Where the Swell Begins

Walter Munk with Cher Pendarvis

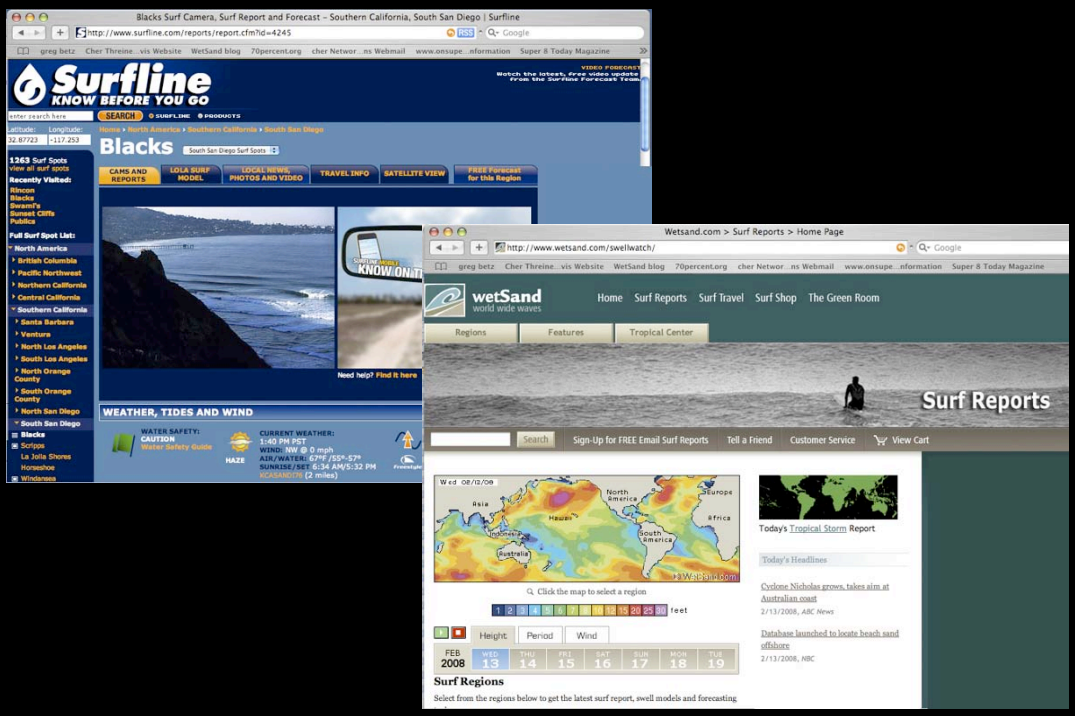
Swells to the horizon

Surfing is a gift, a total involvement that takes us away from other thoughts and the cares of the world . . .

The interaction with the wave is a creative dance with the moving water . . . its the joy of riding a wave . . .

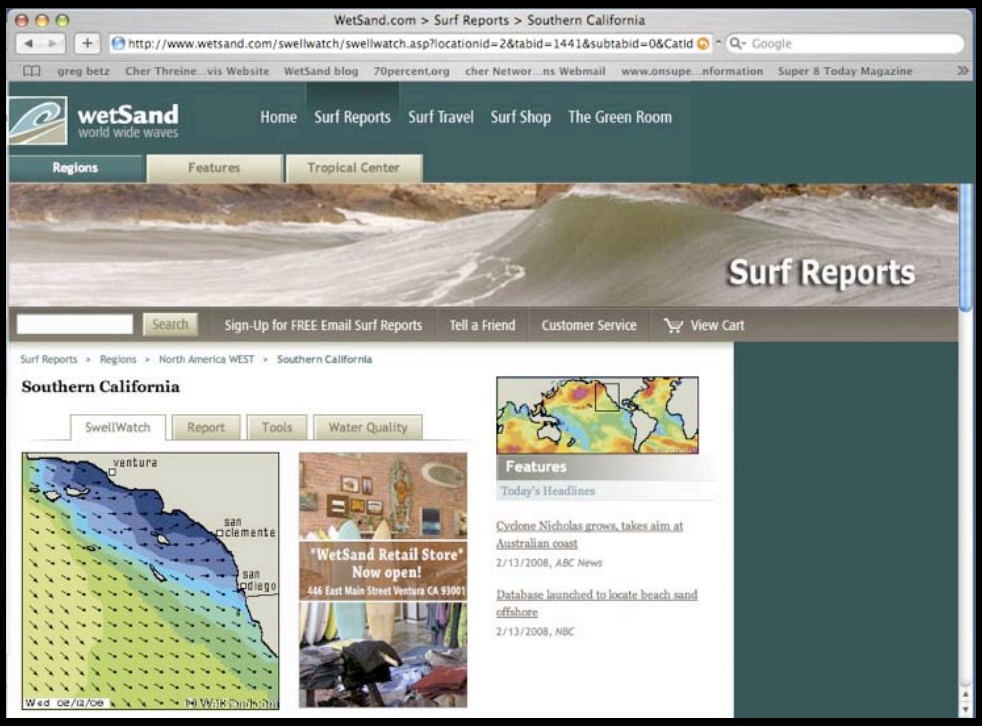
During our early surfing, some of us tried rough prediction from weather maps. . . we'd listen to the weather and then try to predict when to take off from school or work to catch the swell.

