Continental Shelf Research 31 (2011) S39–S53

Contents lists available at ScienceDirect

Continental Shelf Research

journal homepage: www.elsevier.com/locate/csr

Research papers

# Tectonic and glacial related seafloor geomorphology as possible demersal shelf rockfish habitat surrogates—Examples along the Alaskan convergent transform plate boundary

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A R T I C L E  I N F O

*Article history:*
Received 18 July 2010
Received in revised form
4 November 2010
Accepted 10 November 2010
Available online 10 December 2010

*Keywords:*
Surrogates
Marine benthic habitats
Tectonics
Glacial
Alaska
Groundfish

A B S T R A C T

Seafloor geology plays a major role in habitat formation and can be used to remotely identify key habitats for some commercially important fish species. We have used a combination of side-scan sonar mosaics, multibeam bathymetry, and backscatter data, and *in situ* observations and video from the submersible *Delta* to investigate marine benthic habitats in the Eastern Gulf of Alaska. The intent of this paper is to review the results of previous marine benthic habitat mapping efforts completed by us along the transform plate boundary of Alaska and to present new information that show how volcanic, plutonic, and glacial submarine geomorphology can be used to identify potentially important discrete habitat areas. Demersal shelf rockfish, a seven-species management complex of nearshore rockfish, including yelloweye rockfish (*Sebastes ruberrimus*), are found in rugged and highly rugose geomorphologic features. Eroded volcanic edifices, lava fields, and a pit crater, as well as a small shutterridge, deformed and differentially eroded sedimentary bedrock, and highly fractured and faulted plutonic rock outcrops are features that attract adult rockfish. Volcanic edifices that lie along the leaky (magma-conducting) Fairweather transform fault system intercept ocean currents, in turn producing upward eddies that bring nutrients to species residing on the features. We show that geologic processes such as fault deformation, volcanism, and glaciation are critical to the development of Essential Fish Habitats (EFH) for demersal shelf rockfish. Our work is the first attempt to determine a common geologic link between desperate commercial fishing areas in SE Alaska, USA, and to suggest how tectonic and glacial processes, including sea level rise and transgression, can be used to identify seafloor geologic characteristics as surrogates for marine groundfish habitats.



## 1. Introduction

The search for a substitute, or surrogate, for deep-water marine benthic habitats is a critical process in the identification, characterization, and mapping of biological habitats on the seafloor. Although modern acoustic technologies are useful in comprehensively imaging seafloor geomorphology and substrate types the biological communities that occupy the various seafloor features are not well imaged or known. Therefore, physical characteristics of the seafloor that may act as habitat for any species or biological assemblages of concern need to be identified. We concentrate on valuable commercial bottomfish known as demersal shelf rockfish (DSR), which are known by fishers and fisheries researchers to prefer specific rugged, relatively high relief (tens of meters high), seafloor features in Alaska, to show how tectonic and glacial processes produced geomorphology can be used as surrogates for DSR habitats.

For the past 18 yr the Alaska Department of Fish and Game (ADF&G) has been conducting habitat-based *in situ* research to assess populations of DSR. Data collected for our work were used to construct marine benthic habitat maps (e.g., Greene et al., 2007a) that have been used to manage the yelloweye rockfish fisheries of SE Alaska and these maps along with data obtained through submersible dive line-transects are used for setting fisheries quotas (O'Connell et al., 2007). This paper consists of a review of studies that we have been involved in and have reported upon previously as part of our stock assessment studies, as well as the presentation of new information that supports the concept of tectonically produced geomorphology as surrogates for DSR habitats. Demersal shelf rockfish are a seven-species management assemblage of

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doi:10.1016/j.csr.2010.11.004

commercially important rockfish that inhabit rocky, rugged habitat along the continental shelf of Alaska (O'Connell and Carlile, 1993; O'Connell et al., 2007; Brylinsky et al., 2009). Yelloweye rockfish (*Sebastes ruberrimus*) is the dominant commercially important target species of this assemblage. Other fish within the DSR assemblage consist of canary rockfish (*S. pinniger*), china rockfish (*S. nebulosus*), copper rockfish (*S. caurinus*), quillback rockfish (*S. maliger*), rosethorn rockfish (*S. helvomaculatus*), and tiger rockfish (*S. nigrocinctus*), as well as lingcod (*Ophiodon elongatus*).

Tectonic processes resulting in faulting and folding produce rugged and high relief seafloor features. Therefore, areas where active tectonic processes are taking place, such as along tectonic plate boundaries, deform the seafloor and produce geomorphology that may be potential DSR habitats. Many of the seafloor features of the commercial DSR fishing grounds we have studied are aligned and associated with the active Pacific–North American plate boundary generally defined by the north–northwest-trending Queen Charlotte–Fairweather (QC–FW) fault system, a major structural feature that extends from near the northern end of Vancouver Island, Canada, northward to the bight of the Gulf of Alaska (Fig. 1). This fault system, similar to the San Andreas Fault system of California, represents a major transform boundary, which also separates the Pacific Plate from the North American Plate and essentially juxtaposes the continental (granitic basement) rocks of the North American continent from the oceanic basaltic rocks of the Pacific Plate (Atwater, 1970; Plafker et al., 1978). In addition, glacial geologic processes leave coarse-grained (e.g., boulders, cobbles, and pebbles) deposits such as moraines, which form good DSR habitats or in contrast may scour or smooth bedrock relief, which destroys good potential habitats. Knowing where such tectonic and glacial processes occur can lead investigators to identify and protect potential DSR habitat.

