

## **WHP Ref. No.: AR11/ACM25/ACM26**

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### Cruise Plan for The Subduction Experiment

Chief Scientist: Robert A. Weller, Woods Hole Oceanographic Inst.  
Cruise: Oceanus 250 Legs 1 and 2  
Dates: January 25, 1992 to February 25, 1992  
Ship: RV Oceanus

### **Overview**

R/V Oceanus cruise number 250, Leg 1 departed Woods Hole, Massachusetts on 25 January 1992 to recover and redeploy five surface moorings as part of the Office of Naval Research (ONR) funded ASTEX and Subduction Experiments. This cruise involved personnel and equipment from both the Woods Hole Oceanographic Institution (WHOI) and Scripps Institution of Oceanography (SIO). Table 1 lists the Subduction I mooring deployment and recovery information. (The first setting of moorings were deployed in June/July 1991 during Oceanus cruise number 240. A separate cruise summary report is available.) Table 2 lists the Subduction II mooring deployment information. During Oceanus cruise 250 the Subduction I moorings were replaced with five new surface moorings that are intended to stay on station for a period of eight months. A total of 102 recording instruments were deployed on the five Subduction II moorings. There are 9 meteorological packages, 34 current meters, 58 temperature data loggers and one Acoustic Doppler Current Profiler. The schedule as shown below is to replace the moorings in October 1992 and then recover them in June 1993. While transiting between mooring sites hourly XBTs and meteorological observations were taken. This report describes the work that was accomplished during Oceanus 250 Legs 1 and 2, including summaries of the instrumentation that was recovered and deployed, and underway activities, i.e. XBT sections, meteorological observations and ALACE launches. A brief chronology of the cruise events is included.

**Table 1: Subduction I Mooring Deployment and Recovery Positions**

Buoy	Mooring #	Deployment Time (UTC)	Recovery Time	Position (GPS)
NE	914	18 Jun 1991 1642	14 Feb 1992 2315	33 00.07N 21 59.75W
C	915	23 Jun 1991 0026	11 Feb 1992 1120	25 31.90N 28 59.75W
SW	916	25 Jun 1991 1312	02 Feb 1992 0727 *04 Feb 1992 1844	18 00.03N 33 59.96W
SE	917	29 Jun 1991 0137	20 Oct 1991 0000 **08 Feb 1992 0843	18 00.13N 22 00.00W
NW	918	03 Jul 1991 1323	15 Sep 1991 2035 ***23 Feb 1992 1022	32 54.61N 33 53.50W

\* SW Mooring broke free on 3 Nov 1991. Top 110m recovered 2 Feb 1992, remainder of mooring recovered 4 Feb 1992.

\*\* SE Mooring broke free on 10 Oct 1991. Top 50m recovered 30 Oct 1991, remainder of mooring recovered 8 Feb 1992.

\*\*\* NW Mooring broke free on 3 Aug 1991. Top 400m recovered 15 Sep 1991, remainder of mooring recovered 23 Feb 1992.

**Table 2: Subduction II Mooring Deployment Positions**

Buoy	Mooring #	Deployment Time (UTC)	Position (GPS)
SW	924	05 Feb 1992 1318	17 59.93N 34 00.65W
SE	925	09 Feb 1992 0244	17 59.72N 22 00.29W
C	926	12 Feb 1992 1915	25 31.95N 28.57.23W
NE	927	20 Feb 1992 1547	33 01.98N 22 00.27W
NW	928	23 Feb 1992 2328	32 54.42N 33 53.35W

## Scientific Goals

Subduction is the mechanism by which water masses formed in the mixed layer and near surface layer of the ocean through air-sea interactions find their way into the upper thermocline. The basic idea that fluid in the ocean's interior originates at the sea surface is an old one, dating from Iselin and Montgomery in the late 1930's, but only recently have simple models begun to provide a framework for a dynamical understanding of the processes involved in subduction. In essence, the study of the subduction processes and mechanisms involves an understanding of the complete three-dimensional circulation in the upper ocean and the coupling of the mixed layer to the interior of the ocean. The work proposed under the auspices of the Subduction ARI will attempt to understand subduction and its underlying mechanisms through a combination of Eulerian and Lagrangian measurements of velocity, measurements of the tracer distributions and hydrographic properties and modelling. Measurements will be made on synoptic scales in frontal regions as well as on larger scales appropriate to the structure of the quasi-steady wind-driven and thermohaline circulation. The large scale structure of the surface wind and thermal forcing and the upper ocean response will be observed by a moored array of surface meteorological packages, current meters and acoustic doppler profilers. The meteorological data collection is supported jointly by the Subduction and Atlantic Stratocumulus Transition Experiment (ASTEX) programs.