For instance, when we had high pressure on the west coast and isobar lines up by Alaska, we knew we may get a winter swell. In college, we'd plan our school schedules around the tides, and also study ahead so that we had time to surf when the waves were good.



Now we have forecasts and other services available from Surfline, Wetsand and others. You can also sign up to have surf reports sent to your email address.

In this Surfline screen we can check out the direction and size of the current swells and the wind and weather conditions.



This screen shows the direction and size of the current swells.

A fun day at Windansea

A fun day at Ralphs, San Diego harbor

South Swell Shorebreak painting

We did not always have such great tools for forecasting the waves. Dr. Walter Munk was the first to discover how to forecast swells. Walter first came to Scripps Institution of Oceanography in 1939, and after completing his Bachelor's and Master's degrees at CalTech, he took a job at Scripps and worked alongside Dr. Harald Sverdrup, the Director of Scripps Institution of Oceanography.

Big swell at Scripps in 1939

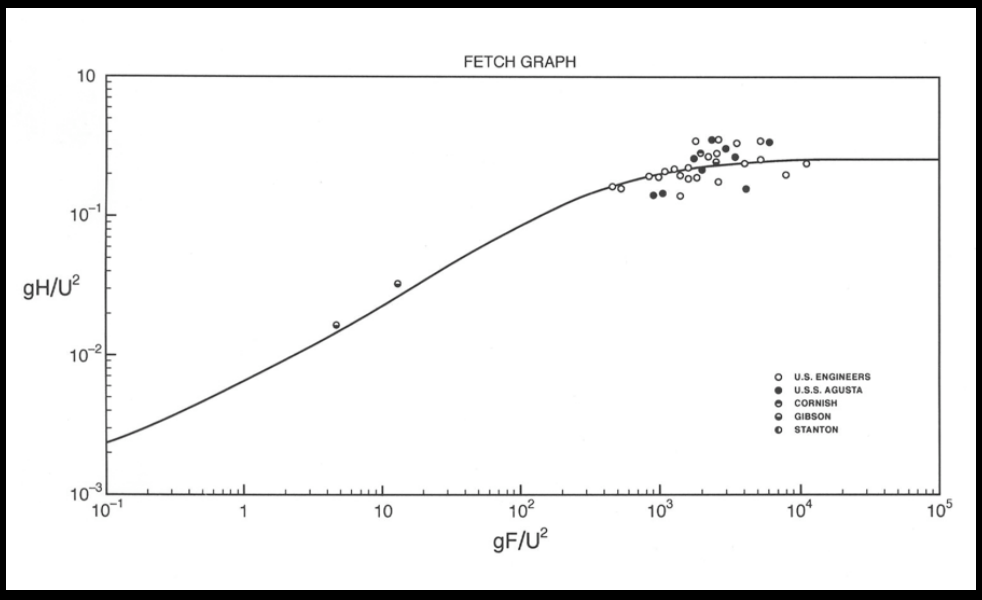
Scripps and Blacks in 1940

The wave prediction problem could be split into three quite distinct subjects: SEA, SWELL, SURF.

