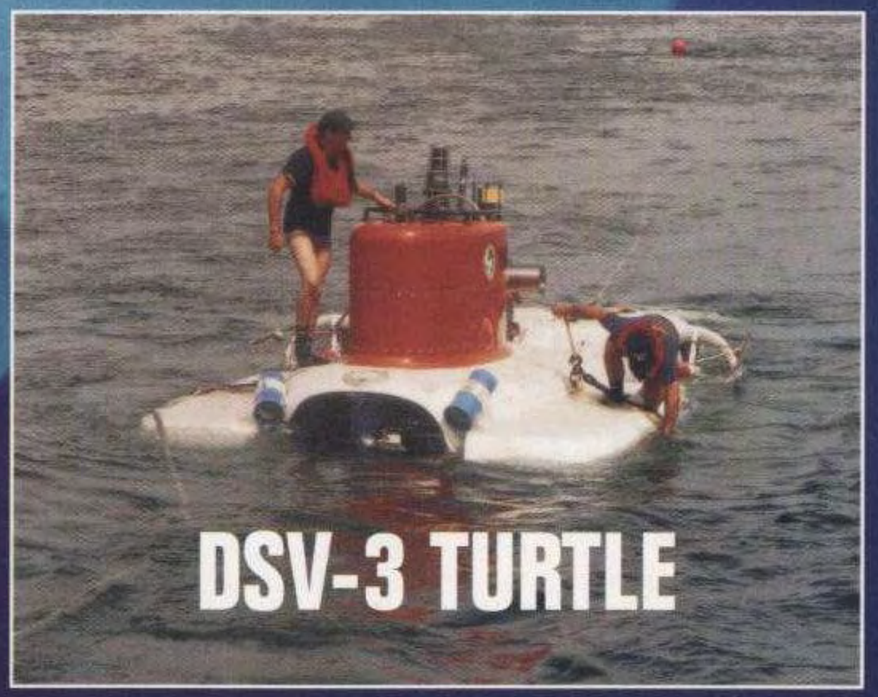
# Deep Submergence Vehicles

DSV-4 SEACLIFF



DSV-3 TURTLE

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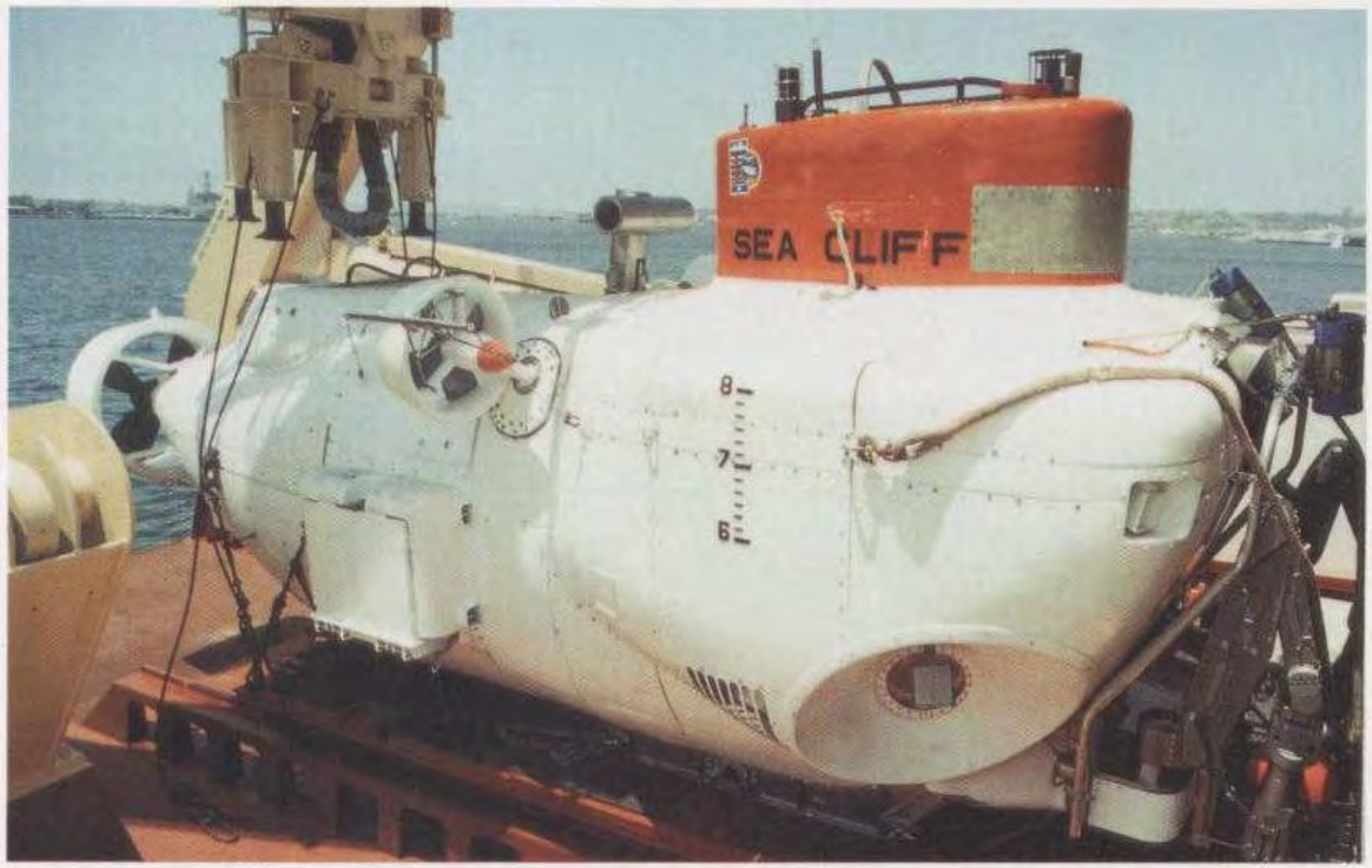


# Introduction

This booklet has been prepared to acquaint new personnel with the accomplishments, missions, capabilities and potential uses of the U.S. Navy research vehicles DSV-3 Turtle and DSV-4 Sea Cliff. Similar in design, equipment, and operation, each vehicle has some unique characteristics and capabilities. These are most notably in depth capability, endurance, and ballast system components. These capabilities are described in this booklet to enable interested parties to decide which vehicle is best suited to their particular mission.

Turtle and Sea Cliff are three-man, deep-diving, self-propelled submersibles that work at depths of 10,000 feet or 20,000 feet respectively. Missions performed include search and recovery, underwater inspection and photography, and oceanographic and geologic research. They are available to all qualified U.S.Government agencies and accredited research organizations.

