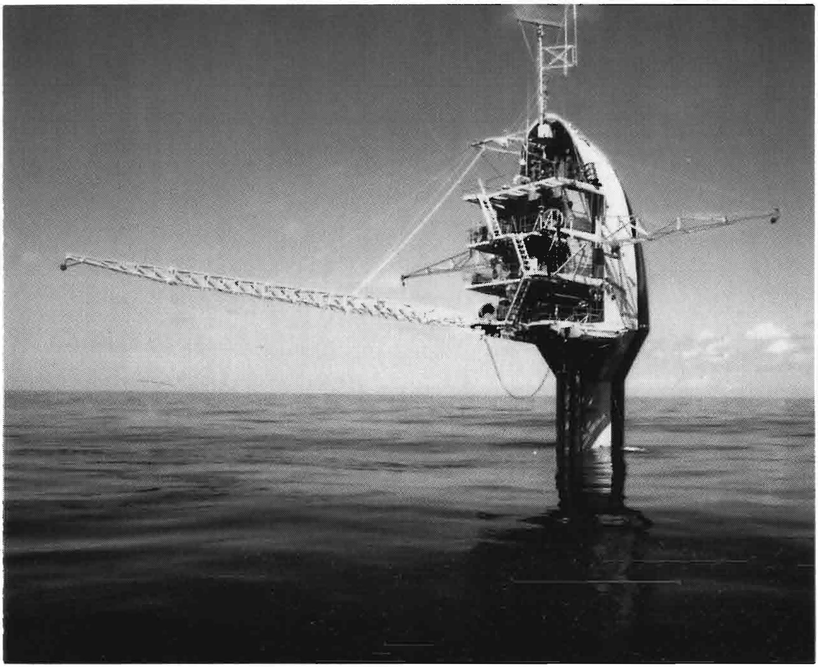


FLIP

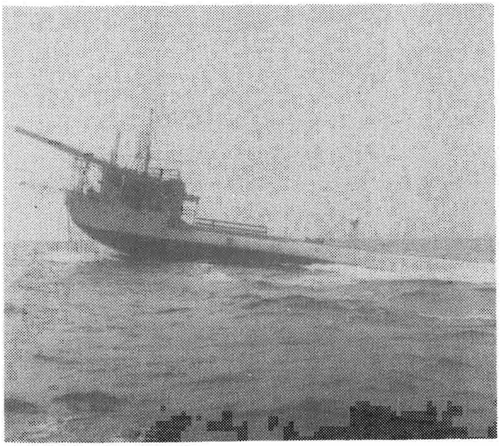
FLoating Instrument Platform

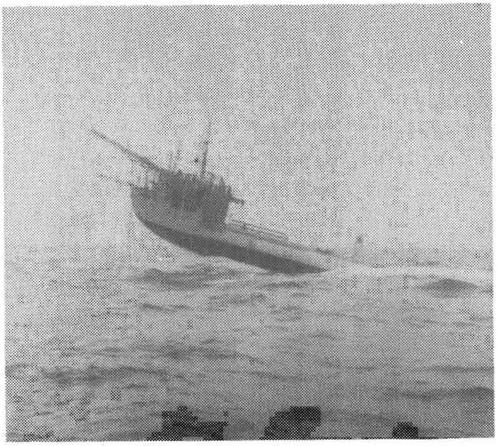
I. INTRODUCTION

FLIP [FLoating Instrument Platform] is a 355 foot manned spar buoy designed as a stable platform for oceanographic research. FLIP is owned by the U.S. Navy and operated by the Marine Physical Laboratory (MPL), Scripps Institution of Oceanography. Originally constructed to measure effects of the environment on long range sound propagation, FLIP has since been used for acoustics, geophysics, meteorological and physical oceanographic research.