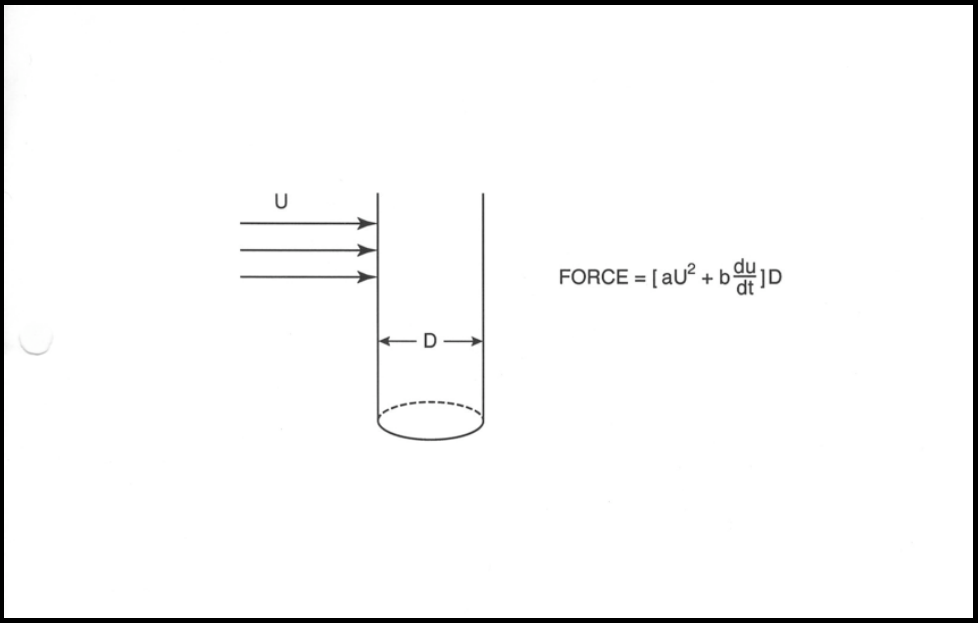
SEA dealt with wave height H and period T as functions of the wind velocity U, fetch F and duration D. These parameters could be combined into dimensionless quantities, such as gH/U^2 and gF/U^2 and plotted against one another.

SWELL involved an attempt to quantify the wave decay between the distant storm and the landing beaches, allowing for dispersion and geometric spreading.

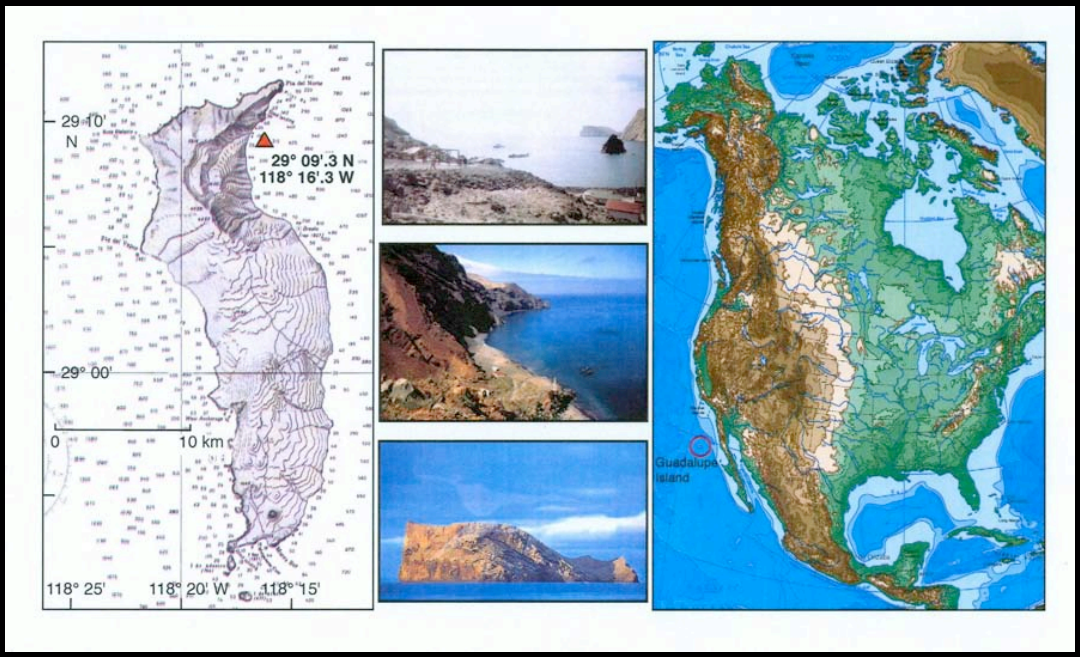
SURF, the transformation in shallow water was computed from conservation in wave energy flux (this audience will appreciate the inadequacy of such a procedure). It was all pretty empirical with scarce data sets. The method remained classified SECRET until some years after the war (Hydrographic Office Publication 601).



