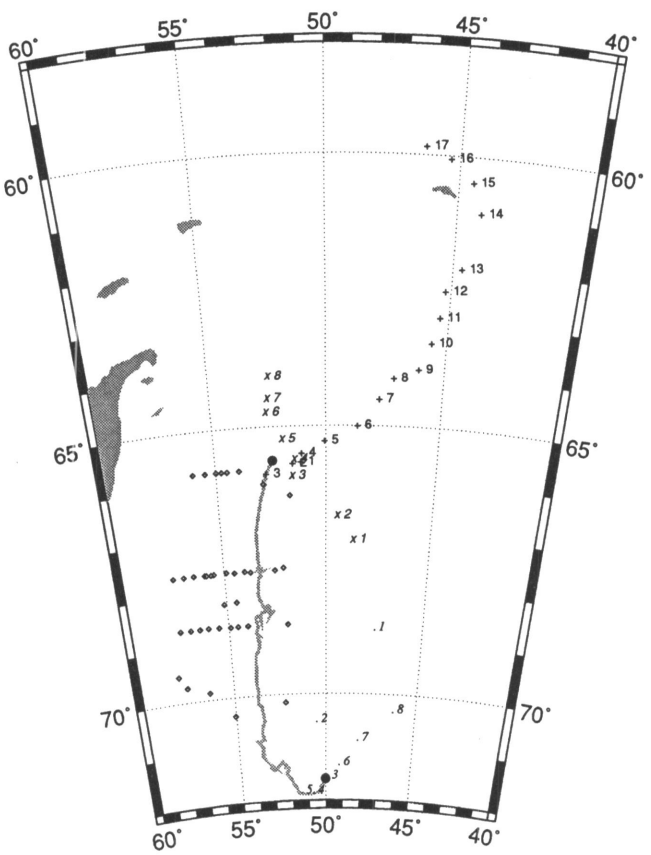
# Physical oceanography studies on *Akademic Federov* and *Nathaniel B. Palmer* 92-1 and 92-2 in support of Ice Station Weddell #1

Arnold L. Gordon, Bruce Huber, and Douglas Martinson

*Lamont-Doherty Geological Observatory*
*Palisades, New York 10964*

The data collected at Ice Station Weddell (ISW) are augmented by conductivity-depth-temperature (CTD) data from *Akademik Federov* (AF) and *Nathaniel B. Palmer* (NBP) during their cruises in support of ISW (figure; Gordon and Lukin 1992).

Deployment of ISW was accomplished from AF, aboard which eight CTD stations were occupied in order to observe the characteristics of water masses flowing into the ISW drift region, An NBIS MKIIIB CTD/O with 12 1.7-liter rosette bottles was used. Water samples were collected for the analysis of salinity, dissolved oxygen, silicate, phosphate, nitrate+nitrate, helium, tritium, and oxygen isotopes. Each cast approached the bottom within limits imposed by the lack of appropriate depth-sounding equipment, typically within 50 meters. Although limited in scope by time restrictions, the survey clearly shows the near-bottom characteristics found entering the ISW region from the southeast.




**Positions of CTD stations obtained from *Federov* (*dots*), *Nathaniel B. Palmer* 92-1 (x), and *Nathaniel B. Palmer* 92-2 (+). The *solid line* shows the drift of ISW, and the diamonds represent CTD stations from ISW-based helicopters.**