Palmer LTER: Small boat design for water column sampling

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The Palmer Long-Term Ecological Research (LTER) Program includes weekly seasonal observations of the marine environment within the foraging range of the Adélie penguin breeding sites near Palmer Station. A zodiac is equipped with two winches for hydrographic, optical, acoustic, and biological measurements within the 3.7-kilometer (km) boating limit (Smith et al., *Antarctic Journal*, in this issue). Key oceanographic equipment deployed from this zodiac, christened the ROZE (Ray's Oceanographic Zodiac Experiment), includes a conductivity-temperature-depth (CTD) system with transmissometer and fluorometer, a profiling reflectance radiometer (PRR), an above-water radiometer, a 120-kilohertz echo sounder, and global positioning system (GPS) navigation (table 1). A laptop computer system provides real-time display of CTD, optical, and acoustical data.

The ROZE (figure 1*A*) is a standard 5.8-meter (m) inflatable zodiac (Mark V) with a soft bottom, a 45-horsepower outboard motor, and a 9.9-horsepower backup motor. This zodiac with multicompartmental flotation was chosen because of cost, safety, flexibility, strength, and low maintenance. The zodiac flooring consists of four aluminum panels and two wooden bow panels. A rear wooden pallet adds

Table 1. Zodiac instrumentation

Function	Manufacturer	Model	Comments
CTD profiling			
CTD profiler	Sea-Bird Elec.	SEACAT SBE19	With pump SBE5-01
Transmittance	SeaTech		25-cm path transmissometer
Fluorescence	SeaTech		Chlorophyll fluorometer
Optoisolator	Sea-Bird Elec.	SBE 28	Reduce noise in data
Electric winch	Custom built		20-cm diameter, 50-cm wide aluminum drum
Winch motor	Dayton		3/4-horsepower variable speed and direction
Gear reduction	Dayton		29:1 speed reducer
Kevlar cable	Cortland Cable	4-conductor	20-gauge, 1,000-lb strength
Slip rings	IEC Corp.	IEL-BX-4	4-conductor
Optical profiling			
Light/underwater	Biospherical	PRR600	7 irradiance + 7 radiance bands
Light/deck	Biospherical	PRR611	7 irradiance bands
Hand winch	Custom built		150-m Kevlar cable
Flotation fins	Custom built		Slow freefall away from boat
Kevlar cable	Cortland Cable	4-conductor	20-gauge, 1,000-lb strength
Slip rings	IEC Corp.	IEL-BX-4	4-conductor
Acoustics			
Echo sounder	BioSonics	Model 102	120-kilohertz krill surveys
Tape interface	BioSonics	Model 171	Interface DAT to sounder
Chart recorder	BioSonics	Model 111	Thermal
Processing board	BioSonics		Mounted in docking station
Interface pod	BioSonics	ESPSCP	Interface SP board to sounder
Interface pod	BioSonics	ESPIP	Interface SP board to sounder
Deck cable	BioSonics	100-foot	Sounder to transducer
Transducer	BioSonics	120-kilohertz	
Data recorder	Sony	TCD-D3	Uses DAT format
Computer			
Computer	DEC	DEC486	Used for CTD, optics, and acoustics processing
Docking station	DEC	PCP3E-AB	
VGA color monitor	DEC	PC7XV-BA	
Power production			
DC-AC inverter	Tripp-Lite	PV1800FC	24-volt
Batteries	AC Delco	Voyager M27MF	Deep cycle 12-volt, RV
Navigation and communications			
GPS	Garmin	GPS 45	Pre-set waypoints for stations
GPS antenna	Garmin	010-10052-00	Remote mount marine
GPS mount	Garmin	010-10048-00	Tilt/swivel
Depth sounder	Furuno	LS-6000	LCD video; fish finder
VHF radio	Standard	GX2330SAB1S1	Horizon Nova
Radio antenna	Shakespeare	5202	2.4-meter very-high-frequency
Antenna mount	Shakespeare	4187	Ratchet type

height, so the zodiac driver can see over instrument boxes mounted on a raised, 2.4-m × 1.5-m platform built across the center of the zodiac. The platform fits inside the zodiac, so pontoons function as a bumper rather than the platform edge. The platform is made from six wood beams supported 30 centimeters (cm) above the zodiac floor by two box beams running lengthwise along the zodiac pontoons and standing on a stack of 5-cm × 15-cm runners (figure 1*B*). Further structural support is provided by a beam directly under the outermost edges of the platform.