## Cruise Participants

Robert A. Weller, Chief Scientist	(WHOI)
Richard P. Trask	(WHOI Research Specialist)
William Ostrom	(WHOI Senior Research Assistant)
Bryan Way	(WHOI Engineering Assistant)
Paul Bouchard	(WHOI Engineering Assistant)
Neil McPhee	(WHOI Engineering Assistant)
Nancy Pennington	(WHOI Senior Research Assistant)
Nan Galbraith	(WHOI Information Systems Associate)
Lloyd Regier	(SIO Design Engineer)
Glenn Pezolli	(SIO Development Technician)

## **Underway Measurements**

From the time the ship left Woods Hole meteorological data from a shipboard IMET system mounted on the bow mast were recorded on optical disk. The IMET parameters included, wind speed, wind direction, air temperature, seawater temperature, relative humidity, precipitation, shortwave radiation, and barometric pressure. One minute averages were recorded. In addition to the data being collected by the IMET sensors, an independent set of hourly meteorological observations were collected and recorded by hand. These included wet and dry bulb temperatures (using a Bendix psychrometer), sea surface temperature (using a bucket thermometer), visual cloud cover estimates, and wind speed, wind direction, and barometric pressure from the ship's sensors, as well as current speed and direction.

A total of 11 SIO Autonomous Lagrangian Circulation Explorers were deployed during OC-250.

Three hundred XBTs were deployed during OC-250. The T-7 probes were purchased from Spartan of Canada. XBT data was logged on a NEC APC IV which has a Spartan data acquisition microprocessor card installed. The digital data is simultaneously logged in memory and plotted on the screen. In all there were very few probes that failed to produce reasonable data.

## **Cruise Track and Mooring Stations**

Oceanus Cruise Number 250 departed Woods Hole on Saturday, January 25, 1992 at 11 :30 UTC. The purpose of the cruise was to recover and redeploy the array of five surface moorings deployed in June/July 1991 as part of the ONR funded ASTEX and Subduction Experiment. This is the second of four scheduled mooring cruises planned for this experiment.

## **Southwest Mooring**

The Oceanus arrived at the drifting toroid buoy at 0515 UTC on Sunday, February 2, 1992 at position 15° 13.09' N, 44° 47.48' W. The buoy's marine lantern was first sighted at a distance of approximately 5 miles . After a brief opportunity for fishing, the buoy and parted mooring were brought aboard. An XBT (#44) was taken while along side the buoy prior to recovery. A total of 6 SIO Vector Measuring Current Meters (VMCMs at 10m, 30m, 50m, 70m, 90m, and 110m), 2 WHOI Brancker temperature recorders (80m,100m) and 1

SIO Brancker temperature recorder (60m) were recovered. The last item to be recovered was the 110 meter current meter.

With the upper part of the mooring aboard the Oceanus got underway at 07:30 UTC for the original Southwest mooring site at 18° 00.03'N, 33° 59.96'W. The ship arrived at the site on 4 February 1992 at 1152 UTC. Upon arriving at the site the location of the anchor was checked by ranging on the acoustic release from approximately 2 miles away. The range obtained confirmed the original anchor position obtained during the setting cruise in June/July 91. The ship was then positioned one-half mile down wind of the anchor position and the release was fired at 1235 UTC. Recovery of the bottom of the mooring was initiated at 1430 UTC. By 1843 UTC the entire parted mooring was on board. The entire mooring was therefore recovered.

With the mooring aboard attention was turned to preparing for redeployment. The deck was cleared and off spooling the wire on the winch was begun. Simultaneously three acoustic releases were wire tested using the CTD winch. Two SIO releases and one WHOI release were tested to a depth of 1000 meters. These operations were followed by rewinding the wire and nylon for the next mooring. While the winding was taking place the ship was positioned 7 miles to the south southwest. This was downwind of the target and slightly south to compensate for a small northerly current.