Inquiries should be addressed to:

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**Attn: Director, Deep Submergence**
**Systems Division**

Govt. offices and agencies to contact regarding vehicle acquisition

**Commander**
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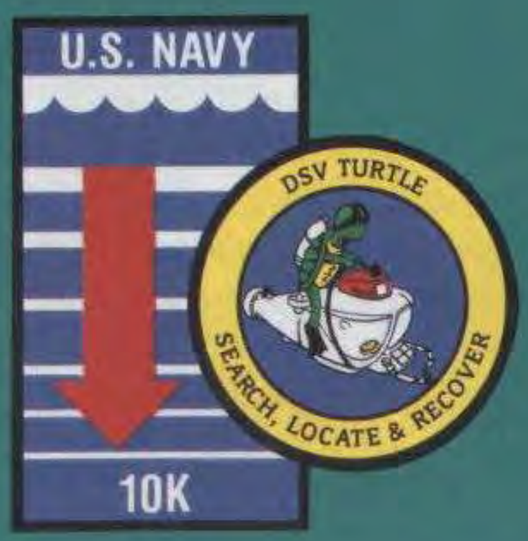
**Naval Sea Systems Command**
**2531 Jefferson Davis Highway**
**Arlington, VA 22242-5160**





# Accomplishments

Since their launchings in 1968, Turtle (DSV-3) and Sea Cliff (DSV-4) have proven their ability to conduct scientific and military operations worldwide; excelling at their missions to search, locate, and recover. These vehicles have participated in numerous successful missions for government and academic institutions, including the Office of Naval Research (ONR), the National Oceanic & Atmospheric Administration (NOAA), and the Naval Research Laboratory (NRL). Both Turtle and Sea Cliff underwent extensive conversions to increase their working depths to 10,000 ft. and 20,000 ft. respectively. Their accomplishments include the following:

***Turtle***

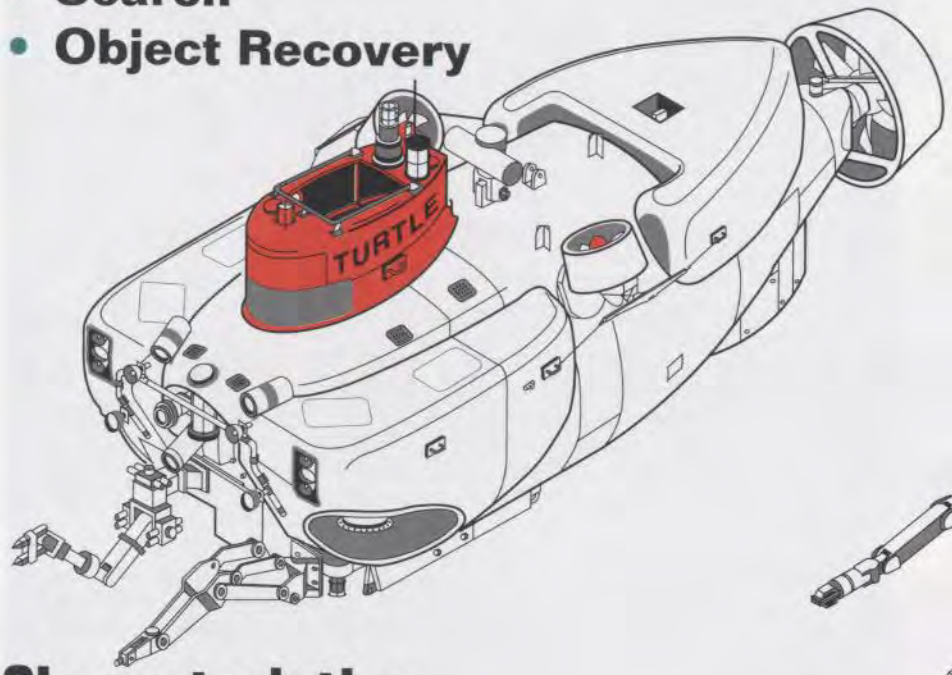
- Participated in inspection and recovery operations at the Barking Sands Tactical Underwater Range (Hawaii, 1972).
- Participated in a submarine structural response test, mapping the debris field of the ex-USS SABALO (1973).
- Conducted science operations in the Gulf of California (1982).
- Received Meritorious Unit Commendation for recovery operations in 1982 and 1983 in Hawaii.
- Participated in numerous recovery operations in Southern California.
- Located and surveyed two downed aircraft (1988).
- Conducted scientific operations on Fieberling and Jasper Seamounts (1988).
- Conducted a joint operation along with Woods Hole's remotely operated vehicle JASON (1988).
- Recovered military materials valued at over $4 million (1990).
- Conducted a science expedition to the East Pacific Rise south of Baja, CA using an experimental sonar to image hydrothermal vent plumes (1990).
- Participated in the Jason Project's 4th annual electronic field trip for young students across North America and Europe. This involved a collaborative effort with the remotely operated vehicle system JASON/MEDEA and an international team of scientists and engineers investigating the hydrothermal vent systems in the Guaymas Basin.