FLIP typically operates in the Eastern Pacific, in the waters between California and Hawaii. Operations as far afield as the Gulf of Alaska (1966) and the Caribbean (1969) have been conducted. In a typical research cruise, FLIP is towed to the experiment site in the horizontal position. Upon arrival, ballast tanks are flooded and FLIP is "flipped" to the vertical, stable orientation (Figure 1). Draft increases from 10′ to 300′ during this process which lasts about 30 minutes. In the vertical, FLIP typically tilts less than 2° rms and moves vertically less than ~10% of the rms surface wave height. An extremely stable platform is thus provided, ideal for many classes of oceanographic research. As many as 16 people, including a crew of 5, can be accommodated for periods up to 30 days without resupply. Observations can be made with the platform either freely drifting or moored. Deep sea and shallow water moors, either single, two or three point, are routinely accomplished, in support of research projects.

Figure 1

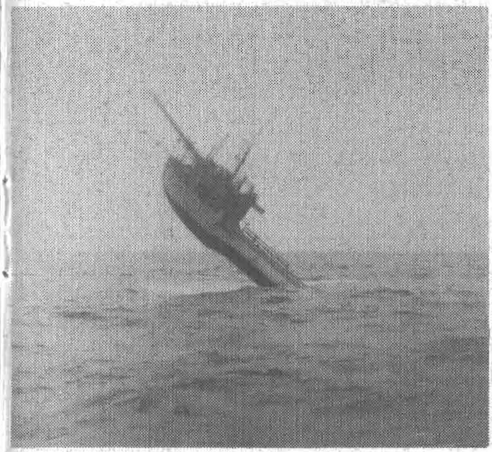


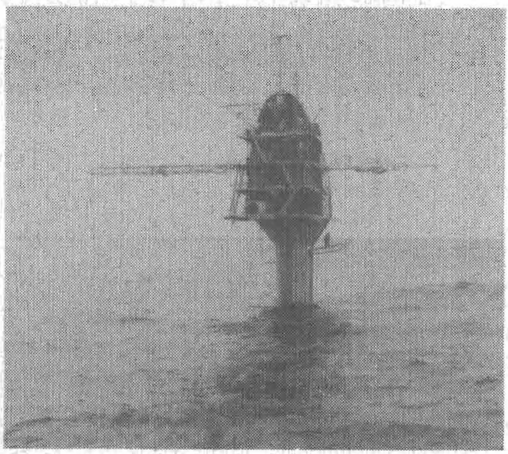


FLIP was developed in the early 1960's under sponsorship of the U.S. Navy's SUBROC program. Initial design studies and model testing were conducted at MPL, with final structural design provided by commercial naval architects. FLIP was constructed by the Gunderson Brothers Engineering Company in Portland, Oregon and launched on June 22, 1962. In the subsequent three decades, FLIP has "flipped" more than three hundred times, in support of a multitude of scientific programs. Now one of the oldest vessels in the U.S. research fleet, FLIP is supported by an active program of inspection, preventive maintenance, and improvement.

Figure 2 shows the general arrangement and inboard profile of FLIP. From the stern, the first 150′ of FLIP's hull is a 20′ cylinder. This tapers to a 12.5′ cylindrical section over a 90′ conical transition. The 40′ bow section is a full, deep spoon type. It is joined to the hull with a partial conical fairing at frame 315.

There are four levels in the bow section: engine room, living quarters/ galley/dining area, laboratory/bridge space and crew quarters. There is an external working platform, about 25′ by 12′, at the engine room level, with three other platforms above it. The platform at the engine room level is also the location of the controls for the flipping operation. Observations below the surface are made by means of instruments fixed to the hull, lowered on cables from booms, or lowered directly from winches mounted on the external working decks.





II. OPERATIONAL CAPABILITIES

A. Mode of Operation

FLIP can be used in either a moored or free-drifting mode depending on the requirements of the scientific program. Drifting, FLIP moves in response to the winds and upper ocean currents. Speeds over the bottom can approach 0.5 kt in 25 kt winds. Speeds relative to the water are generally less. The hull will naturally "weather-vane", orienting such that the keel is into the wind. The working decks are thus in the lee of the hull, protected from wind.

Deep ocean moors have been accomplished routinely since 1969, in water depths to 5000 m. One and one-half inch nylon line is used, connected to dead weight anchors by break-away links. In two- and three-point moors, both the azimuth and position of the platform can be tightly controlled. The typical watch circle is 80-200 m when FLIP is tri-moored in 4 km water.