The deployment of the upper instrumentation (10 and 30m VMCMs) and buoy (in that order) went quite smoothly. With the buoy in the water the ship initially had just enough way on to maintain steerage. As more instrumentation and wire were deployed the speed through the water was increased to .5 knot and then to 1.0 knot. Mid way through the deployment the mooring was towed while 1800 meters of nylon and 500 meters of polypropylene were wound onto the winch. The plan was to continue to tow until the water depth was within 40 meters of the planned depth. Unfortunately during our approach the water was several hundred meters shallower than what was needed. Towing had to continue at a slow pace until the design depth was obtained. As the ship approached the original target the water depth increased for a sufficient distance to permit the deployment of the mooring. The anchor was deployed at 1318 UTC on 5 February 1992.

Following the anchor deployment the ship was repositioned to watch the Toroid ride through the water as the anchor went to the bottom. The toroid behaved considerably different during this deployment than in previous deployments in June/July 91. The speed through the water was much less (.7 kt), the buoy was not heeled over as much.

Two hours of intense meteorological observations were made as the buoy settled into position. Meteorological observations were obtained by the hand held and bridge sensors and logged with the IMET data every 15 minutes. At the same time the VAWR Argos transmissions were received directly from the buoy via the Telonics receiver aboard ship. These data were compared at the end of the two hour period. All observations compared well. These observations are used as a check of instrument performance and as a final calibration point before leaving the site. An acoustic release survey followed. The ship got underway for the Southeast mooring location (18° N and 22° W) at 1750 UTC 5 February 1992. The meteorological watch was resumed and hourly XBTs were started at 1900 UTC.

### **Southeast Mooring**

The R/V Oceanus arrived at the Southeast site at 0507 UTC on 8 Feb 1992. This mooring was originally set on 29 June 1991 and had parted on 10 October 1991. Since all that remained were the subsurface components with no recovery aids such as a flashing light we waited until daylight to release it.

While we waited a three point acoustic release survey was conducted. The results of that survey showed that the release was within 150 meters of the position determined when the mooring was set. Also during the wait for daylight time was spent determining the set and drift of the ship which would aid in the deployment.

The acoustic release was fired at 0853 UTC 8 February 1992 and the mooring was sighted at 0936. Recovery was initiated at the release end of the mooring and proceeded very smoothly. The entire mooring was on board by 1155 UTC.

The deck was cleared, glass balls transferred, and the discus buoy to be deployed was moved into deployment position. A test lowering of three acoustic releases followed along with the off spooling of the recovered mooring and the rewinding of the new mooring

Deployment of the Southeast mooring began at 2224 UTC on 8 February 1992. The ship was positioned 4 miles to the southwest of the target. This starting position was downwind and slightly to the north to compensate for a southerly drift experienced earlier. The deployment went along quite smoothly. Since the bottom was very flat and exact positioning was not important the deployment proceeded right through to anchor drop without any towing aside from that which was needed to wind the remainder of the mooring onto the winch. The anchor was deployed at 0244 UTC on 9 February 1992. Following the deployment, four hours were spent taking meteorological observations every 15 minutes while standing by the surface buoy. An acoustic release survey was then conducted. At the conclusion of the release survey the ship got underway for the Central mooring site.

### **Central Mooring**

The R/V Oceanus arrived at the Central mooring site at 1100 UTC on 11 February 1992. At a distance of approximately 1.5 miles an acoustic range to the release was taken to ascertain whether the anchor was in the same position as when it was deployed. The range obtained confirmed the original anchor position. The ship then got into position to make an approach for recovery. With the buoy just off the bow of the ship the release commands were sent and confirmation of release received. The ship then moved in for recovery. The buoy appeared in good condition and came aboard without any damage. There was a minimal amount of growth on the buoy indicating the anti fouling paint worked well during the eight months it was in the water. On some sections of the hull the paint had worn away and it is unclear whether the same application of paint would work for a much longer deployment. The same was noticed with the VMCMs that were recovered. All the VMCMs appeared in good condition.

The mooring was off spooled and the new mooring components were wound onto the winch beginning with the wire to nylon shot. The buoy bridle and bridle mounted instruments were given a coat of anti-fouling paint. At the completion of the preparatory work a decision was made to rest for the remainder of the evening and begin the deployment after breakfast the following day.

The deployment of the second setting of the Central mooring began at 1037 UTC on 12 February 1992. The ship was positioned 5 miles downwind (east-southeast of the site) and proceeded at an average speed of about .6 knots over the bottom. After the wire to nylon shot was deployed it was necessary to tow the mooring for about 2 hours while the remainder of the mooring was wound onto the winch. The last cluster of balls were deployed along with the release and the mooring was towed for about 30 minutes until the appropriate water depth was obtained. The anchor was deployed at 1915 UTC, 12 February 92. Following the deployment an acoustic release survey was conducted. The ship then returned to within .25 miles of the surface buoy. Meteorological observations were made every 15 minutes until 0100 UTC 13 February 92 at which time the Oceanus got underway for the Northeast mooring. Hourly meteorological observations were resumed and hourly XBTs were started at 0200 UTC.