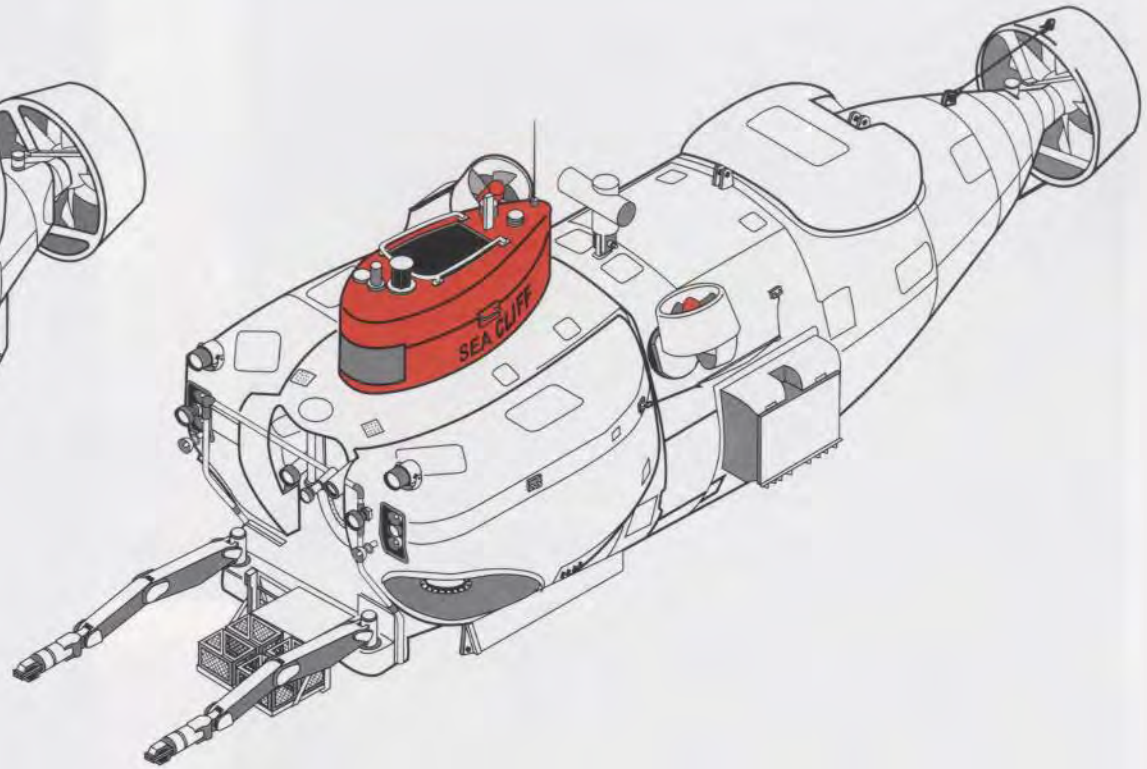
***Sea Cliff***

- Recovered a cargo door from United Airlines Flight 811 off the coast of Hawaii (1990).
- Conducted a video survey of dumping sites off the Farallon Islands near San Francisco (1991).
- Located the wreckage of the dirigible Makon lost 55 years ago off the coast of Monterey, California (1990).
- Conducted diving operations in support of recovery of an MK 50 torpedo and unused equipment on the Pacific Missile Range Facility (PMRF). More than $1,000,000 of Navy property was recovered in addition to repairing two hydroplane arrays on the Fleet Operational Readiness Accuracy Check Site (FOR ACS).
- Conducted a series of 14 dives in the Hawaiian operating area in support of the National Oceanic and Atmospheric Administration (NOAA) (1992).
- In the commemoration of the 50th anniversary of the Guadalcanal campaign, photographed for National Geographic numerous U.S., Japanese, and Australian warships sunk during various offshore battles (1992).
- Conducted scientific study of tube vents and worms off the coast of Oregon (1995).

# Missions

- **Oceanographic Research**
- **Geological Survey**
- **Search**
- **Object Recovery**




# Characteristics

## Turtle

| | | | |
|---|---|---|---|
| **Capacity:** | 3 people | **Descent Rate:** | 100 ft/min |
| **Length:** | 26 ft | **Ascent Rate:** | 100 ft/min |
| **Width:** | 10 ft | **Vehicle Frame:** | Aluminum |
| **Height:** | 13 ft | **Personnel Sphere:** | High-yield strength steel (HY-100) |
| **Weight:** | ~50,000 lb | | |
| **Operating Depth:** | 10,000 ft at 1 atm | **Viewports:** | 3 (forward, port, & starboard) |
| **Max Speed:** | 2.5 kn | **Skin:** | Glass-reinforced plastic |
| **Endurance*:** | 10 h (nominal) 18 h (extended) | | |

## Sea Cliff

| | | | |
|---|---|---|---|
| **Capacity:** | 3 people | **Descent Rate:** | 100 ft/min |
| **Length:** | 31.5 ft | **Ascent Rate:** | 100 ft/min |
| **Width:** | 10.5 ft | **Vehicle Frame:** | Titanium |
| **Height:** | 12 ft | **Personnel Sphere:** | Titanium |
| **Weight:** | ~55,000 lb | **Viewports:** | 3 (forward, port, & starboard) |
| **Operating Depth:** | 20,000 ft at 1 atm | **Skin:** | Glass-reinforced plastic |
| **Max Speed:** | 2.5 kn | | |
| **Endurance*:** | 10 h (nominal) 18 h (extended) | | |

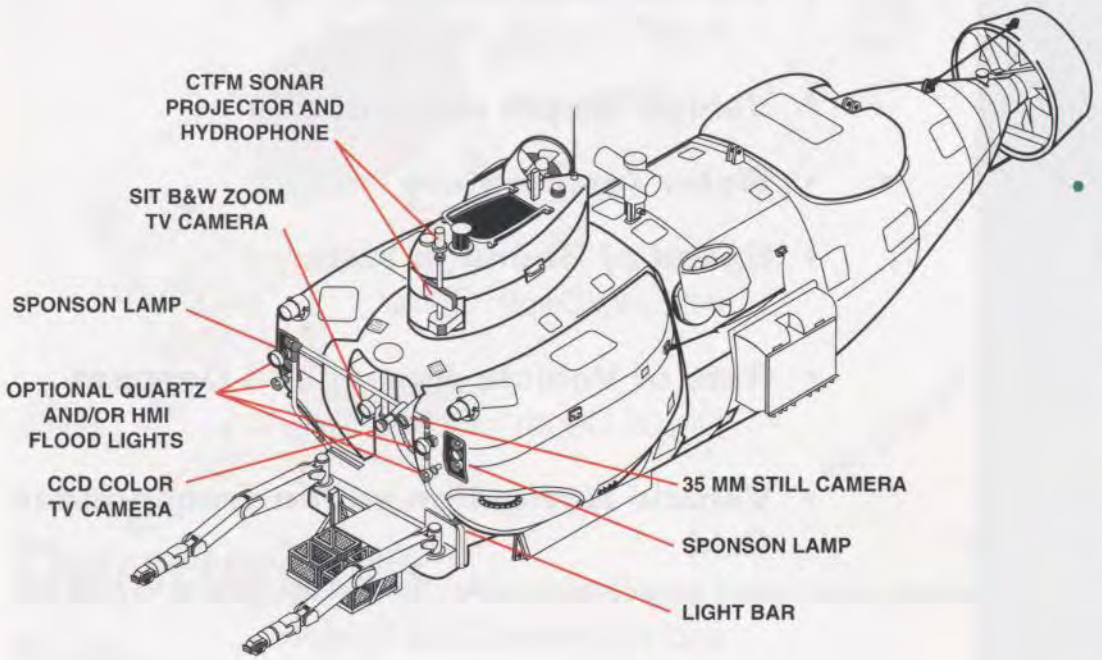
* Endurance is based on main battery capacity, not life support.

# Summary of Capabilities


## Navigation

- **Vehicle True Heading**
- **Vehicle Magnetic Heading**
  - KVH Magnetic Compass
- **Vehicle Depth and Altitude**
- **Water Temperature**
- **Speed of Sound in Water**
  - Altitude/Depth Sonar
- **Rate of Vehicle Ascent and Descent**
  - Digital Depth Indicator
- **Vehicle Navigation within Transponder Grid**
  - Long Baseline Acoustic Navigation System and Integrated Data System
- **Vehicle Locator**
  - Surface Identification Light
  - UHF/VHF Communication

