Using Multibeam Bathymetry to Investigate Marine Geology and Potential Marine Reserves in the San Juan Islands, Washington, USA

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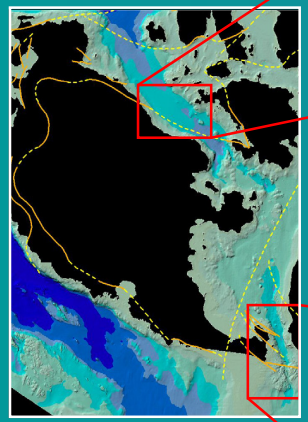
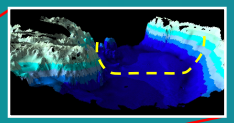
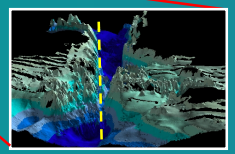


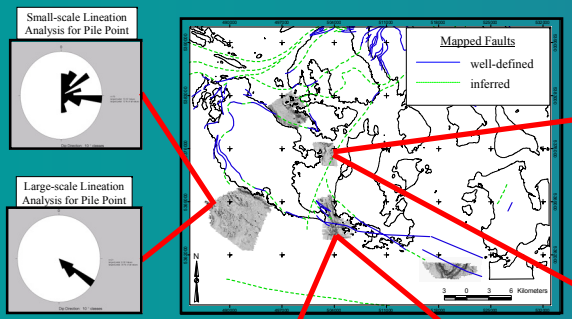


The U-shaped channel illustrated to the left is characteristic of northern San Juan Channel. This represents the classical morphology of a glacially scoured valley. This U-shaped channel continues south to Friday Harbor, where the channel narrows and the morphology changes abruptly.

The tectonic history of the San Juan Islands (SJI) involved numerous episodes of plate collisions, transform motion, uplift, and subsidence associated with not only plate motions, but glacial processes as well. The morphology of the seafloor among the SJI reflects a combination of these processes. Unfortunately, little marine geologic work has been done in the San Juan Islands. The marine geologic portion of this study was undertaken in part to more clearly discern the origin(s) of San Juan Channel as well as to further constrain inferred faults and fault dynamics based upon bottom morphology and lineament analysis. The collection of multibeam bathymetry has provided high resolution (2m) images of bedrock outcrops and glacial-marine features. The differing morphology between northern and southern San Juan Channel indicates the possibility that the northern channel may have undergone more extensive glacial scouring, while the southern channel may have formed mainly due to modern and ancient faulting. However, sediment thickness data may reveal that differences in surface morphology may be the result of restricted sediment transport from north to south within the channel.

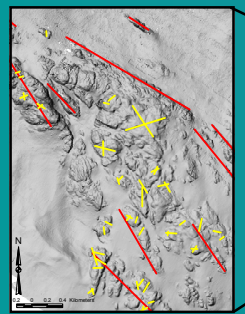


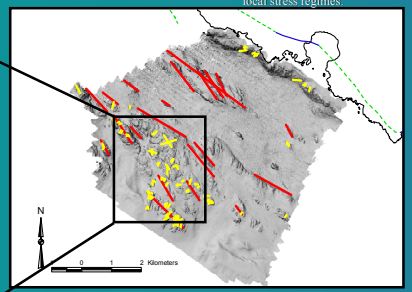
The image to the left shows the southern portion of San Juan Channel, where the morphology appears to be almost completely fault-controlled. The yellow dashed line highlights a possible fault trending approximately N/S. As seen in the larger figure on the far left, faults oriented NE/SW have also been mapped in this area.



In an attempt to further understand the stress regime of the imaged bedrock, a lineation analysis was done at three of the five sites (Pile Point, Davis Point, and Turn Island). Large-scale lineations were defined as features longer than 300m, while small-scale lineations were those that were shorter than 300m. Orientation data were plotted as Rose Diagrams and shown in the map above in relation to currently mapped faults in the area. The figures below illustrate how lineations were identified at Pile Point in southern Haro Strait.

Based on this preliminary lineation analysis, it appears that both the large and small-scale lineations are associated with local faulting. A majority of the lineation orientations align parallel to mapped faults or within approximately 30 degrees of these faults. Because the faults in this area range in age from Cretaceous to Modern, further comparison based upon fault age could provide more detailed information about local stress regimes.





COLLABORATOR

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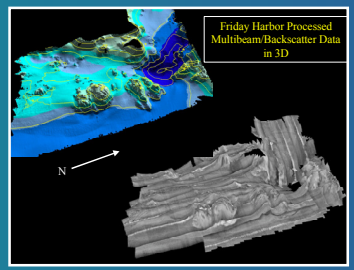
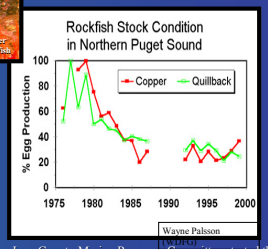
ABSTRACT

