Final Report for Period: 08/2006 - 07/2007 **Submitted on:** 09/13/2007

Principal Investigator: Kuehl, Steven A. **Award ID:** 0405524

Organization: William & Mary Marine Inst

Title:

Collaborative Research - Resolution of the Stratigraphic Record for a High Input, Collision-Margin Shelf Basin: The MARGINS Waipaoa Focus Area

Project Participants

Senior Personnel

Name: Kuehl, Steven
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Carter, Lionel
Worked for more than 160 Hours: Yes
Contribution to Project:
Foreign (NZ) collaborator.

Name: Orpin, Alan
Worked for more than 160 Hours: Yes
Contribution to Project:
Foreign (NZ) collaborator

Name: Palmer, Alan
Worked for more than 160 Hours: No
Contribution to Project:
Massey University (NZ) Foreign collaborator.

Name: Marsaglia, Cathleen
Worked for more than 160 Hours: Yes
Contribution to Project:
CSUN Collaborator.

Post-doc

Graduate Student

Name: Rose, Lila
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. Thesis based on this study.

Name: Miller, Andrea
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. Thesis based on this study.

Name: Bever, Aaron
Worked for more than 160 Hours: No
Contribution to Project:
VIMS Cruise participant.

Name: Sumners, Ben

Worked for more than 160 Hours: No
Contribution to Project:
ECU Cruise participant.

Name: Ohneiser, Christian
Worked for more than 160 Hours: No
Contribution to Project:
Otago University (NZ) Cruise participant.

Name: Quinn, Alissa
Worked for more than 160 Hours: No
Contribution to Project:
Otago University (NZ) Cruise participant.

Undergraduate Student

Name: Cudby, Victoria
Worked for more than 160 Hours: No
Contribution to Project:
Massey University (NZ) Cruise participant.

Name: Teirney, Maia
Worked for more than 160 Hours: No
Contribution to Project:
Massey University (NZ) Cruise participant.

Name: Behr, Whitney
Worked for more than 160 Hours: No
Contribution to Project:
CSUN Cruise participant.

Name: Dawson, Shelby
Worked for more than 160 Hours: No
Contribution to Project:
CSUN Cruise participant.

Name: Jauregui, Daniel
Worked for more than 160 Hours: No
Contribution to Project:
CSUN Cruise participant.

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

NIWA

GNS

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

Continental margins have long been recognized as important and rich reservoirs of information on earth history, and contain a detailed record of climate, geomorphic evolution and land-use practices, sea level, tectonics, and oceanographic processes. As compared with the deep-sea record, margins have a far greater potential to preserve high-resolution continental records because of their proximity and high sediment inputs from rivers. This work examined the sedimentary signals preserved within the Holocene shelf mud deposit off the Waipaoa River (NZ), a MARGINS focus area selected through broad community input. The proposed work represents a natural complement to other MARGINS Waipaoa field-based proposals being submitted during this cycle, and is an essential component of parallel community modeling efforts that propose to model the entire source-to-sink system of the Waipaoa.

The major objective of this study is to determine the nature and resolution of the Mid-Late Holocene marine stratigraphic record off the Waipaoa with respect to known terrestrial and oceanographic changes. Because of the high supply of sediments, and a tectonic shelf basin which traps much of these sediments, the Waipaoa shelf offers an exceptional opportunity to examine the degree to which terrestrial, climatic and anthropogenic signals are propagated onto an active shelf and preserved in its strata.

An extremely successful oceanographic research cruise in 2005 conducted high-resolution (Chirp) reflection and sidescan surveys of the shelf mud deposit, along with targeted coring efforts in order to define and quantify the Holocene stratigraphic record of the Waipaoa shelf mud deposit. Multisensor core logging was used to generate synthetic seismograms, which in turn enable us to definitively relate acoustic reflectors to downcore changes in bulk density and lithology. Box and kasten cores were collected for Pb-210 geochronology in order to compare historical sediment dipersal patterns with those that dominate during Holocene timescales. Chronostratigraphic analysis of sediment cores are facilitated by the numerous well-constrained tephra layers within the time-period of interest, as well as recent deposition rates from radioisotope geochronology.