# Summary of Capabilities




## Search

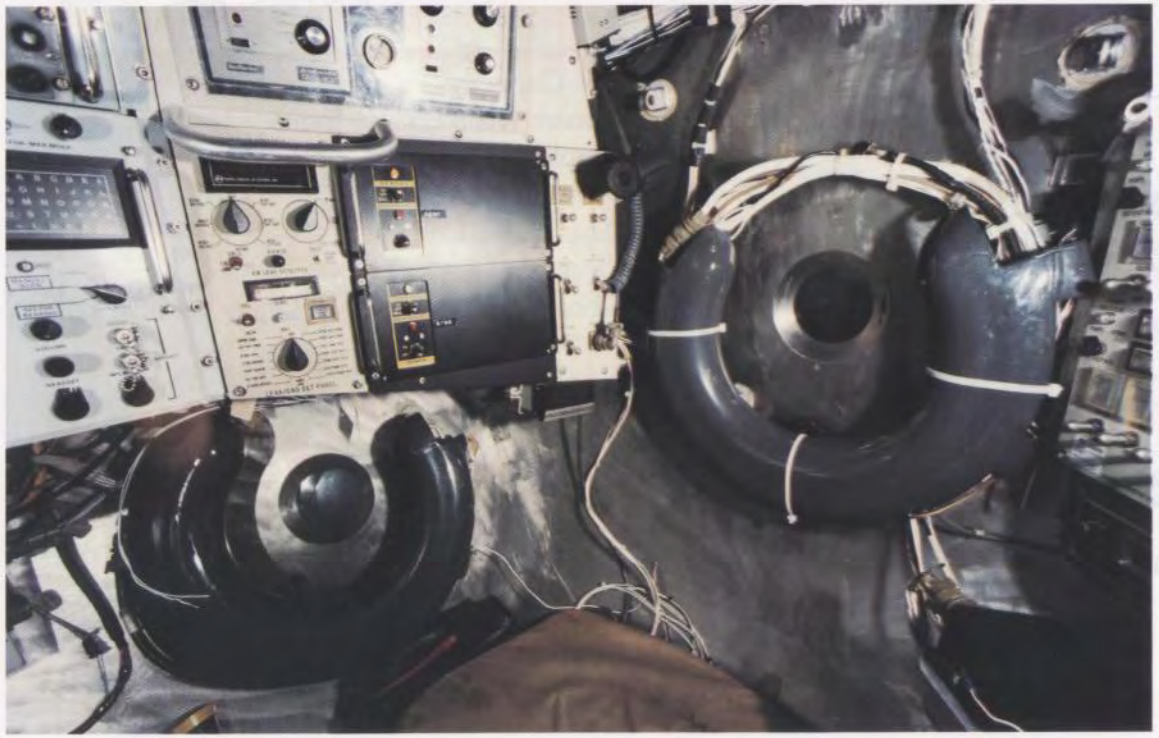
- **Search Sonar System**
  - Continuous-Transmission Frequency-Modulated (CTFM) Sonar
    - Range: 3 to 1500 yards in five range scales
    - Scan Width: 340°
    - Projector Beam Width: 15 ± 0.5°
    - Hydrophone Beam Width: 60 ± 1.5°

- **Vehicle Camera System**
  - Black & White Zoom TV Camera
  - Color TV Camera
    - Broadcast Quality 3-Chip CCD Color Camera
  - TV Camera Pan & Tilt Unit
    - Horizontal (Pan) Range: 340°
    - Vertical (Tilt) Range: 190°
  - 35-mm Still Camera
    - Film Capacity: 600 Frames (approx.)
  - Micro-Laser Scaling System*
  - Hi-8 Video Recorder*
  - Still Cameras and TV Cameras can be relocated to support mission-specific requirements

- **Outboard Lighting Capacity**
  - Two Sponson Mounted Metal Halide (HMI) Flood Lamps
  - Four Sponson Mounted Quartz Incandescent Flood Lamps
  - Light Bar Mounted
    - Eight HMI Flood Lamps
    - Six Incandescent Flood Lamps
    - Lamps can be relocated to support mission-specific lighting requirements

* Temporary modifications installed dependent on mission requirements.

