Graduate School of Oceanography
University of Rhode Island
Narragansett, Rhode Island 02882

Cruise Report
R/V ENDEAVOR Cruise 112

Project: A geophysical survey of the Chile triple junction in the southeastern Pacific Ocean

Schedule: Departed Callao, Peru - January 23, 1984
Arrived Easter Island - February 17, 1984

Region of Investigation:

South of Easter Island in the southeastern Pacific
30°-37°S, 100°-117°W

Funding/Principal Investigator:

NSF: OCE83-08894 to Roger L. Larson

Scientific Party:

Roger L. Larson	URI	Chief Scientist
Peter J. Michael	Smithsonian Institution	Petrologist
Nancy M. Adams	URI	Research Specialist
Sandra A. Fontana	URI	Graduate Student
Douglas S. Cwienk	URI	Graduate Student
David A. Nelson	URI	Marine Technician
Peggy A. Larson	-	Scientific Observer

Purpose:

To conduct a reconnaissance geophysical survey with 3.5 kHz, 12 kHz echo sounders and a magnetometer of the Chile Fracture Zone and the Chile triple junction in the southeastern Pacific Ocean in order to map the present-day plate boundaries and outline the recent tectonic history of the region. To dredge volcanic rocks from these plate boundaries for petrologic and geochemical studies.

Cruise Narrative:

EN-112 began at 1710Z on January 23 when we cast off from Callao, Peru. After fire and boat drill and a scientific meeting, we began scientific watches at 2300Z. The 3.5 kHz PDR was operational at 1810Z. The first week of the cruise was taken up with full speed transit to the work area. Steaming at 12 kts for several days allowed us to estimate maximum fuel usage during the leg and determine that we had adequate, but just adequate, fuel in our full, 55,000 gal tank. At 12 kts ENDEAVOR will burn about 1750 gals of fuel in 24 hours.

Cruise Narrative cont'd:

At 1827Z on January 28 we streamed the magnetometer and began its operation. What proved to be a heat sensitive problem was soon discovered and was with us the entire leg due to lack of spares for the heat sensitive part. This was solved in jury-rig fashion by blocking the electronic box open and installing a box fan to cool the interior.

During the transit week we set up the PDRs so that we ran and recorded the 3.5 kHz PDR on a one-sec sweep for high resolution and sediment penetration and the 12 kHz PDR on a 10-sec sweep as a monitor of absolute depth and regional geology. This is a very workable arrangement, although the high-amplitude 3.5 kHz signal cannot be filtered out of the 12 kHz system, so the 3.5 kHz keypulse occurs as crosstalk in horizontal black bars across the 12 kHz record.

On January 30 we reached the eastern end of the survey area and began a series of sawtooth track crossings of the Chile fracture zone from 100°W to the triple junction area at 109°W. The fracture zone appears as broad, broken terrain from 100°W to 104°W with a general trend of 275°-280°. Between 104° and 105°W there is a small en-echelon offset to the north. From 105°W to 109°W it is a much more localized feature, occurring as a deep lineated crack with a strike of 280°-285°. It is abruptly terminated at the eastern spreading center of the Chile triple junction.

Four dredge hauls were attempted in the Chile Fracture Zone, and two were successful. Dredge D1 on January 31 was aborted after lowering the dredge only 250 m due to a broken brass level wind guide on the Smatco winch. This was due to side loading the level wind guide that in turn resulted from initial misalignment of the level wind roller. Dredges D1-A and D2 were both successful. The results are tabulated below. Dredge D3 was lost on February 5 due to premature rupture of the weak link. After becoming hung up in the fracture zone, we were in the process of maneuvering the vessel to obtain a different pulling direction while keeping fairly heavy tension on the cable. The weak link failed at a maximum load of 9.8 tons with 3706 m of wire out. The dead weight of cable and bomb was 3.4 tons, so the weak link failure was at 9.8 - 3.4 = 6.4 tons = 12,800 lbs. The weak link was rigged for breaking tension of 17,400 lbs according to Brian McCauly's measurements or 19,800 lbs according to manufacturer's specifications. After losing this dredge we examined the weak link shear pins from dredge D2 that were loaded to a maximum load of 9.8 tons - 3.7 tons (for the bomb and 4702 m of cable) = 6.1 tons = 12,200 lbs. This was the same arrangement of shear pins, and they were severely deformed, indicating that losing dredge D3 was not a fluke. The true breaking strength of these weak links appears to be substantially less than 93% of the sum of the individual shear pin strengths for large loads and multiple pin arrangements, that is the manufacturer's breaking strength statement.