The platform, sitting 5 cm above the zodiac to prevent abrasion of the pontoons, is lashed to the zodiac. Two instrument boxes have hinged doors that close during travel for protection. Gas cans sit securely on the fourth floor panel behind the pallet. Emergency supplies include oars and an extinguisher for electrical fires. Two batteries are kept in a raised, covered wooden box under the platform.

On the platform, two winches, one electric and one hand powered, are located forward of the instrument boxes. When not in use, the CTD is secured by a bracket mounted forward and to port, and the acoustic transducer is secured to starboard. L-shaped davits with a height of 1.8 m and a reach of 1.2 m are centered on each side, extend through the platform to sit on the stack of runners, and swing both forward and aft.

A GPS antenna is mounted on the port davit. Installed on the starboard davit are a PRR deck unit and a radio antenna with a ratchet mount that folds to avoid shadowing the deck light sensor.

The starboard instrument box has three shelves:

- GPS, very-high-frequency radio, depth sounder, and a ground fault circuit interrupt for safety;
- computer monitor, PRR power box, CTD interface box, and controller for the electric winch, and
- DEC486 laptop computer with a separate color monitor and docking station.

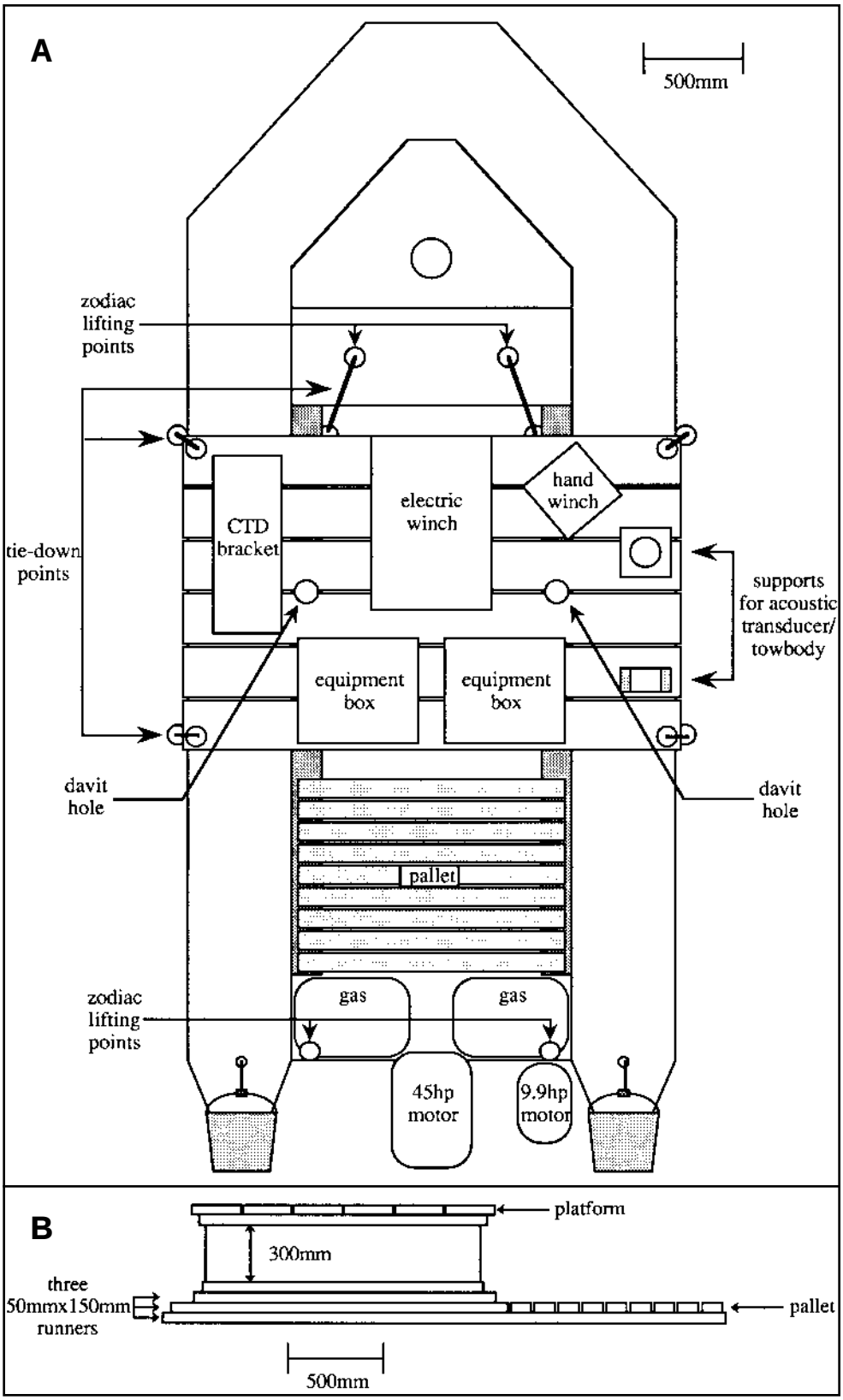

Figure 1. *A.* Overhead schematic of zodiac layout. (hp denotes horsepower.) *B*. Side schematic of zodiac platform. (mm denotes millimeter.)

Table 2. Zodiac power budget

Equipment	Watts	Amps
125-volt alternating current		
Winch motor	900	9.42
Laptop computer	55	4.58
Color monitor	85	7.08
CTD	55	4.58
Profiling radiometer	55	4.58
GPS	2	0.16
Scientific echo sounder	32	2.67
Tape interface unit	25	2.08
Thermal chart recorder	30	2.50
DAT tape recorder	15	1.25
12-volt direct current		
Furuno fishfinder	10	0.83
VHF radio	25	2.08

Figure 2. Photograph of zodiac being removed from water.

The port box contains BioSonics acoustic sounding system electronics including a scientific echo sounder, thermal chart recorder, and tape interface unit as well as a DAT tape recorder and a direct current/alternating current inverter.