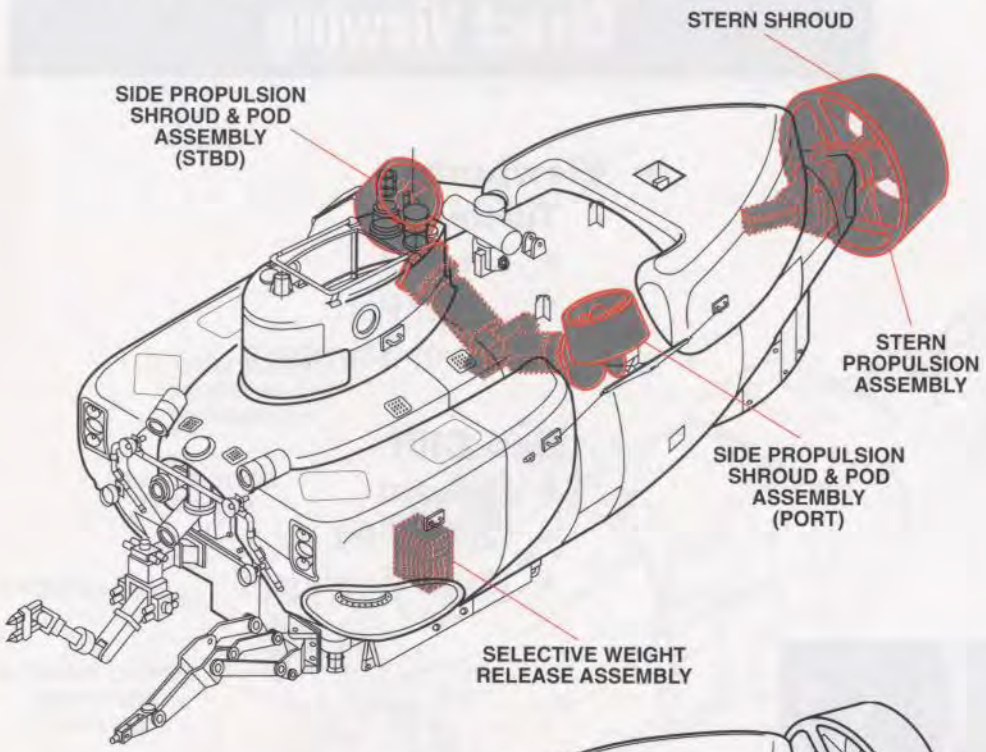
# Summary of Capabilities

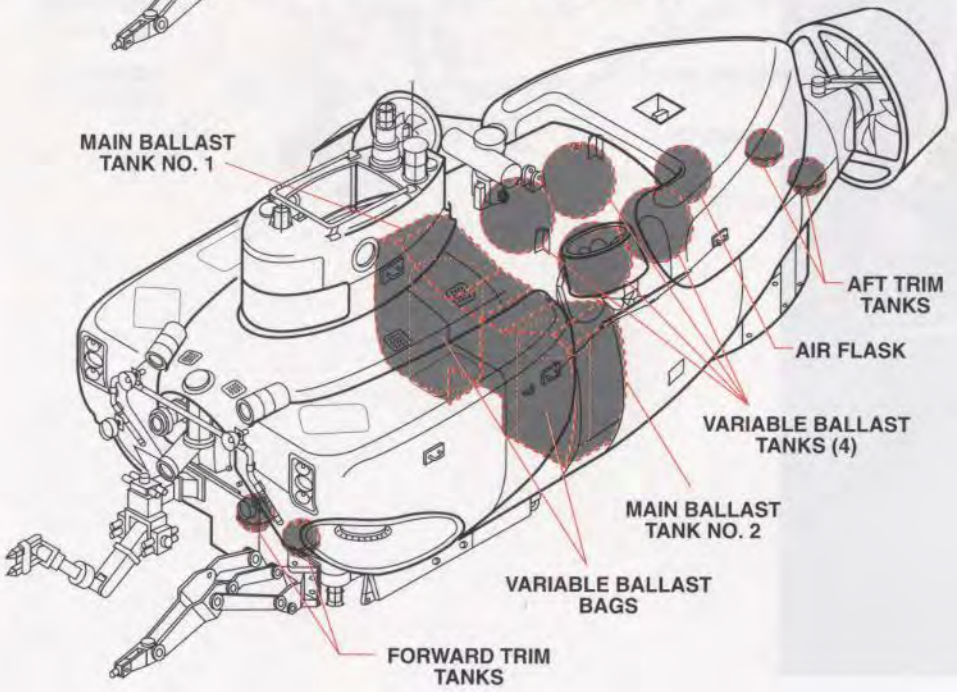


## Direct Viewing

- **Viewports**
  - **Turtle**
    - Forward
    - Lower Port
    - Lower Starboard
  - **Sea Cliff**
    - Forward
    - Lower Port
    - Lower Starboard

# Summary of Capabilities



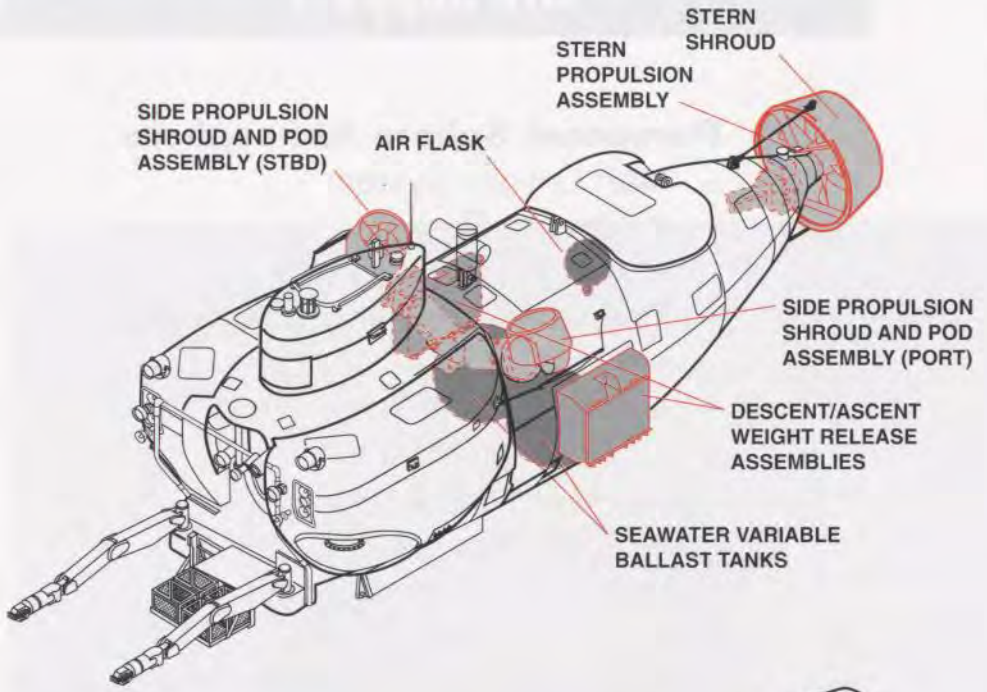



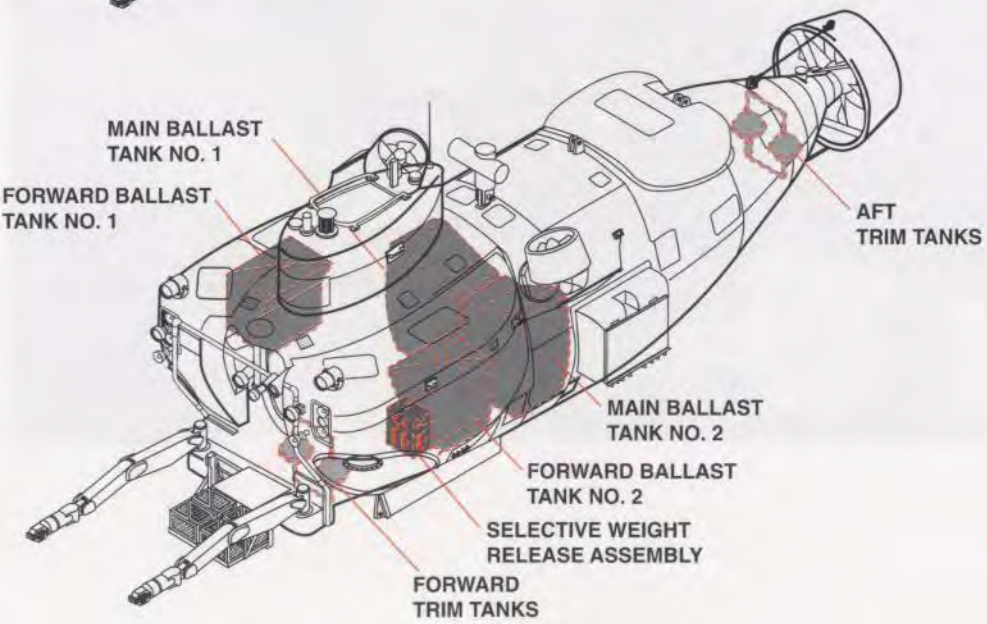

## Ship Control - Turtle

- **Steering and Propulsion**
  - Single Stern Propeller and Shroud
    - Forward and Aft Vehicle Propulsion
    - Port and Starboard Vehicle Maneuvering
    - Hydraulic Motor Controlled
    - Trainable 45° Port and Starboard
  - Port and Starboard Side Propulsion Units
    - Electric Motor Controlled
    - Trainable through 360°
    - Reversible
    - Variable Speed

- **Buoyancy Control**
  - Air Flask
    - 3000 psi
    - 1.5 cubic ft. Capacity
  - Port and Starboard Main Ballast Tanks
    - 3159-lb Displacement (max.)
  - Forward and Aft Trim Tanks
    - Weight Distribution Control
    - 115-psi Operating Pressure
  - Port and Starboard Variable Ballast Tanks/Variable Ballast Bladders
    - 745-lb Capacity
  - Selective Weight Release System
    - Steel Plates (30)
      Weight: 18.6 lb in Air
      16.2 lb in Water