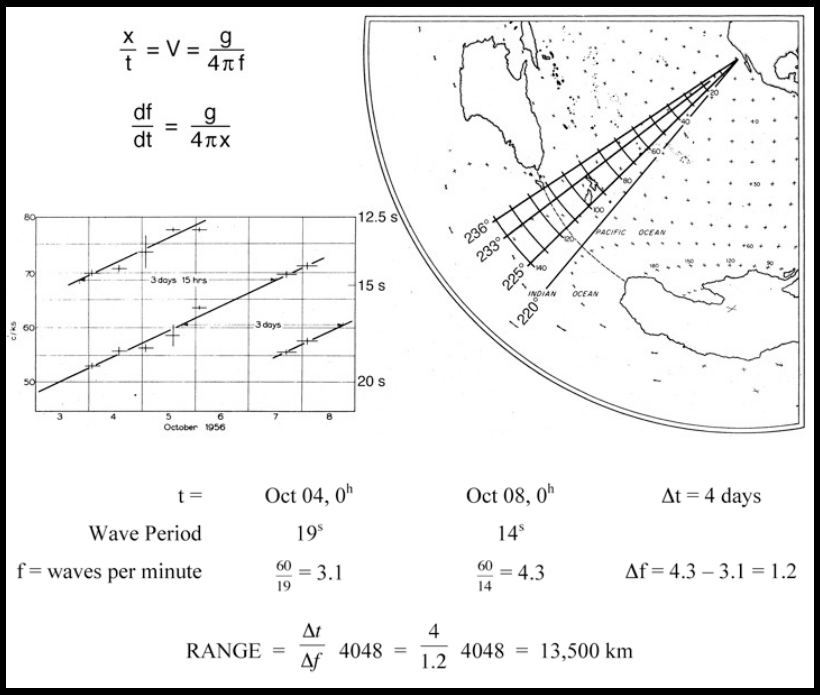
Dimensionless plot for predicting the wave height H as a function of windspeed U and storm fetch F. Only very few observations were available for predicting the dimensions of the sea.



Wave force on a cylinder of diameter D. A prediction based on these formula led to early demise of a Humble Oil drilling platform.



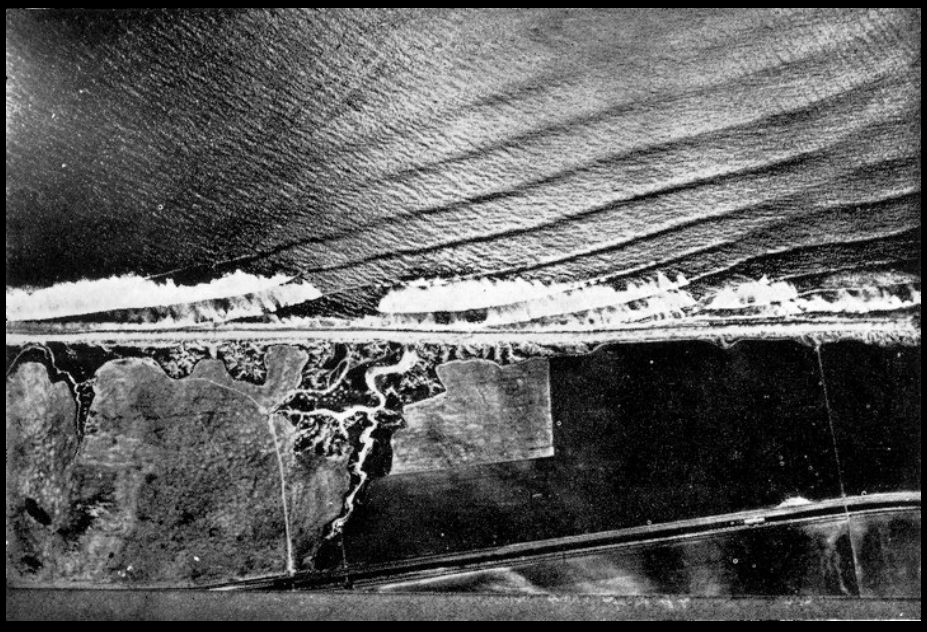
Guadalupe Island. A sea floor pressure recorder at the north eastern end of the island (red triangle) recorded the arrival of distant ocean swell.