Mooring is an involved process. For a full tri-moor in deep water, approximately 80 tons of mooring gear must be transported to the site (usually aboard the tow vessel) and deployed. Deployment can be accomplished in 12-16 hours in moderate weather. At the conclusion of the experiment, mooring lines are recovered and re-used. The anchors and anchor chain, approximately ten tons per leg, are left on the bottom.

Once moored, acoustic transponder systems can be deployed to provide precise positioning of subsurface sensors and arrays deployed from the platform. When combined with GPS, the absolute position of sensors can be determined to within a few meters.

B. Laboratories

The Bridge/Lab (Figure 3) serves as the command center for the platform. Communication systems and the azimuth orientation system are controlled from this location. The remainder of the lab is available for research use. The main laboratory is located keelward of the bridge/lab and is open directly to it when FLIP is in the vertical orientation. A combined total of 500 square feet of laboratory space is available.

Scientific equipment is typically installed on FLIP in three-bay instrument relay racks. The racks are strongly reinforced to accommodate the loads associated with the flipping process. Instrumentation is loaded into the racks while ashore. The full racks are rotated onto their sides prior to dockside loading of the platform. Access to instrumentation is available both in the horizontal and vertical. The main laboratory can accommodate as many as four instrument racks; the bridge/lab can accommodate one.

In addition to the electronics laboratory, significant space is available below the water line for research instrumentation. Tank 5 (frames 150′ - 160′) is kept dry and at atmospheric pressure. It is connected to the surface/bow via an 18 inch diameter access tube.

C. Machinery and Equipment

Electrical power for the air compressors and other ship's services is provided by two 150 KW diesel generator sets located in the machinery space. Both the main generators are mounted in trunnions. A 40 KW auxiliary diesel generator set is also mounted in trunnions and provides power during the flipping operation. Air-ride mounts are used to isolate engine vibrations from the hull. Two air compressors are mounted in trunnions in Tank 10 between frames 300 and 315. The compressed air (3000 cu. ft., 250 psi) is stored in eight bottles located below Tank 10. A reverse-osmosis fresh watermaker is capable of producing 400 gals/day. A 7-ton chilled water air conditioning unit provides air conditioning in all compartments except the engine and air compressor rooms. Each compartment has its own thermostat for individual temperature control. Two Elliot 20 man SOLAS inflatable life rafts are stored externally, port and starboard. They can be released manually or hydrostatically. Individual life preservers (PFD's) are stored in a locker on the forecastle. Immersion suits (survival suits) are provided. An EPIRB (Emergency Position Indicating Radio Beacon) is mounted on the mast. A 13 foot Boston Whaler outboard boat is available for transfer of personnel and equipment, subject to weather conditions.

D. Azimuth Orientation System

A hydraulically operated orientation system (thruster) is installed to maintain azimuthal direction when in the vertical position. The system consists of a 60 HP electro-hydraulic unit driving a ducted fan thruster mounted on the hull at frame 250. The motor and A-end pumps are mounted in Tank 10 and are controlled by a servo-system located in the bridge/lab. A MK 27-4 gyro-compass in Tank 10 is used to indicate the ship's heading. It also provides heading information to the azimuth orientation system.

E. Electronics, Communications and Navigation

The radar is a Furuno model 1021 with a range of 100 miles and is located in the bridge/lab. Communication equipment, also located in the bridge/lab include:

HF/SSB(USB)	ICOM 700 (2)	2-23 MHz
VHF	Standard Maxi	25-1 watt
	Standard Titan	25-1 watt
Cellular telephone		
INMARSAT	Japan Radio Co. Ltd.	
Epirb	Alden 406 Sat Find	Solas Approved

F. Equipment Deployment

FLIP offers a unique capability to deploy complex payloads at precise locations in the ocean environment, with minimal disturbance to ambient atmospheric and oceanic flows. Unlike offshore towers or semi-submersibles, wet-end payloads can be installed without the use of divers. Heavy instruments can be secured to the hull, thoroughly tested at dockside, and delivered to the operating site, protected from heavy seas. If, after flipping, problems are experienced, instruments can be accessed by transitioning back to the horizontal position.