After losing the URI dredge at dredge D3, we continued dredging with a Scripps dredge whose main design difference is a rigid tongue instead of a heavy chain bridle. When used directly behind the bomb weight, this design difference has a flaw that exerts a downward directed force on the joint between the tongue and the bomb when the dredge hangs up. This results in sideloading this joint which cracked, but luckily did not fracture the weld at the bottom bail of the bomb weight during both stations D4 and D7. This downward force does not occur if the URI dredge hangs up because the chain bridle will rotate up to continue exerting horizontal stress on the joint. This could be cured with the Scripps dredge if it was decoupled from the bomb weight by 6 - 10 feet of heavy chain.

Throughout these dredge stations and the remaining ones in the cruise the Smatco winch had at least two recurring and unresolved problems. The most aggrevating is the strong tendency of the large (120 hp) traction head motors to "powerdown" or drop "offline" when the traction heads are engaged. When this happens you can neither reel in nor pay out wire until the re-start sequence is initiated. On at least one occasion the power loss was due to an overloaded generator that was also powering the bow thruster at the time, but generally the powerdown syndrome appears related to safety switches on the traction head motors that offline the system when only slightly loaded. The other recurring problem is the relatively poor level winding ability of the winch. I felt constrained to operating only up to 75 m/min because of recurring situations where the wire backs up over previously laid wraps or jumps forward. On one occasion a loose wrap of wire was wound on the reel at 75 m/min.

Another characteristic of this winch that should be explained to all scientific and deck personnel using it is that the takeup reel motor (40 hp) exerts a constant 3000 lbs of tension on the takeup reel and cable whenever it is turned on. Thus, if slack somehow develops in the system such that less than 3000 lbs of tension is on the cable, the take up reel will <u>automatically</u> start up to re-establish 3000 lbs of tension. This was explained in no uncertain terms to me by the Chief Engineer <u>after</u> a seaman and I had been repositioning slack cable on the traction heads without shutting off the takeup reel motor. An active indoctrination in the dangers of using this winch plus signs warning of automatic machinery might at least save us from successful lawsuits, if not preserve the lives and limbs of personnel.

Having completed the survey of the Chile Fracture Zone, on February 5-6 we engaged in a similar survey of a potential transform fault that would connect the Pacific Antarctic Ridge to the eastern ridge at the triple junction. No obvious bathymetric lineation or deep relief was observed, which led us to conclude that no such structural connection exists. This conclusion is supported by a general lack of seismic activity or gravity signature.

After the "non-fracture zone" survey we successfully dredged the Pacific-Antarctic Ridge at dredge site D-3A.

We then began a survey of another potential transform fault between the Pacific-Antarctic Ridge and the western ridge of the triple junction. This survey revealed lineated bathymetry coincident with earthquake epicenters and a moderate-sized gravity anomaly. The bathymetric lineation is exactly parallel to that expected for a transform across the Pacific-Antarctic plate boundary. The westernmost crossing on February 8 revealed typical abyssal hill bathymetry to the south on the Pacific plate that steps up abruptly to a very flat, possibly lava lake plateau, across the plate boundary. The fine scale morphology of this plateau is remarkable in that it is very flat and devoid of hyperbolic echos.

Cruise Narrative cont'd:

After surveying the Pacific-Antarctic transform we successfully dredged the western ridge of the triple junction area at dredge site D4.

We then steamed west across the strike of this ridge out to 116°30'W and back again in an attempt to correlate magnetic anomalies. No identifiable anomalies and very few lineations were discovered at this latitude (33°-34°S). We continued this profile to the eastern ridge where we encountered a well-preserved sequence out to anomaly 2A on both flanks. In addition, anomaly 3 is well-preserved on the eastern flank, but the identification breaks down beyond that. On this profile, the morphology exhibits an obvious rough-smooth boundary at the limits of the correlatable anomalies. An obvious rift valley and flanking rift mountain characterize the spreading center. This entire sequence appears to have resulted from fast spreading from 2A or 3 time down to Jaramillio (J) time, at which point spreading slowed by about a factor of two and generated the rift mountains and rift valley. These rates and rate changes appear to be a close approximation of the Antarctic-Nazca plate boundary farther to the east (east of 100°W).

We then began a series of east-west lines that became shorter and closer together to the north to trace the eastern ridge and its lineation sequence to its apex. The lineation sequence is fan-shaped, asymmetric, and propagates to the north. Spreading rates slow and lineations converge by a minor amount on the east flank, but on the west flank the spreading rate change along strike and the lineation convergence is extreme, especially for anomaly 2A. The rough/smooth basement boundary persisted somewhat to the north on the eastern flank, but as rates slowed inside the lineation sequence, the basement became rougher and the boundary less distinct at the edge of the lineation pattern.