### **Northeast Mooring**

The ship arrived at the Northeast mooring at 2253 UTC on 14 February 92 . At a distance of approximately 1.5 miles an acoustic range to the release was taken to ascertain whether the anchor was in the same position as when it was deployed. The range obtained confirmed the original anchor position. The ship then got into position to make an approach for recovery. With the buoy just off the bow of the ship the release commands were sent. The ship then moved in for recovery. The buoy was brought aboard without any problems.

There were considerably more goose neck barnacles on the underside of the Northeast buoy than was observed on the Central buoy and the 10 meter VMCM also had quite a few growing on it as well. The VMCMs at 10 and 30 meters and the test sting at 20 meters had the majority of growth.

Following the recovery of the Northeast mooring the R/V Oceanus got underway for Madiera. The ship arrived in Funchal, Madiera at 0800Z on 16 February 92. Work immediately began to turnaround the two recovered buoys and instrumentation for deployment on the Northeast and Northwest moorings. The upper part of the Northeast mooring was wound onto the winch. The remaining reels were secured on deck. In all there were three full days of work getting everything ready for the second leg.



The Oceanus departed Madiera at 0800 UTC on 19 February 1992 enroute to the Northeast mooring. The ship arrived at the Northeast site at 0600 UTC on 20 February 92. As the ship approached the site a brief depth survey was conducted. While on location the set and drift of the ship was established to determine the start position for the mooring work. While steaming into the wind (northeast) at approximately 1 knot the ship was set to the northwest. A start position four miles to the southeast of the target was decided upon.

The deployment commenced at 0915 UTC and proceeded very smoothly. Since the bottom was very flat and it was not necessary to hit any particular target the mooring anchor was deployed as soon as it was prepared. The anchor was deployed at 1547 UTC on 20 February 1992. After the mooring had settled out an acoustic release survey was conducted. Following the acoustic survey, meteorological observations were taken every 15 minutes for four hours while the ship was within .25 miles of the surface buoy. The Oceanus then got underway for the Northwest buoy at 2152 UTC on 20 February 1992. Hourly XBTs were resumed at 2300 UTC.

### **Northwest Mooring**

The ship arrived at the Northwest mooring site at 0230 UTC on 23 February 1992. Since this mooring had parted in August 1991 there was nothing on the surface and it was preferable to wait until daylight before recovery was attempted. While waiting the ship interrogated the release to determine if it was still operable and to see if it was in the same location as when deployed. The release responded without any trouble and appeared to be in the same position. A depth survey was conducted to determine the depth variability in the immediate target area. The new mooring design for the northwest site permitted a +60 meters depth window around the design depth without producing any significant effect on the mooring's performance. The area within those limitations was identified as the "strike zone". Deployment anywhere within the "strike zone" would be permissible. Time was also spent determining the set and drift of the ship at the drop site and the start position.

With daylight the ship was positioned .3 miles downwind of the anchor position and the release was fired at 0854 UTC. The mooring was sighted at 0909 UTC and was completely recovered by 1119 UTC.

A set and drift exercise conducted during the off spooling and winding indicated that the ship should be positioned to the southeast of the site and steam to the west. A slight northerly current would set the ship to the northwest. The ship was positioned 4 miles downwind of the mooring site to begin deployment.

The deployment began at 1756 UTC on 23 February 1992. The upper temperature instruments and buoy were deployed very smoothly. The mooring was towed for approximately 45 minutes while the nylonpolypropylene shot was wound onto the winch. Deployment resumed and the mooring was again towed with the glass balls and release outboard. The anchor was deployed at 2328 UTC on 23 February 1992.

After the mooring had settled out an acoustic release survey was conducted. Meteorological observations were taken every 15 minutes for four hours while the ship was positioned .25 miles downwind of the buoy. At 0545 UTC 24 February 1992 the ship got underway for Ponta Delgada, Azores. Hourly XBTs were resumed at 0900 UTC with the last XBT deployed at 2000 UTC.

The ship arrived in the Azores on 26 February 1992 at 0900 UTC.