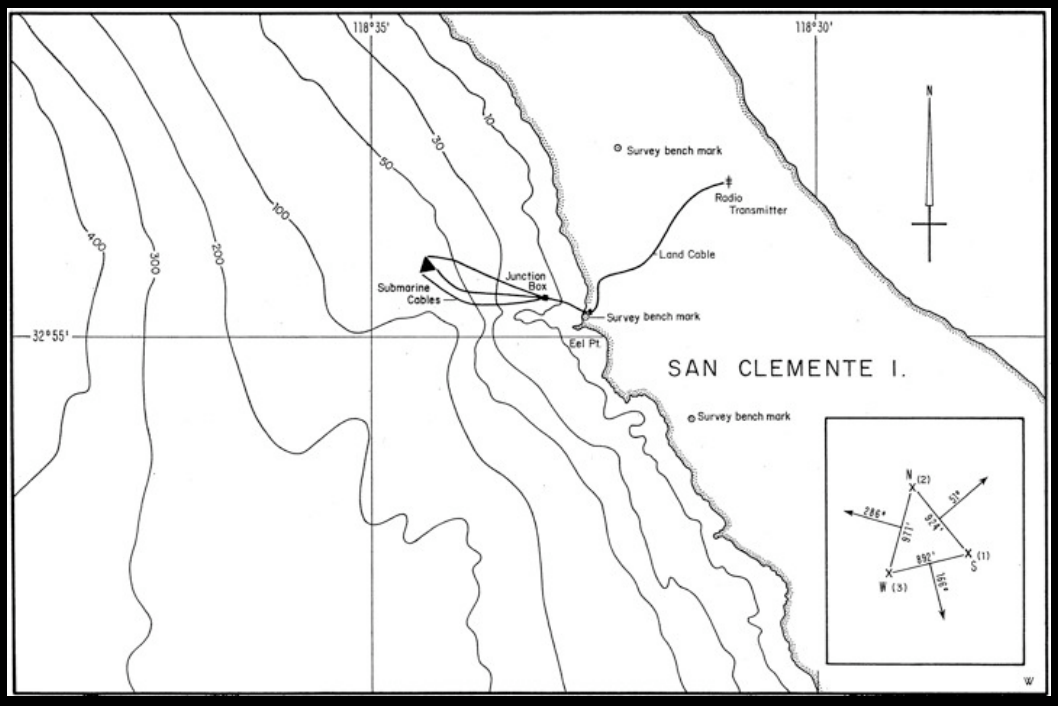
t =	Oct 04, 0^h	Oct 08, 0^h	$\Delta t = 4$ days
Wave Period	19^s	14^s	
f = waves per minute	$\frac{60}{19} = 3.1$	$\frac{60}{14} = 4.3$	$\Delta f = 4.3 - 3.1 = 1.2$

$$\text{RANGE} = \frac{\Delta t}{\Delta f}\ 4048 = \frac{4}{1.2}\ 4048 = 13{,}500 \text{ km}$$