The rift valley was dredged successfully at locations D5 and D6.

North of the D6 location the magnetic anomaly sequence breaks down entirely, although the rift valley and rift mountains appear to continue across short transform offsets. This area is also characterized by a cluster of earthquake epicenters that presumably result from motion on the short transforms. The alternate hypothesis is that the entire ridge is transformed to the west at this location along Francheteau's "Bullard Fracture Zone."

The western end of the northernmost profile revealed a huge depression that dropped below 5000 m. This appears localized as it is nearly surrounded by other tracks that do not show depths below 3500 m. It is aseismic, has little if any gravity signature, and its tectonic significance is unknown. One other "non-fracture zone" depression was mapped on the western flank trending sub-parallel to the rift valley.

After the northernmost profile across the eastern ridge, we executed a short sawtooth survey to test the hypothesis that the motion on the eastern ridge is transformed to the west at this latitude across Francheteau's "Bullard Fracture Zone." Although the survey covered rough, broken terrain during most of its extent, no consistantly lineated bathymetry was mapped, and only occasional deep depressions were crossed that appear to be local features. Thus, we conclude that the Bullard Fracture Zone does not exist at this location.

Cruise Narrative cont'd:

Upon conclusion of the Bullard Fracture Zone survey we successfully dredged the western ridge of the triple junction where it exists as a doubled ridge, or super-overlapper. This will be compared with the sample of the ridge just to the east.

We then steamed to Easter Island where we anchored at 1800Z, February 17 and ended EN-112 after steaming 6500 nautical miles and collecting 4841 nautical miles of magnetometer data and 6291 nautical miles of echo sounding data.

Several general conclusions and unanswered questions result from preliminary inspection of these results.

1. The western half of the Chile Fracture Zone generally follows the trends of its earthquake epicenters and gravity anomalies. It does not consist of a series of en echelon offsets that would parallel the trends inferred to the east by Klitgord, et al. (1973). Thus, it is likely that these latter trends are in error and spreading is non-orthogonal on the Chile Ridge.

2. The Chile Fracture Zone terminates abruptly against the eastern ridge of the triple junction.

3. There is no obvious structural connection of this eastern ridge to the Pacific-Antarctic Ridge. Thus, the conventional, long-standing hypothesis of a microplate at this triple junction is disproved.

4. The transform connecting the Pacific-Antarctic Ridge to the western ridge of the triple junction is exactly parallel to Pacific-Antarctic plate motion, in accord with point 3.

5. The western ridge does not record any sort of coherent spreading pattern for an unknown reason, although this may result from its existance as double ridge or super-overlapper that broadens the effective zone of crustal formation.

6. The eastern ridge began spreading at this location at 2A or 3 time, and the western part of the Chile transform (west of 105°W) probably established itself at that same time.

7. The eastern ridge has magnetic lineations that are strongly asymmetric, strongly convergent, and propagate to the north.

8. The convergent lineations, especially on the west flank, indicate a very near pole of rotation, probably south of 30°S.

9. Although the pole of rotation is very near, the spreading rate and spreading rate changes are a close approximation of other Nazca-Antarctic lineations to the east. This is especially true of the eastern flank.

10. No transform is required at the north end of this ridge, because it simply dies out near the pole of rotation.

Cruise Narrative cont'd:

11. Although there does not appear to be a microplate as it has classically been described, a paradox exists because there is no obvious Nazca-Antarctic plate boundary west of the eastern ridge.

12. This may be partially explained by a still-undetected transform between the eastern ridge and the Pacific-Antarctic Ridge, or by non-rigid behavior of the crust west of the west flank of the eastern ridge. Certainly there is much broken terrain and many large depressions in this area. However, the coherent magnetic lineations of the eastern ridge's west flank imply the necessity for a transform to separate them from the Antarctic plate. A large arcuate fracture zone does exist in this area, but it appears to be too far west.

13. The most obvious followup studies in this area would be with ocean bottom seismometers placed at locations suspected to be diffuse transforms or propagating rifts, and Don Hussong's new Sea MARC. Sea MARC would yield a high-resolution side scan image of potential transforms and other plate boundaries that are not obvious in more conventional geophysical profiles.