Lighter weight instrument packages (< 1000 lbs) can be deployed from booms which are routinely attached to the platform. Extremely precise handling of these packages is possible using simple winches. All booms are certified and weight tested.

Vertical arrays of sensors, acoustic or oceanographic, can be lowered to full ocean depth using FLIP's hydrographic winch. The winch, routinely rigged with 0.380″ wire, is capable of handling loads up to 3,000 lbs. Given the stability of the platform, extremely sensitive instruments can be deployed. A 15,000 lb Lebus winch and a 3,000 lb Crossline winch are also available for use with a variety of electromechanical wires.

Sensors can be attached to the hull on existing or custom-made foundations. A variety of booms and winches are available for deploying instruments from the external working decks. For unique requirements, the MPL shop can construct special equipment to assist in the deployment of sensors.

G. Habitability

Quarters are somewhat limited on FLIP. There is a fully equipped galley, and seating for 8 people. The space between frames 323 and 331 consists of three levels in the horizontal position: At the uppermost level, there are two bunks for the Officer-in-Charge and First Mate, as well as a head with a shower for the horizontal position. Below is a galley, a dining table and a head with a shower for the vertical position. At the lowest level, there is a berthing compartment with

Figure 3

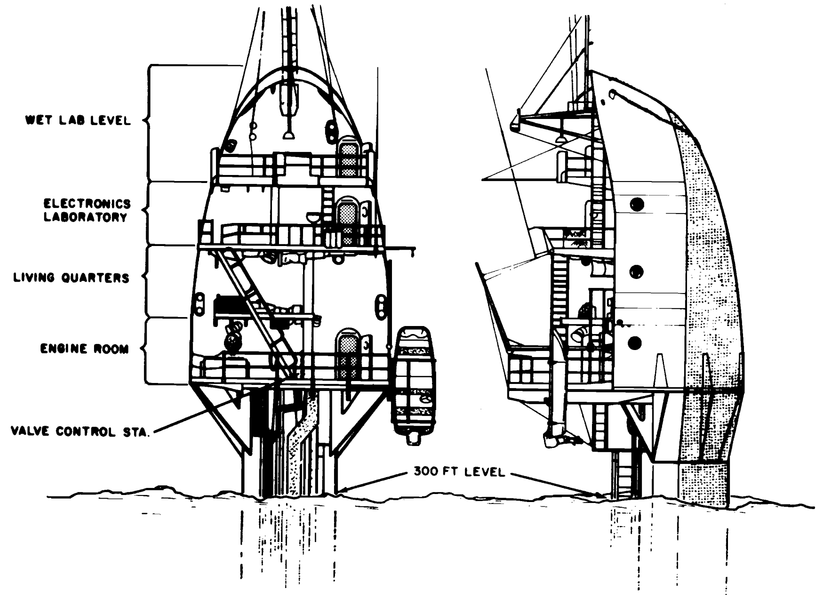
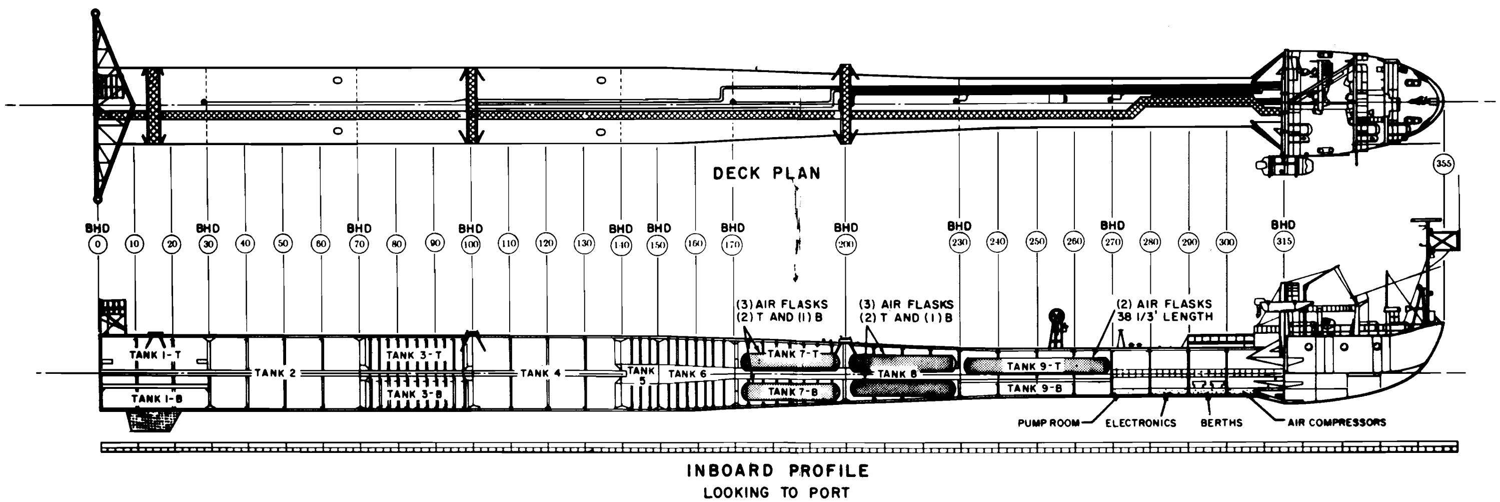


