A Relationship Between
Ocean Circulation and Volume
Reverberation in the Subarctic Northeast
Pacific Ocean (Gulf of Alaska)

A Paper Presented at the
111th Meeting of the Acoustical Society of America,
Cleveland, Ohio, 12-16 May 1986

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PREFACE

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A RELATIONSHIP BETWEEN OCEAN CIRCULATION AND VOLUME REVERBERATION IN THE SUBARCTIC NORTHEAST PACIFIC OCEAN (GULF OF ALASKA)

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Earlier investigations have shown a significant change in integrated scattering and spectral characteristics when transmitting into the subarctic (above 40 north latitude) northeast Pacific Ocean. An analysis of an extensive series of volume reverberation measurements obtained by Turner indicates a strong influence of the counterclockwise circulation around the Alaskan Gyre on the distribution of scattering strengths. At higher frequencies (5-20 kHz) the greater scattering strengths are found in the relatively warm California undercurrent water which flows around the perimeter of the gyre. At lower (1.25-5 kHz) frequencies, the greater scattering strengths are found in the relatively cold water such as found in the upwelled subarctic water at the center of the gyre. This implies a significant change in the type of scatterers between these frequency domains.

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VIEWGRAPH 1

This paper presents an apparent relationship between ocean circulation and volume reverberation in the Subarctic Northeast Pacific Ocean.

-- Next viewgraph, please. --
In the North Pacific Ocean the principal circulation gyre extends from the equator to only 40° North latitude (corresponding to the coast of Northern California). This leaves a large Subarctic region to the North that has its own unique characteristics.

-- Next viewgraph, please. --
Scrimger and Turner have previously shown a significant change in integrated scattering strength when transiting into the Subarctic region. This was a track from Vancouver to Hawaii and back into the Subarctic region.

-- Next viewgraph, please. --
Chapman, et al., as part of their epic circumnavigation of the western hemisphere, reported a change in the spectral content of column strength for two stations in this Subarctic region. Specifically, there appeared to be two independent mechanisms, one below 5 kilohertz and one (or more) above.

-- Next viewgraph, please. --
The circulation in the Subarctic Northeast Pacific is dominated by flow around the Alaskan gyre. Relatively warm water circulates around the perimeter while relatively cold water upwells in the center of the gyre.

-- Next viewgraph, please. --
To quantify volume reverberation throughout the Northeast Subarctic Pacific (Gulf of Alaska), Turner conducted an extensive series of measurements for both summer and winter conditions. The standard measurement technique with explosive sources was used and data were reported for four octave frequency bands: 1.25 to 2.5 kHz, 2.5 to 5 kHz, 5 to 10 kHz, and 10 to 20 kHz. Night stations are shown by dark circles, day stations by light circles.

-- Next viewgraph, please.--
Turner initially plotted the data as a function of latitude for all but one track. Typical results are shown here for the 10 to 20 kHz and 5 to 10 kHz bands. Rather than showing a simple trend the data have some unexpected changes.

-- Next viewgraph, please. --
Recently Powell, Chow, and Browning have shown that the depth of the deep sound channel axis in the Subarctic Northeast Pacific does not decrease with latitude but rather contours are concentric about the Alaskan gyre. The deepest axis depth is associated with the warm water around the perimeter, the shallowest with the cold water in the center of the gyre.

--- Next viewgraph, please. ---
VIEWGRAPH 9

This pattern intensifies under winter conditions with the axis reaching the surface in the center of the gyre.

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It seemed logical to analyze Turner's data to see if a similar pattern developed. Here is the result for the highest frequency band (10 to 20 kilohertz), the solid contours are for summer, the dashed contours for winter. The highest column scattering strengths are associated with the warmer water around the perimeter of the gyre; here levels are generally lower under winter conditions.

The lowest levels are found in the colder water at the center of the gyre.

— Next viewgraph, please. —
VIEWGRAPH 11

A similar pattern is found for the next lower frequency band, 5 to 10 kilohertz. In all these figures, we are showing day stations only.

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As we go to lower frequencies, the 2.5 to 5 kilohertz band, the pattern changes. More importantly, the trend completely reverses. The lowest column strengths now appear to be associated with the warm water influx in the southeast corner. The area of highest column strength is associated with the colder water to the northwest and this region expands southeastward during the winter.

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VIEWGRAPH 13

This pattern is confirmed by the lowest frequency band, 1.25 to 2.5 kilohertz. As Chapman's earlier work had indicated, we appear to have two distinct and independent frequency regimes with the demarcation being at 5 kilohertz.

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CONCLUSIONS
SUBARCTIC NORTHEAST PACIFIC OCEAN (GULF OF ALASKA)

- AT HIGHER FREQUENCIES (5-20 kHz) GREATER VOLUME REVERBERATION FOUND IN WARMER WATER AROUND NORTHERN AND EASTERN PERIMETER OF ALASKAN GYRE

- AT LOWER FREQUENCIES (1.25-5 kHz) GREATER VOLUME REVERBERATION FOUND IN COLDER WATER UPWELLED IN THE CENTER OF THE ALASKAN CYRE

- RESULTS SUGGEST THE POSSIBILITY OF TWO DISTINCT SCATTERING REGIMES AND MECHANISMS

VIEWGRAPH 14

We can summarize our results as follows:

- At higher frequencies (5 to 20 kilohertz) greater volume reverberation is found in warmer water around the perimeter of the Alaskan gyre.

- For lower frequencies (1.25 to 5 kilohertz) greater volume reverberation is found in relatively colder water.

These results suggest the possibility of two distinct scattering regimes and mechanisms.