Dredge Hauls:

Stn. #	Location	Depth	Recovery and Rock Types
1A	35°56'S,103°40'W Chile Fracture Zone	3800 m	500-1000 lbs crystalline and glassy basalts, greenstones and dolorites
2	35°22'S,105°35'W Chile Fracture Zone	4500 m	500-1000 lbs basalts, conglomeratic basalts, greenstones, some minor glass
3A	35°37'S,110°43'W Pacific-Atlantic Ridge	2730 m	40 lbs basalts with some manganese coating, minor glass, pillow fragments and rinds
4	33°27'S,112°30'W Western Ridge, triple junction	2400 m	500 lbs very fresh basalt, sheet flow fragments, much glass
5	33°39'S,109°13'W Eastern Ridge, triple junction	2870 m	1000-1500 lbs large pillow basalts much glass with plagioclase phenocrysts
6	33°19'S,109°09'W Eastern Ridge, triple junction	3080 m	One lb basalt fragments with glass and minor manganese
7	32°07'S,112°16'W Western Ridge, triple junction	2500 m	150 lbs pillow basalts and some sheet flow fragments, much glass, minor manganese

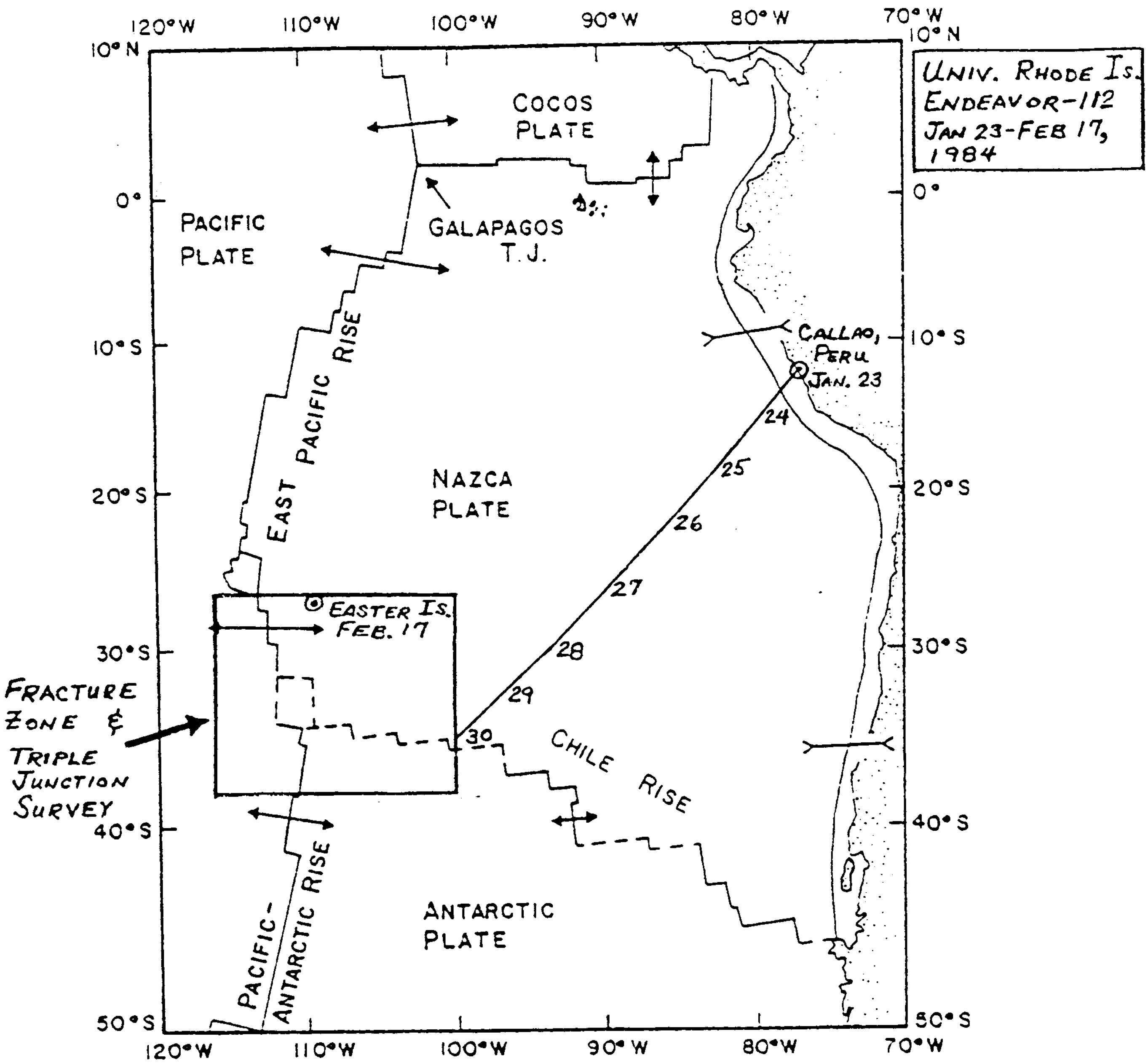


Figure 1 - Schematic map of the plates and plate boundaries in the southeastern Pacific showing relative velocities, triple junctions and possible microplates (near Easter Island and at the Chile triple junction). INSET BOX SHOWS AREA OF FIGURE 2.