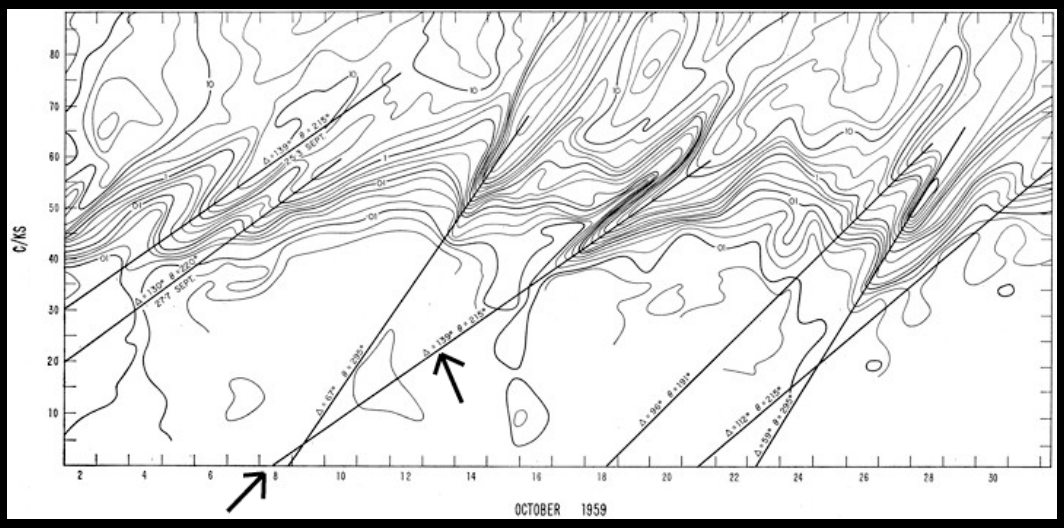
Early long waves 19s followed by 4 days of shorter 14s waves. In our case the decrease from 19s waves to 14s waves in 4 days is consistent with an incredible source distance of 13,500 km. The Pacific Ocean is big, but not that big!



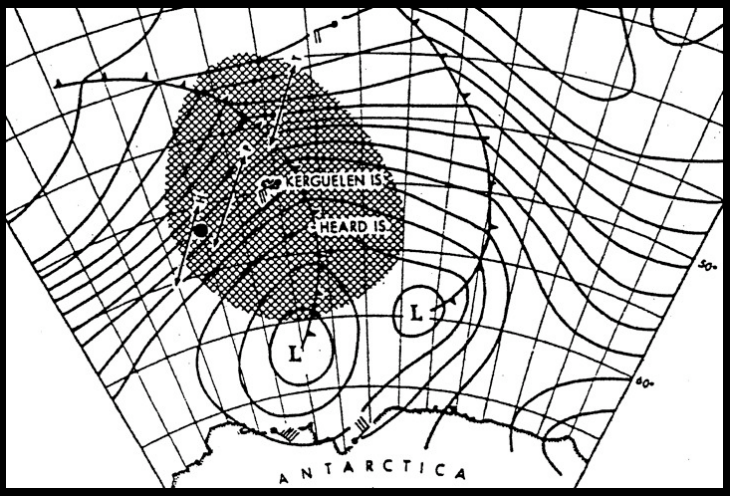
First we tried to infer the wave direction from a beautiful set of aerial photographs taken by John Isaacs during the war. The trouble is that all wave crests turn parallel to shore as they come into shallow water, and allowing for this refraction is difficult especially when offshore shoals and islands are in the way.



Frank Snodgrass established a triangluar wave recording array on the western shores of San Clemente Island to measure the direction from which the swell is coming.

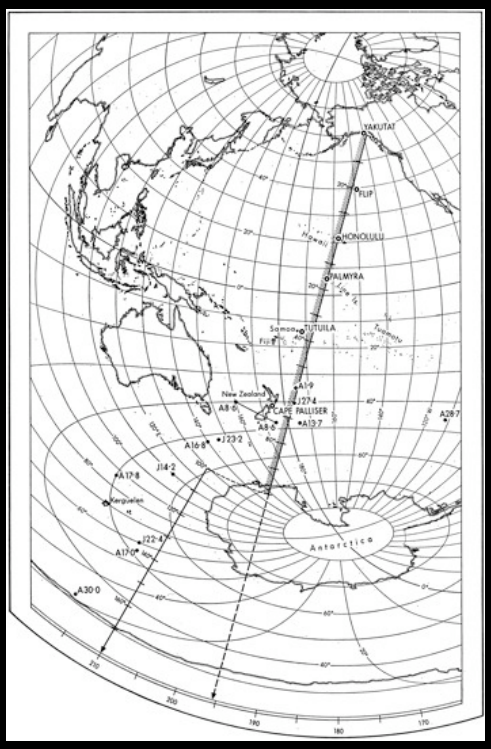


Data from the San Clemente array showed the arrival of swells from distant storms. The storm of 8 October 1959 from direction 215° came from a distance of 15,100 km, placing the source at near Heard Island in the Indian Ocean.