# Summary of Capabilities




## Ship Control - Sea Cliff

- **Steering and Propulsion**
  - Single Stern Propeller and Shroud
    - Forward and Aft Vehicle Propulsion
    - Port and Starboard Vehicle Maneuvering
    - Hydraulic Motor Controlled
    - Trainable 45° Port and Starboard
  - Port and Starboard Side Propulsion Units
    - Electric Motor Controlled
    - Trainable through 360°
    - Reversible
    - Variable Speed

- **Buoyancy Control**
  - Air Flask
    - 3000 psi
    - 1.5 cubic ft. Capacity
  - Port and Starboard Main Ballast Tanks
    - 3264-lb Displacement
  - Port and Starboard Forward Ballast Tanks
    - 1945-lb Displacement
  - Forward and Aft Trim Tanks
    - Weight Distribution Control
  - Port and Starboard Seawater Variable Ballast Tanks
    - 1000-lb Capacity
  - Descent/Ascent Weight Release System
    - Descent Weight: 1200 lb
    - Ascent Weight: 800 lb
  - Selective Weight Release System
    - Steel Plates (30)

      Weight Per Plate: 18.6 lb in Air
      16.2 lb in Water

# Summary of Capabilities

## Life Support

- **Personnel Sphere Atmosphere**
  - Main Oxygen System
    - Oxygen Flasks
    - Oxygen Control Panel
  - Emergency Breathing System (EBS)
    - Oxygen Flask
    - EBS Control Panel
    - Breathing Masks
  - Air Purification System
    - LiOH Filter Canister
    - Charcoal Filter Canister
    - Blower Fans
  - Life Support lasts approximately 64 hours

- **Monitoring System**
  - $O_2$ Analyzers
  - $Co_2$ Analyzers
  - $O_2$ Pressure Indicator Panel
  - Temperature and Humidity Indicator
  - Cabin Pressure Gage
  - Portable $CO_2$ and $O_2$ Analyzer

# Summary of Capabilities

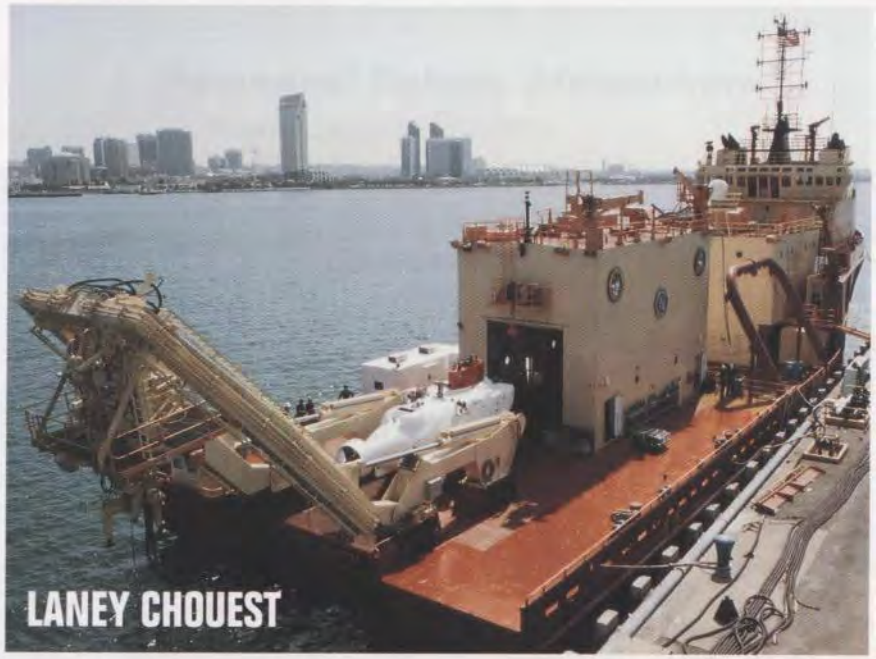
## Communications

- **Radio System**
  - Line-of-Sight Two-Way Audio Communication
- **Underwater Telephone**
  - Chief Means of Communication by Code or Voice when Submerged
- **Sound-Powered Telephone**
  - Launch and Recovery Communications Between Topside Swimmers and Vehicle Crew
- **Emergency Breathing System (EBS) Communication System**
  - Emergency Communications when Wearing Emergency Breathing Masks

# Summary of Capabilities

- **Laney Chouest**
  - Navigational Equipment
    - Integrated Navigation System
    - Peripherals Inputs
      - GPS and Transit Satellites
      - Racal Micro Fix
      - Loran C
    - Ultra Short Baseline Navigation System
    - Long Baseline Navigation System
  - Other Electronic Systems
    - Underwater Telephones (2)
      - AN-UQC Compatible
    - VHF Radios (3)
    - 1 KW Single Side Base Radio
      - Telex Capability
    - Satcom
    - Sea Beam Swath Bathymeter Sonar
      - 25,000 ft
    - Precision Depth Digitizer
    - EM Speed Log
  - A-Frames
    - Caley Hydraulic, Stern Mounted
      - 87,000 lb Design Load
      - NAVSEA P-9290 Certified
      - Tension and Pendulation Compensated

## Handling




  - A-Frames (Cont.)
    - Retractable, Side Mounted
      - 20,000 lb Load
      - 18,000 lb Line Pull Salvage Wired
  - Accommodations
    - 14 Crew
    - 40 Additional
    - 2-man Ship Hospital
  - Endurance
    - 90 days at Sea
    - 6000 NM @ 12 Knots