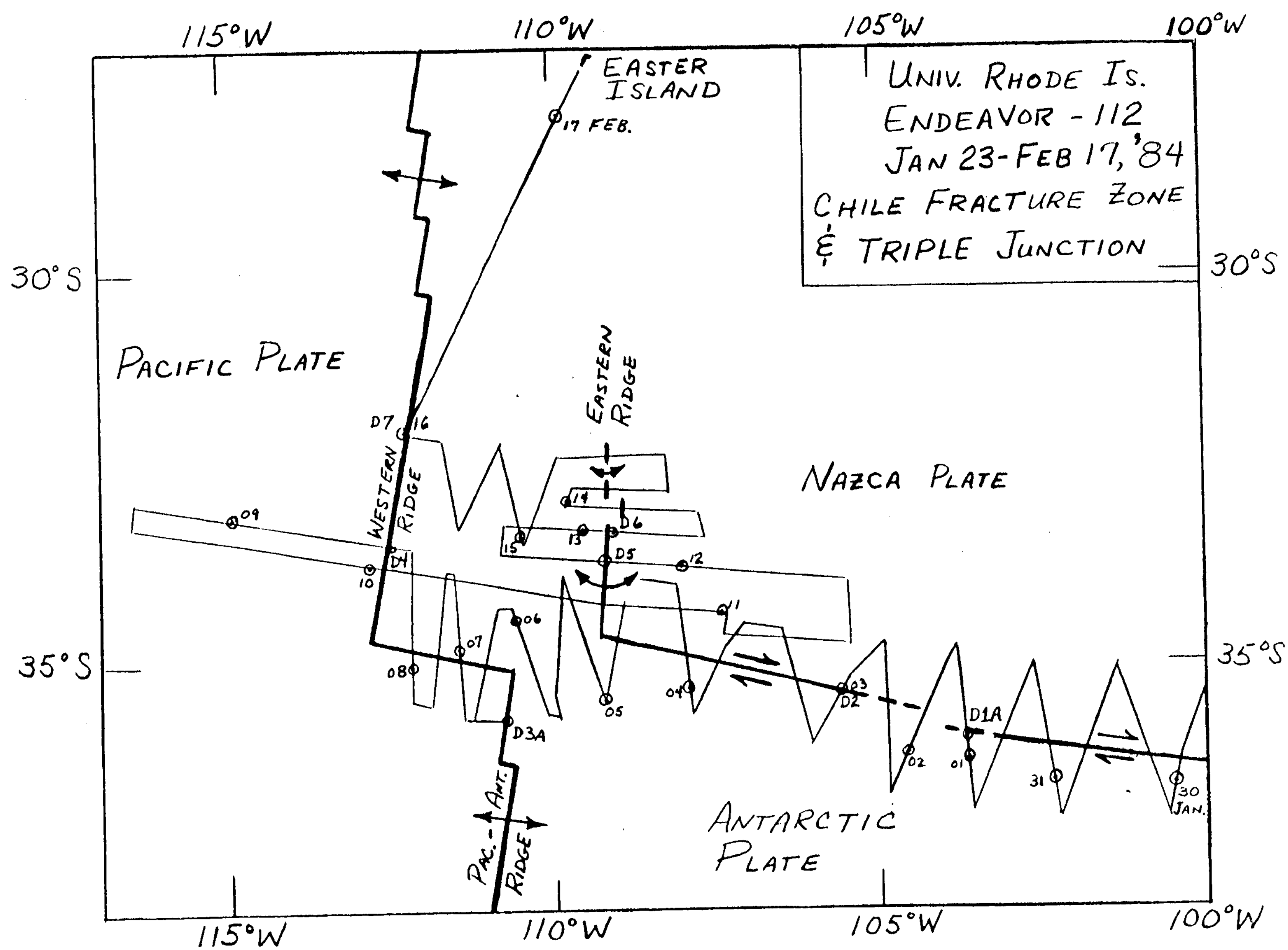
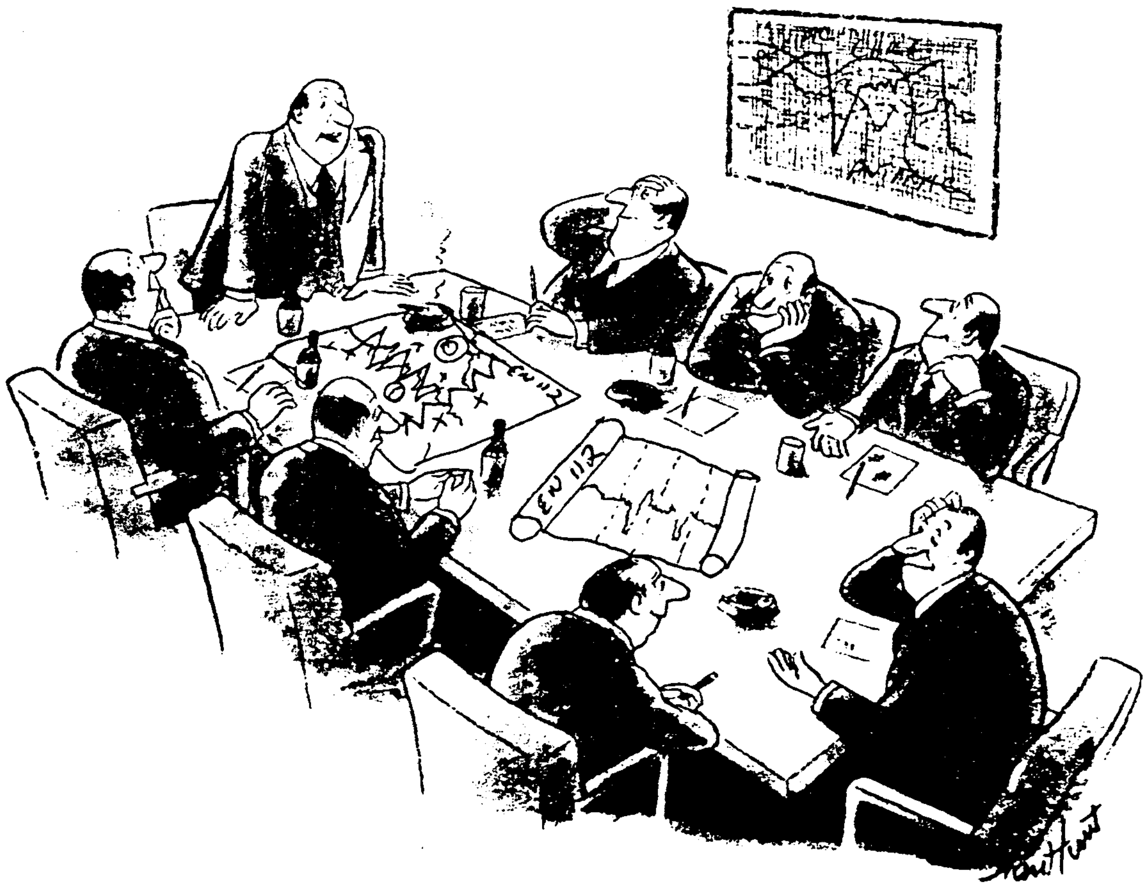