Figure 2



four bunks for the scientific party adjacent to a space for a second dining/ conference table. Berthing facilities for the crew and additional scientific personnel are located in the crews quarters forward and in a portion of Tank 10. A total of 11 berths are available for the scientific complement.

III. FLIP DEPLOYMENTS

Operations have included studies of ocean wave attenuation, sound propagation bearing accuracy and phase fluctuations, microthermal/turbulence studies, ambient noise, seismic wave recording, meteorological research, studies of internal waves, Langmuir cell circulation, momentum flux and other upper ocean physics phenomena.

Although designed with an endurance capability of 30 days at sea, an operation of 45 days duration occurred in 1963 in which FLIP became a drifting "island" between Hawaii and Alaska, about 1800 miles from San Diego. FLIP augmented an array of island based sensors to study storm generated waves from the South Pacific. FLIP was vertical on station for 27 consecutive days. Food, fuel and water were transferred to FLIP from its towship during this period.

While on station, gale force winds and seas were practically continuous and offered ample opportunity to measure FLIP's response characteristics. Maximum vertical motion was measured at less than 10% wave height; seas to 35 feet were encountered. Since that operation, there have been four deployments to the Hawaiian area. FLIP operated out of Honolulu for periods of 7 months, 3 months, 2 months and 5 months respectively. From early July to early August 1969, FLIP operated in the Caribbean as part of the mesoscale Barbados Oceanographic and Meteorology Experiment (BOMEX) off Barbados, and also in an experiment north of Puerto Rico on the Nares Abyssal Plain on bearing accuracy in relation to bottom topography.

While under tow in the horizontal, tow speed as high as 10 knots can be attained depending on weather. Navy tugs (ATF and T-ATF) and commercial tugs have been used for towing FLIP. Vertical tows at up to 1 kt have been conducted for station keeping or small changes in location.

IV. RESEARCH EXAMPLES

The stability of FLIP has enabled an intimate connection between scientists, their instruments and the air-sea environment. Relative to conventional platforms, FLIP based instruments have easy access to the undisturbed ocean and atmosphere and scientists have easy access to their instruments.