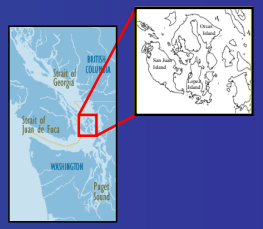
In the fall of 2000 Moss Landing Marine Laboratories surveyed five areas within the San Juan Archipelago (SJA) using a RESON 8101 multibeam bathymetric system. Both bathymetry and backscatter data were collected. This survey aimed to 1) investigate the marine geologic history of the SJA, and 2) identify habitats of declining bottomfish species such as rockfish (*Sebastes*), as part of a regional effort to create a system of marine reserves within the SJA. Previous scientific work identified these areas as potential reserves based upon biologic and physical oceanographic conditions. Two of the five survey sites were located within San Juan Channel, with one site situated at the narrow passage between San Juan Channel and the Strait of Juan de Fuca. Sites were also surveyed in southern Rosario and southern Haro Straits. Survey depths ranged from 3m along the rocky shorelines to 300m in Haro Strait.



Sun-shaded images produced from the processed data reveal seafloor with numerous high relief bedrock outcrops among mainly reworked glacial sediments. A majority of the bedrock imaged appears fractured and jointed, most likely due to a combination of ancient subduction processes and modern strike-slip movement. Evidence of glacial marine processes is widespread among the five sites. Northern San Juan Channel appears to have formed by glacial scouring, as seen by the characteristic U-shaped channel. In contrast, southern San Juan Channel most likely formed by movement along an ancient thrust fault. Crescent-shaped Lawson Reef in southern Rosario Strait represents a glacial marine deposit, possibly at the mouth of a sub-glacial stream. A combination of tectonic, glacial, and tidal processes shaped the seafloor through time within the SJA. The morphology of the seafloor, in turn, created physical habitats for many marine species, while also directly influencing circulation patterns within the islands. Areas of high relief identified using slope analysis highlighted potential bottomfish habitat. When combined with previously collected fisheries, physical oceanographic, and nearshore habitat GIS datasets, an outline of potential marine reserves was constructed.

The San Juan Islands are located just west of mainland Washington and just east of southern Vancouver Island. The marine waters among the islands are home to countless marine species. Unfortunately, many of these species' populations are declining. In particular, a number of bottomfish species, including rockfish (*Sebastes*), have been in decline since the early 1980's.





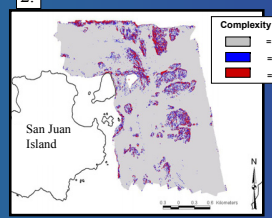
The San Juan County Marine Resource Committee started the Bottomfish Recovery program in 1996, and as a result, 8 voluntary "no take" zones have been established within the San Juan Archipelago (SJA). In order to set up a legally-enforced system of marine reserves, comprehensive marine studies need to be undertaken.

1.

As part of a collaborative scientific effort to create a system of marine reserves, Moss Landing Marine Laboratories has undertaken a multi-year study to collect high-resolution (2-3m) multibeam bathymetric data and identify marine habitats, specifically rockfish habitats, within the SJA. A larval dispersal model is being used to choose potential reserves. According to this model; habitat for adult, juvenile, and larval rockfish needs to be included within the reserve boundaries.

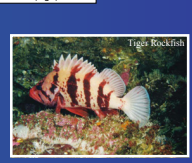
Multibeam bathymetry data was used to identify areas of complex seafloor, which was interpreted as potential adult rockfish habitat. Complexity has been measured in using a statistical analysis of slope on a 2m grid. In order to measure this parameter in ArcView®, an ordered series of calculations were performed. Individual site grids were merged prior to analysis in order to standardize the resulting complexity index for the region.

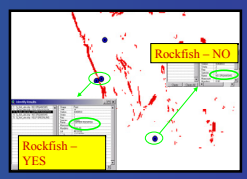
2.



The first step involved creating a sun-shaded relief map from the bathymetry grid to visually identify high relief areas (1.). The next step involved conducting a slope analysis of the bathymetry grid. Slope was calculated based upon adjacent depth values. Then the standard deviation of adjacent slope values was calculated using neighborhood statistics (2.). Standard deviation values of 2 or greater were then considered potential rockfish habitat (3.).

The Figure below shows a sun-shaded 3D image looking north in San Juan Channel near Friday Harbor. This image was created using *Fledermaus* 3D visualization software. 2D datasets can be overlaid on this image to get a better idea of the spatial orientation of the data.





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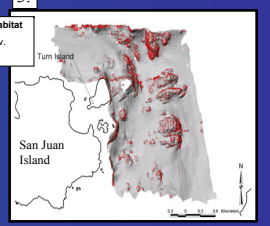

In an attempt to verify that the computer-generated rockfish habitat in fact harbors rockfish, previously collected fisheries data was overlaid on this habitat analysis. Each video drop station has a corresponding data table with information on species type, substrate type, biocover, etc… This analysis confirmed that critical bottomfish species had at one time existed on or directly adjacent to the computer-generated highly complex habitat. In order to begin the process of site selection for possible marine protected areas, numerous datasets need to be overlaid and viewed regionally as well as locally. The figure below includes potential adult rockfish habitat, as well as potential larval recruitement sites.