FIGURE 2- TRACK OF ENDEAVOR 112. DOTS DENOTE DATES



"Then again, gentlemen, we're in complete agreement in the sense that nobody knows the answer to any of the questions that have been raised."

CRUISE REPORT

UNOLS
Rev. 4/8?

SHIP UTILIZATION DATA

SHIP NAME R/V ENDEAVOR

CRUISE (LEG) NO. EN-112

AREA OF OPERATIONS: Southeast Pacific Ocean

DAYS AT SEA 26 | DAYS IN PORT 3

OPERATING INST. University of Rhode Island

DATES 21 JAN-19 FEB, 1984

PORT CALLS:

PLACE	DATES
Callao, Peru	JAN 23
Easter Island	FEB 17

PARTICIPATING PERSONNEL

CODE	NAME	TITLE	AFFILIATION
1.	Larson, Roger L.	Chief Scientist, PhD	URI
2.	Michael, Peter J.	Petrologist, PhD,	Smithsonian Inst.
3.	Adams, Nancy M.	Mar. Res. Spec.	URI
4.	Fontana, Sandra A.	Graduate Student	URI
5.	Cwienk, Douglas S.	Graduate Student	URI
6.	Nelson, David A.	Marine Tech.	URI
7.	Larson, Peggy A.	Scientific Obs.	-

Use Reverse If Additional Space Required.