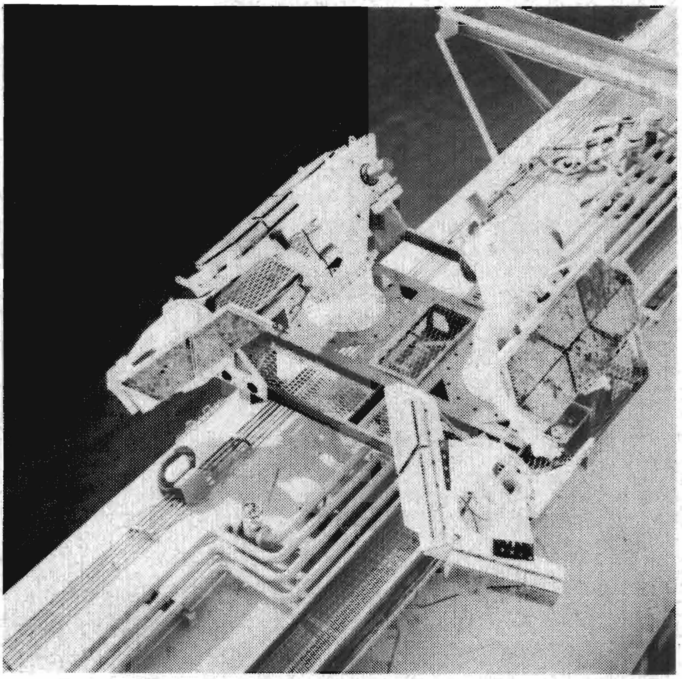


Figure 4. The 75 kHz Doppler sonar system first used from FLIP in November 1979. Velocity profiles can be obtained to ranges of 1.5 km, depth of 1.2 km.

A. Doppler Sonar Development

As an example of the types of observations now made from FLIP, one can consider Doppler sonar observations of ocean currents. Doppler sonars transmit narrow beams of high frequency (50-1000 kHz) sound. The sound scatters off plankton drifting in the upper ocean. From the Doppler shift of the echo, the velocity of the scatterers (and hence the water velocity) can be determined as a function of range. Doppler Sonar development was initiated at MPL in 1974, using conventional echo sounds. By 1980 a multi-beam special purpose 75 kHz system was operational (Figure 4). The system transmitted at a peak power of 16 kw. Velocity profiles were obtained to depths of the order 800 m in 1980, increasing to 1200 m by 1986.

In the mid-1980's sea-surface scanning sonar technology was developed (Figure 5), enabling a quantitative investigation of the strain rate of the ocean surface (e.g. Figure 6). Subsequently coded pulse transmissions and multi-beam imaging sonars have been developed, again using FLIP as a base.

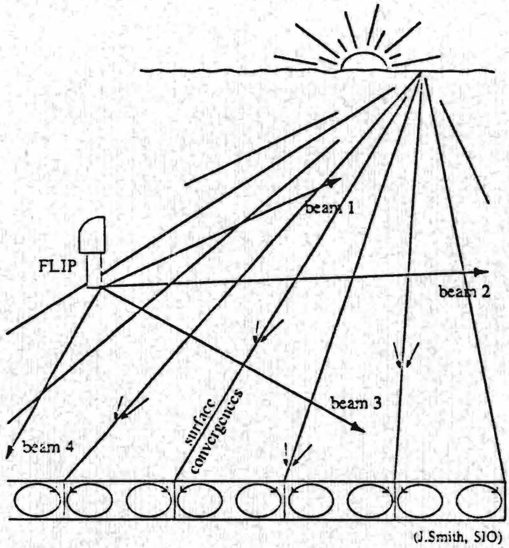


Figure 5. Schematic view of Langmuir circulation and the 4-sonar beam extending from FLIP. The convergence "stripes" are observed to lie within 20° or so of the wind direction. The velocity scales are a percent to a few percent of the windspeed.