A crude attempt to draw the weather map for the 9 October, 1959 storm. The results were simple and decisive: distant sources were within a beam between 210° and 220° True, which is the angle subtended by the Antarctic to New Zealand window as seen from San Clemente.

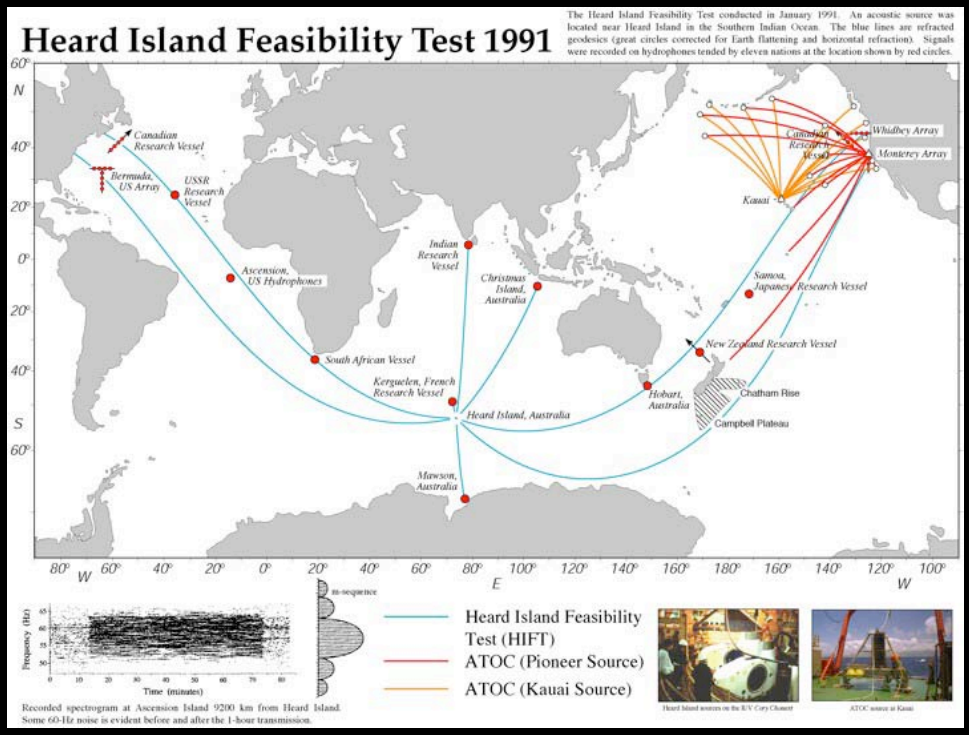
As an example take the storm of 8 October 1959: direction 215° True, range 15,400 km from San Clemente Island. This put the center of the storm over Heard Island, an uninhabited island in the south Indian Ocean.



The stations were deployed along a 10,000 km great circle route from New Zealand to Alaska.

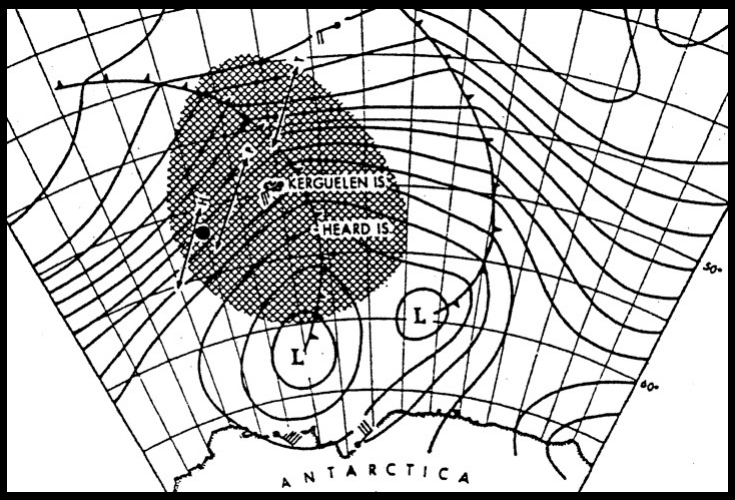
Walter and his family on Samoa in their fale on Tutuila Island, American Samoa.
By that time Judith Munk had volunteered for the 4 AM to 8 AM watch.