WAS RESEARCH CONDUCTED IN FOREIGN WATERS? No COUNTRY: --

PRIMARY PROJECTS (those which govern the principal operations, area and movements of the ship)
GEOPHYSICAL SURVEYING

PROJECT TITLE AND PRINCIPAL INVESTIGATOR	SPONSORING ACTIVITY	GRANT OR CONTRACT NUMBER	PARTICIPATING PERSONNEL (AS CODED ABOVE)
A marine geophysical survey of the Chile Triple Junction Roger L. Larson DISCIPLINE: Submarine Geology & Geophysics	NSF	NSF-OCE83-08894	1,2,3,4,5,6,7

ANCILLARY PROJECTS (which are accomplished on a not-to-interfere basis and contribute to the overall effectiveness of the cruise) ROCK DREDGING

PROJECT TITLE AND PRINCIPAL INVESTIGATOR	SPONSORING ACTIVITY	GRANT OR CONTRACT NUMBER	PARTICIPATING PERSONNEL (AS CODED ABOVE)
A marine geophysical survey of the Chile Triple Junction Roger L. Larson	NSF	NSF-OCE83-08894	1,2,5

SIGNATURE Roger L. Larson DATE 23 Feb 1984
CHIEF SCIENTIST

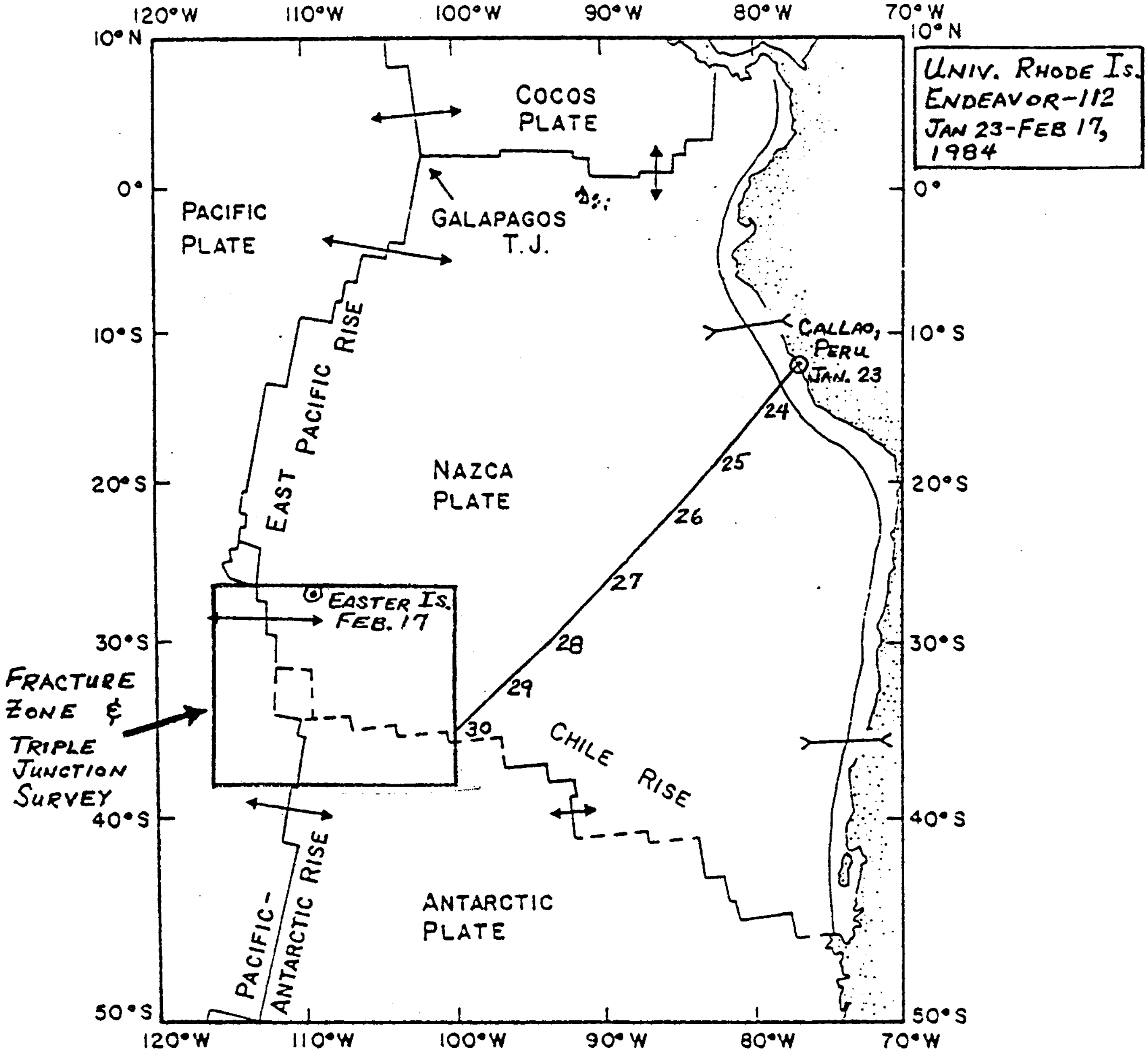
TOTAL SCIENTISTS 2 TOTAL TECHNICIANS 2
TOTAL GRAD STUDENTS 2 TOTAL STUDENTS/OBSERVERS 1