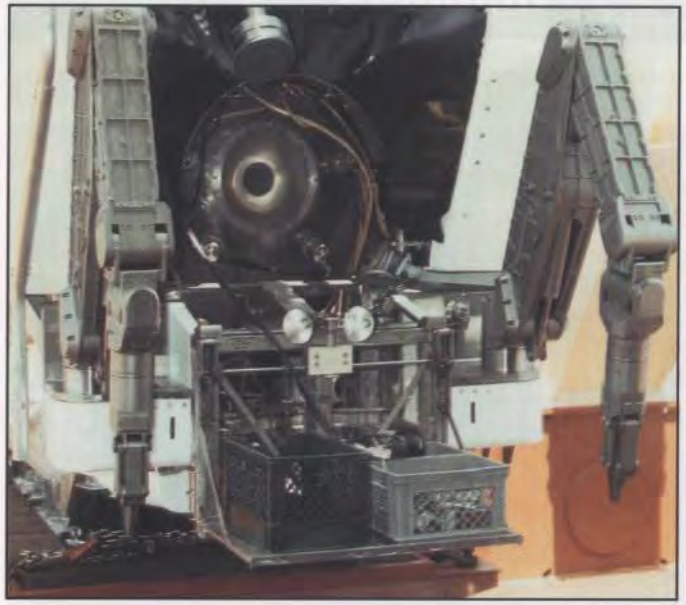
# Summary of Capabilities

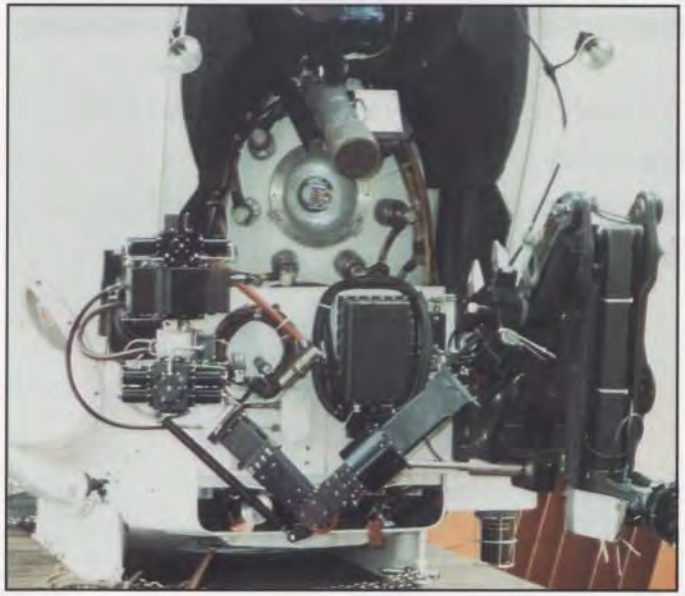
- **Dolores Chouest**
  - Navigational Equipment
    - Integrated Navigation System
    - Peripherals Inputs
      - GPS
      - Loran C
      - Satellite Navigation
    - Ultra Short Baseline Navigation System
    - Long Baseline Navigation System
  - Other Electronic Systems
    - Underwater Telephones (2)
    - Sirnrad Fathometer
      - 30,000 ft
    - VHF Radios (2)
    - Single Side Base Radio
    - Satcom
    - Emerson Uninterruptible Power Systems (2)
  - Lift System
    - Elevator Open-Well
      - 103,000 lb Lifting Capability
      - NAVSEA P-9290 Certified
  - Accommodations
    - 7 Crew
    - 35 Additional
    - 2-Man Ship Hospital

## Handling


  - Endurance
    - 90 days at Sea
    - 6000 NM @ 12 Knots

# Summary of Capabilities





## Work

**SEACLIFF**

- **Coarse Work**
  - Port Manipulator Arm
    - Hand and Arm Motion
      - Gripping
      - Drilling
      - Cutting
- **Dexterous Work**
  - Starboard Force-Sensitive Manipulator Arm
    - Wrist and Arm Motion with Dexterity
- **Small Item Collection**
  - Sample Basket
- **Attachable Tools**

**TURTLE**

- **Coarse Work**
  - Starboard Manipulator Arm
    - Hand and Arm Motion with Force
      - Gripping
      - Drilling
      - Cutting
- **Dexterous Work**
  - Port Force-Sensitive Manipulator Arm
    - Delicate Finger/Wrist Manipulation
- **Small Item Collection**
  - Sample Basket
- **Attachable Tools**

# Vehicle Description

## General Description

Turtle (DSV-3) and Sea Cliff (DSV-4) are untethered three-man submersibles capable of diving to 10,000 feet and 20,000 feet respectively. They are ideally suited for use in oceanographic and geological research, exploration, search and recovery, and salvage. The vehicles are powered by silver-zinc batteries that are charged by their respective support ships which transport them to their work areas. The batteries supply all of the power for the electrical and propulsion systems.

Each vehicle is maneuvered and propelled by a single hydraulically driven rear propeller and two side propellers that are trainable in 360 degrees. Buoyancy is controlled by a combination of ballast tanks and droppable weights.

Navigation and depth measuring systems guide the pilot to within a few feet of the bottom where banks of lights attached to the vehicle light up the dive site area. The black and white and color tv cameras and a 35mm camera then become effective in close in search, navigation, and documentation. Attached to each vehicle are two manipulator arms with specialized tools that are interchangeable at mission depths.

While submerged, communication is maintained with the support ship by underwater telephone. Each vehicle is equipped with an Integrated Data System which is a computerized system that provides an operator interface to and gathers data from the Long Baseline (LBL) Navigation System which is fundamental in a successful deep diving operation. Additionally, a Pisces video annotation system superimposes vehicle sensor input (depth, altitude, time, heading, temperature, sound velocity and position) on Hi-8 video tape for post-mission evaluation and archiving.

## General Description

A pressure-proof sphere houses the crew. Viewports in the sphere permit direct observation of the area. Their life support systems consist of a Main Oxygen System, an Air Purification System, and an Emergency Breathing System. The Main Oxygen System replenishes the oxygen for about 64 hours for a three-person crew and their Air Purification System removes the contaminating carbon dioxide and odors. The Emergency Breathing System provides about 32 hours of backup oxygen for 3 people. This emergency system would be used only if the atmosphere in the crew sphere became contaminated or the Main Oxygen System failed.

Turtle and Sea Cliff have several unique emergency features that enable the crew to safely return to the surface should the vehicle become trapped or damaged while submerged, including the ability to jettison selective weights, the two manipulators, and both batteries.

Mission endurance, specified in the table below, is dependent on the main battery capacity.

| | Length | Width | Height | Weight | Operating Depth | Max Speed | Endurance | Descent Rate | Ascent Rate | Vehicle Frame | Personnel Sphere | View Ports | Skin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TURTLE | 26 ft | 10 ft | 10 ft | ~ 50,000 lb | 10,000 ft @ 1 atm | 2.5 kn | 10 h (nom.) 18 h (extnd.) | 100 ft/min | 100 ft/min | Aluminum | High-Yield Strength Steel (HY 100) | 3 (forward, port & stbd) | Glass-Reinforced Plastic |
| SEA CLIFF | 31.5 ft | 10.5 ft | 12 ft | ~ 55,000 lb | 20,000 ft @ 1 atm | 2.5 kn | 10 h (nom.) 18 h (extnd.) | 100 ft/min | 100 ft/min | Titanium | Titanium | 3 (forward, port, & stbd) | Glass-Reinforced Plastic |

## Navigation

The primary function of the vehicle navigation system is to determine the position of the vehicle throughout its operation. The vehicle is required to maneuver from the ocean surface to within tens of feet of a target on the ocean floor. It therefore requires precise positioning data of a far greater accuracy than is used in normal sea navigation.

The vehicle navigation system has the Gyro Compass and the KVH magnetic Compass from which it can obtain heading data. Depth below the surface and altitude above bottom is supplied by the Altitude/Depth Sonar, and rate of ascent or descent is provided by the Digital Depth Indicator. Additional depth information is supplied by a Mechanical Depth Gauge. For navigating within a transponder field, the Long Baseline (LBL) Acoustical Navigation System is necessary.

Additionally, the navigation system includes a computerized Integrated Data System, which manages navigation within a transponder field and provides a navigation plot display showing vehicle position in relation to the field.

The vehicle is capable of independent navigation within a transponder field, but deep dive operations are done in conjunction with a surface support ship in which the ship concurrently tracks the vehicle as it navigates within the transponder field.