Upon arrival at Heard Island, we were greet by a two km high snow covered volcano, that had been climbed only once. The island is uninhabited; the huts in the foreground are used by Australian biologists during summer visits.



Geodesics (great circle routes), from the Heard Island source to receivers in various ocean basins.

The remainder of the Corey-Chouest acoustic transmitter



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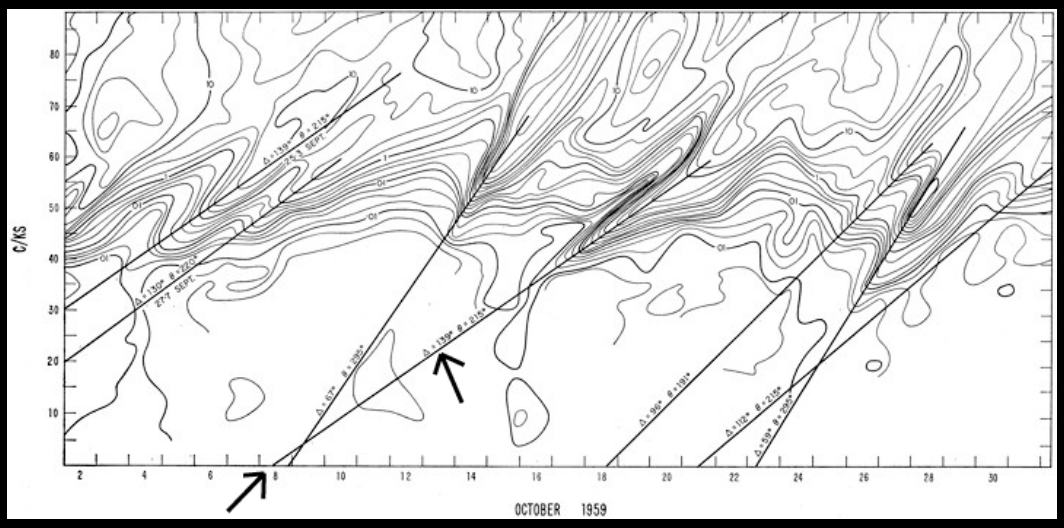

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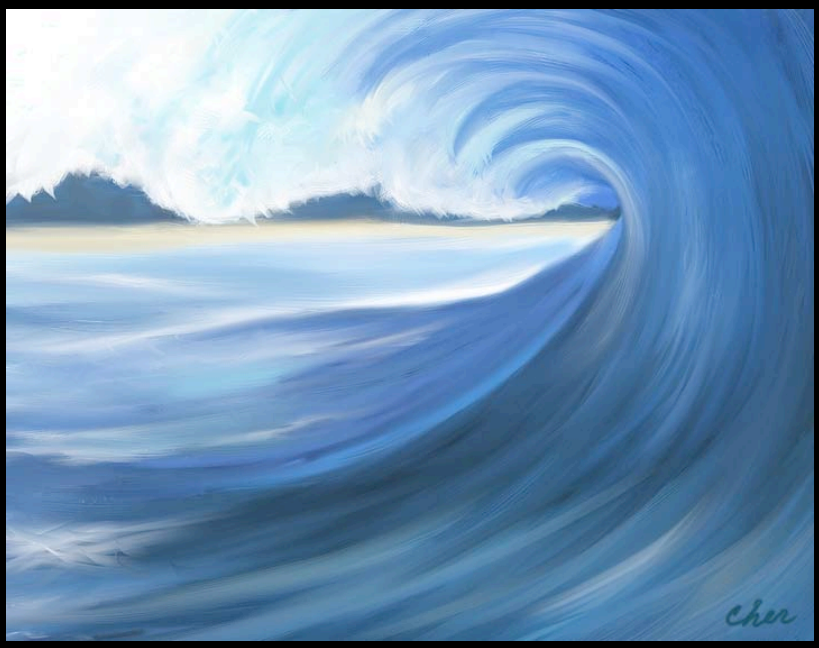

In the Barrel