ATTACH PAGE SIZE CRUISE TRACK

COST ALLOCATION DATA

DAYS CHARGED	AGENCY OR ACTIVITY CHARGED	GRANT OR CONTRACT NO.
29	NSF	OCE-83-08894

SIGNATURE [signature] DATE 2-24-84



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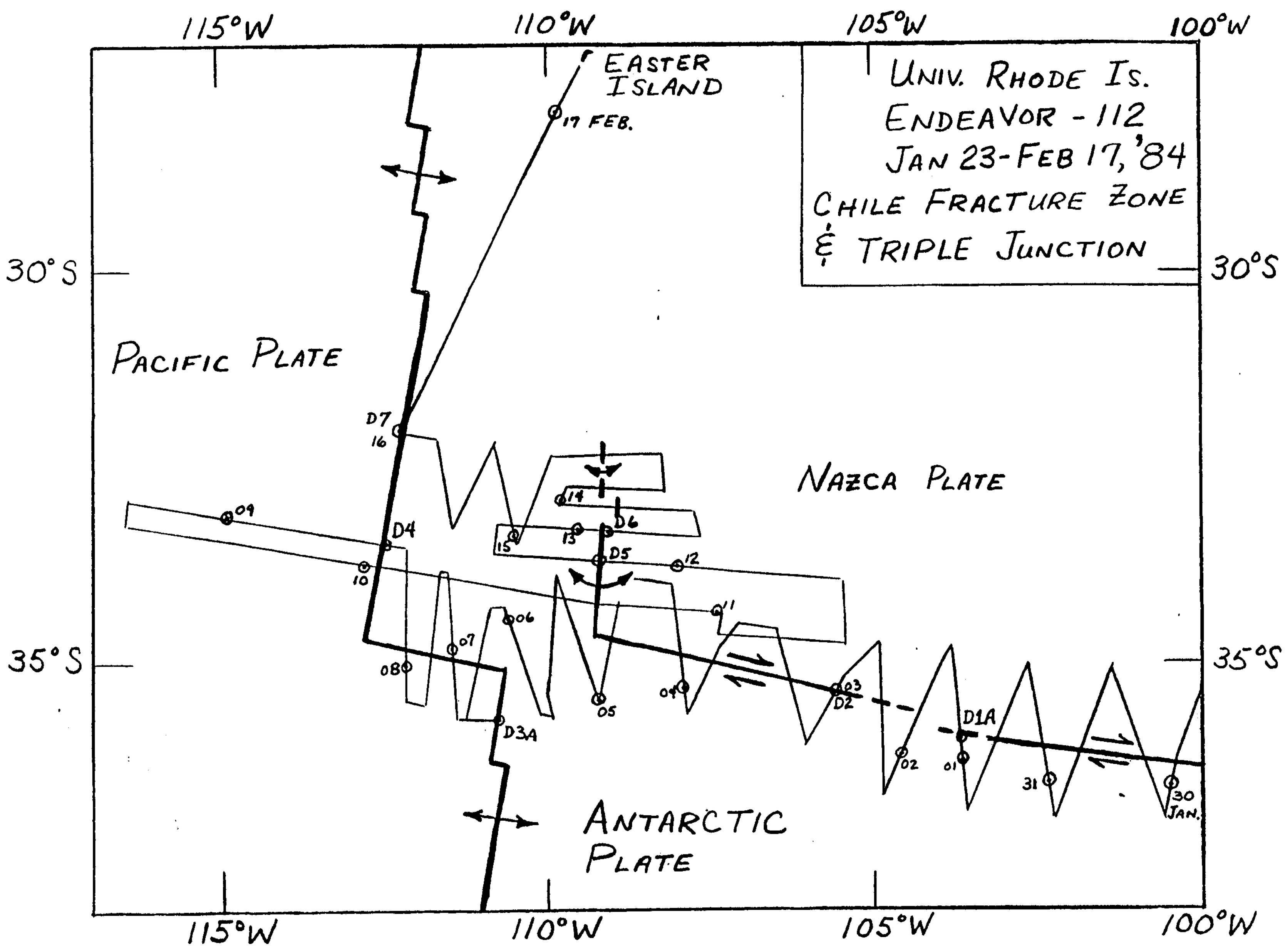

Figure 2- Track of Endeavor 112. Dots denote dates (1200Z positions) and dredge haul locations.