The power budget (table 2) includes a maximum steady battery current load of 30 amps with the winch operating. Peaks up to 60 amps occur when the winch is starting under full load. The draw decreases to 20 amps with the acoustic gear off. Two 12-volt deep-cycle marine batteries provide 105 amp-hours, sufficient power for five stations of CTD and PRR casts to 90 m. Currently, the inverter is 24 volts with an 1,800 watt output. An optoisolator box protects instrument electronics. The radio and depth sounder have an external connection directly to the battery.

The 12-volt batteries are recharged overnight with a Voyager 20-amp charger (Deltran Corp.) modified to charge optimally at approximately 13°C rather than the standard 23°C. Six batteries include two on the zodiac, two charging, and two spares. The battery-powered inverter is a big improvement over previous gasoline-generator configurations.

A sampling party has the driver aft and one or two others forward of the platform. A GPS navigation unit locates stations accurately as well as provides safety should visibility become limited. Both winches are equipped with 150 m of Kevlar conducting cable. The electric winch is used to deploy the CTD from the port davit. The PRR is deployed using a hand winch to facilitate a free-fall release (Waters, Smith, and Lewis 1990). The acoustic transducer is towed from the starboard davit alongside the boat within 1 m of the surface. The driver maintains a zodiac event log while all in-water instruments are launched by personnel in the bow, from either side of the zodiac. A very-high-frequency radio mounted for ease of access along with its antenna have improved communications with Palmer Station during field sampling.

At the end of a day's sampling, the computer is removed for data transfer and batteries are removed for recharging. The CTD and PRR are removed from the boat for fresh-water rinsing and laboratory storage for drying. Equipment left on the zodiac is covered by tarps. By turning on the inverter in the morning, the computer and the monitor warm up the instrument boxes, quickly removing condensation.

The zodiacs remain in the water as long as ice conditions permit. If ice conditions suddenly change at Palmer Station, ROZE with all equipment aboard can be lifted free of the water within 10 minutes using eight sling arms on a lifting ring lifted by a movable crane. Experience with leopard seals indicated that tying buckets onto the conical end of pontoons would prevent bite puncture damage when ROZE is moored at the station (figure 2). In summary, the ROZE has provided a flexible, robust oceanographic sampling platform for the past five seasons.

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