Surface ship support requires that both the vehicle and ship share the same navigation data, waypoint, transponder, and sound velocity profile data. A typical deep dive operation must begin with predive planning between the support ship and vehicle personnel. The transponder field is then established by the support ship dropping transponders to the bottom approximately two miles apart. Precise positions of each of the transponders in the field are then determined by the support ship calibration procedure.

If a transponder field is not used, the DSV support ship tracks the DSV using ultra short baseline tracking.

## Ship Control

Two systems are concerned with vehicle control: Steering and Propulsion and Buoyancy.

Steering and propulsion are provided by a single, shrouded stern propeller assembly and port and starboard side propulsion units.

Forward and aft vehicle motion and port and starboard maneuvering are provided by the hydraulically-driven shrouded stern propeller, which is trainable 45° to starboard or to port.

The side propulsion units provide vehicle maneuvering. The units are trainable through 360°. Both units move simultaneously in the same direction and since the electrically-driven propellers are individually reversible, roll motion can be obtained. These two systems provide all aspects of vehicle maneuvering and attitude except trim, which is provided by the Trim System.

Vehicle buoyancy is controlled by a combination of filling or emptying ballast tanks and dropping preloaded weights.

Prior to a diving operation, weights are loaded into weight-dropping fixtures on the vehicle, and an air flask is charged from the support ship source to about 3000 psi. This flask supplies the air for blowing water from the main ballast system.

At deep diving levels, buoyancy is controlled by a combination of releasing some of the preloaded weights and adjusting the amount of ballast in the Variable Ballast System with a powered pump. The variable ballast is used to change either the vehicle displacement for the Turtle or the vehicle weight for the Sea Cliff.

The Trim System employs oil hydraulics to compensate for weight distribution. By transferal between the forward and aft trim tanks, vehicle trim caused by weight changes can be corrected.

# Vehicle Description

## Search

Continuous Transmission Frequency Modulated (CTFM) sonar provides the vehicle with the information to effect underwater research, exploration, and salvage. The CTFM can also be used to supplement the navigation equipment by providing transponder range and bearing or a pinger marker bearing within a transponder field or to a marked target. The CTFM operates in three modes: sonar mode, transponder mode, and marker mode.

Sonar mode provides both bearing and range. The system operates by repetitively varying its transmitted signal in a sawtooth manner from high frequency to low frequency. The difference between the transmitted frequency and the return from an acoustically reflective object is used to determine object range. Range is selectable from 15 to a maximum of 1500 yards.

Transponder mode can be used to locate items in a debris field and provide the range and bearing of each piece of debris relative to the vehicle. A transponder is attached to specific pieces of debris within a given debris field. Each transponder is preset to a unique frequency within the CTFM transmit frequency bandpass. This permits the vehicle to locate each piece of debris by the unique transmit frequency of its attached transponder. By further signal processing, the CTFM is able to determine range of the transponder.

When a marker beacon is used to mark a specific piece of debris in a debris field, only bearing information is available to the vehicle.

Sonar searching requires scanning, which is done in automatic sector bearing mode, automatic scanning mode, or manual scanning mode.

In automatic sector bearing mode, a 60° sector is scanned. The sector is manually centered on a target bearing, and a sector can be set to scan any area from 220° to 140° relative.

## Search

The automatic scanning mode provides selection of one of three scan widths: narrow (60°), medium (120°), and wide (340°). A target is normally acquired in wide scan mode and successively narrowed from wide through medium to narrow scan.

In manual scanning mode, the vehicle 2.5° sonar beam is positioned clockwise (cw) or counterclockwise (ccw) and stopped at any bearing from 190° to 170° relative.

Operating independently, but complementing the CTFM Sonar System, are a 3-chip CCD color, zoom camera, 1-chip CCD color camera, and a 35-mm still camera. The video and still cameras are housed in watertight casings. The video cameras are mounted on a Pan and Tilt Unit attached to the exterior bow of the vehicle. The positioning of the outboard lighting, strobes, still camera and video cameras can be changed to support mission specific requirements.

The Still Camera System consists of a Control Panel and a 35-mm Camera in conjunction with two Underwater Electronic Strobe lights. One hundred feet of film provide approximately 800 exposures. The Still Camera System is used primarily near the ocean bottom in clear water to take still photographs as a permanent record of observations made on the mission.

All lighting is provided by the vehicle Outboard Lighting System since sunlight does not penetrate to working depths. Up to 14 lamps (8 metal halide flood lamps and 6 quartz incandescent) may be installed on the vehicle.

# Vehicle Description

## Communications

The Communications System provides the means for the crew to communicate with surface personnel. During all phases of a dive mission, communications are maintained at all times between the DSV and the surface support ship.

The Communications System comprises a Radio System, an Underwater Telephone, a Sound-Powered Telephone, and an Emergency Breathing System (EBS) Communications System.

The Radio System is used for surface communication with the support ship and any other surface vessels participating in the mission. Prior to a dive, the Radio System is used by the crew during launch of the vehicle from the support ship and during predive checks and procedures. After the vehicle has surfaced, the Radio System is used for recovery operations.

The Underwater Telephone can transmit and receive both voice and coded sound transmissions while the DSV is submerged. The unit is compatible with an AN/UQC-1 series underwater telephone. While submerged, the crew routinely uses the Underwater Telephone to report the condition of the vehicle, to request permission to dive or surface, and to report or receive other operational data.

Topside swimmers and the crew inside the sphere use the Sound-Powered Telephone during launch and recovery of the DSV. The Sound-Powered Telephone consists of two handsets, one for the crew and one for the swimmers. The topside swimmers are connected to the crew through a pressure-proof telephone jack on the vehicle Sail.

The EBS Communications System is used during an emergency situation requiring the crew of the DSV to wear emergency breathing masks. An EBS Communications Panel enables the connection microphones located within the three masks. Controls on the Communications Panel allow voice transmission by the Radio System, the Underwater Telephone, or the Sound-Powered Telephone. Received voice information is emitted from a loudspeaker in the EBS Communications Panel.

## Work and Object Recovery

The DSV has two manipulator arms that enable grasping, manipulating, working on, and recovering objects on the ocean floor. The Manipulator System consists of internal controls; two outboard, hydraulically-driven arms, and special tools that are attachable or detachable at mission depth.

The internal controls for manipulating the external arms are miniature arms that are manipulated by the left and right arms and hands of an operator. The external hydraulically-driven arms emulate the motions of the miniature arms. One of the arm systems has a force-feedback feature that provides the operator with feel for how much pressure is being applied to the object being manipulated. This feature is particularly useful in handling delicate objects.

Small objects to be carried to the surface by DSV are placed in a sample basket.

When objects are too large or too heavy for the DSV alone, the support ship provides the necessary lifting apparatus to raise the object to the surface. In this situation, the DSV provides the services of locating the object, securing the recovery attachment tools, and attaching the required lifting lines.