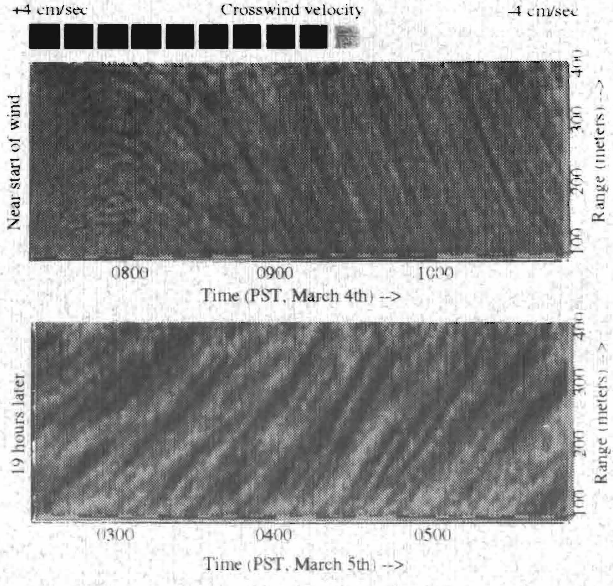
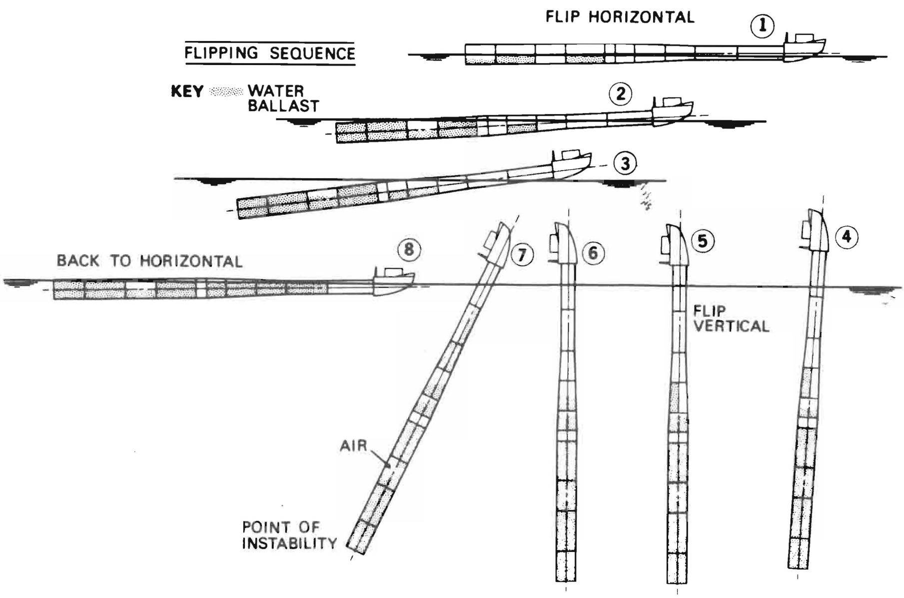


Figure 6. Two samples of sonar velocity data from SWAPP. The first sample is near the beginning of a wind event. The wind increased suddenly at about 7:30; small "ripples" are apparent, especially near the 150 m range. After that, there is rapid evolution toward larger scales; also the mean flow increases, creating the diagonal stripes seen over the second half of this sample. The second sample is some 19 hours later, and shows "fully developed" Langmuir circulation.

B. Vertical Hydrophone Array Deployments

Vertical arrays of hydrophones can be lowered from FLIP to study sound propagation and ambient noise. They can be assembled on the working platforms of FLIP (in the vertical position) and lowered as a line array. A pennant with weights is used to fairlead the array through a guide at the bottom of FLIP's hull to prevent entanglement. Past studies have been conducted with a wide variety of arrays ranging in lengths from a few hundred meters to three thousand meters in both the drifting and moored modes of operation. Primarily these deployments have been carried out with FLIP moored. Mooring not only reduces flow noise contamination but also makes it possible to use transponder array element location (AEL) systems to determine hydrophone positions. With commercial acoustic transponders, relative positions of hydrophones can be measured to 1-2 meters. Using the on-board Global Positioning System (GPS) receiver, positions of array hydrophones can be tied to absolute earth coordinates.

FLIP also has proven to be a capable platform for carrying out signal propagation and ambient noise experiments in relatively shallow (~200 m) water with the deployment of acoustic arrays on the ocean bottom. A 48-element vertical array and a 64-element horizontal planar array have been deployed on the sea floor and cabled back to FLIP for recording.



MARINE PHYSICAL LABORATORY

MPL

PRINCIPAL DIMENSIONS & CHARACTERISTICS

Length Overall	355′ - 0″
Hull Diameter Maximum	20′ - 0″
Hull Diameter, Minimum	12′ - 6″
Draft Horizontal Normal fwd	10′ - 5″
Draft Vertical Normal	300′ - 0″

Displacement	1500	tons (Horizontal, 2000 tons (Vertical)
Displacement	800.0	tons (including concrete ballast)
Transverse Center of Gravity	0.4′	Below Centerline Axis of Hull
Longitudinal Center of Gravity	182.0′	Forward of After End

POINT OF CONTACT

Persons interested in learning more about the capabilities of FLIP, or about availability to support specific research, development, or test programs should contact:

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