From our studies of DSR stock assessment we observed distinct relationships between volcanic features, ice deposited features such as tills, outwash, and moraines associated with the last glacial advance and retreat (Hamilton, 1994), and seafloor deformation formed from transform fault tectonics with the existence of desirable habitats for bottomfish (Greene et al., 2007a). These habitats consist of high relief, rugged or rugose seafloor features that generally interrupt a flat seafloor. This morphology causes turbulence in current flow that concentrates nutrients and provides space for refuge. For example, yelloweye rockfish are most abundant in habitats that exhibit high relief and in boulder fields where the void-to-clast ratio is large (O'Connell and Carlile, 1993). We also present unpublished work that

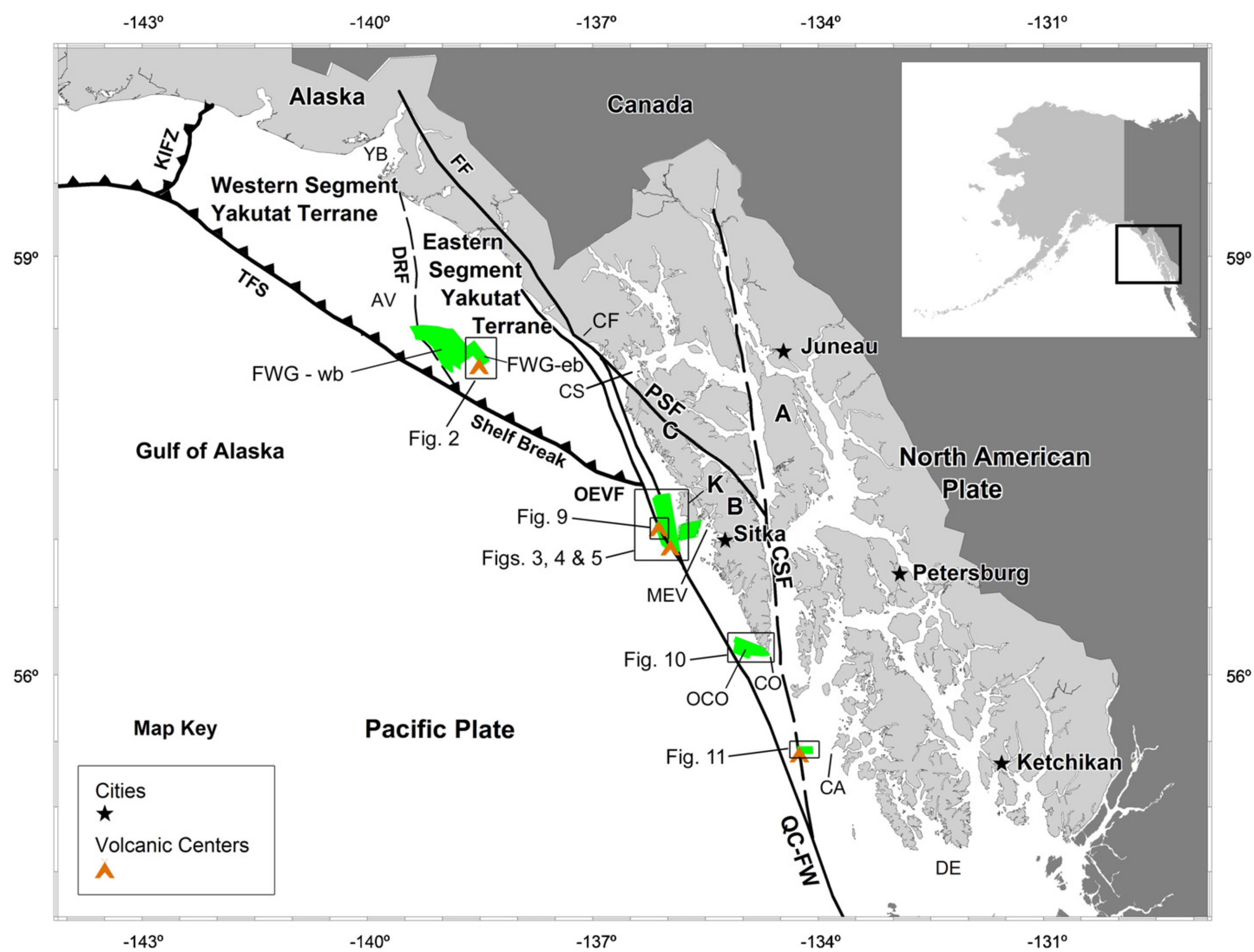


**Fig. 1.** Map showing location and orientation of the Queen Charlotte–Fairweather fault system and associated faults in our study region with locations of study areas. A=Admiralty Island, AV=Alsek Valley, B=Baranof Island, C=Chichagof Island, CA=Cape Addington, CF=Cape Fairweather, CO=Cape Ommaney, CS=Cross Sound, CSF=Chatham Strait Fault, DE=Dixon Entrance, FF=Fairweather Fault, FG-eb=Fairweather Ground—eastern bank, FG-wb=Fairweather Ground—western bank, K=Kruzof Island, MEV=Mount Edgecumbe volcano, OEVF=Offshore Edgecumbe Volcanic Field, OCA=Offshore Cape Addington Volcanic Field, OCO=Offshore Cape Ommaney area, PSF=Peril Strait Fault, QC–FW=Queen Charlotte–Fairweather fault system, YB=Yakutat Bay.