This work serves as the basis for M.S. or Ph.D. degree programs for students at the College of William and Mary, Duke University and Victoria University (NZ). In addition, several other graduate and undergraduate students from the U.S. and New Zealand gained valuable experience through their participation in the oceanographic cruise.

Findings:

Preliminary results from these expeditions reveal sediment dispersal patterns and stratigraphic architecture that contrast markedly with those observed off rivers draining passive continental margins, where tectonic plate motions are more subtle and sediment yields are generally much lower. Typical of small mountainous rivers, the Waipaoa produces episodic high sediment concentrations, and much of this material settles on the shelf. The Waipaoa also shows clear evidence of off-shelf sediment escape, attesting to the efficiency of such rivers in delivering terrestrial material to the deep sea.

Radiochemical and sedimentological results confirm the presence of three modern sediment depocenters on the shelf: two on the midshelf, one north and one south of the river mouth; and a third on the outer shelf, seaward of shore parallel anticlines. In each of these depocenters, accumulation rates during the past century are high (1 cm/y) and generally correspond with post-glacial sediment thicknesses measured from high-resolution seismic reflection. Interestingly, the stratigraphic character of the depocenters differs such that the midshelf depocenters preserve physical stratification and terrigenous input signals, whereas the outer shelf depocenter is more homogeneous. Modern sediment is also escaping the shelf to accumulate in some submarine gullies and canyons on the upper slope, at rates similar to those in the shelf depocenters. Elsewhere on the slope accumulation rates are an order of magnitude lower than the shelf, consistent with longer-term rates recorded from late Holocene tephra stratigraphy. Hence, off-shelf sediment escape is both rapid and highly focused. Although sedimentary organic matter is discharged from the river along with the lithogenic particles that transit the margin, there is a depletion in terrestrial organic carbon seaward across the margin and a commensurate increase in marine organic carbon content. While these observations have lead to a general understanding of the system, dispersal mechanisms through the WSS are still poorly understood and require additional study to identify relevant sources of material to and transport pathways within the study area.

Training and Development:

A number of graduate and undergraduate students from the U.S. and New Zealand participated in the oceanographic research cruise, gaining valuable experience in modern at-sea sample and data collections techniques. A subset of these are using the project results for Ph.D., M.S. and undergraduate research studies.

Outreach Activities:

Journal Publications

Kuehl, S.A., Alexander, C., Carter, L., Gerald, L., Gerber, T., Harris, C., McNinch, J., Orpin, L., Pratson, L., Syvitski, J., and Walsh, J.P., "Understanding sediment transfer from land to ocean", Eos, p. 281, vol. 87, (2006). Published,

Orpin, AR; Alexander, C; Carter, L; Kuehl, S; Walsh, JP, "Temporal and spatial complexity in post-glacial sedimentation on the tectonically active, Poverty Bay continental margin of New Zealand", CONTINENTAL SHELF RESEARCH, p. 2205, vol. 26, (2006). Published, 10.1016/j.csr.2006.07.02

Kniskern, T.A., Kuehl, S.A., Harris, C.K. and Carter, L., "Sediment accumulation patterns and fine-strata formation on the Waiapu River shelf", Marine Geology, p. , vol. , ( ). Submitted,

Books or Other One-time Publications

Alexander, C., J. Walsh, B. Sumner, A. Orpin and S. Kuehl, "Continental slope sediment delivery and storage on an active margin", (2006). , Published
Bibliography: Eos Trans. AGU, 87(52) Fall Meet. Suppl., Abstract OS12A-03

Gerald, L.E. and S.A. Kuehl, "Characteristics and preservation of event beds on the continental shelf off the Waiapu River, New Zealand", (2006). , Published
Bibliography: Eos Trans. AGU, 87(52) Fall Meet. Suppl., Abstract OS23B-1649

Miller, J.A. and S.A. Kuehl, "Shelf sediment trapping for a high-yield, tectonically-active margin: A modern sediment budget off the Waipaoa River, NZ", (2006). , Published
Bibliography: Eos Trans. AGU, 87(52) Fall Meet. Suppl., Abstract OS23B-1648.

Rodriguez, C., S.A. Kuehl, L. Addington and L. Pratson, "Contrasting Holocene and recent shelf sedimentation patterns off Waipaoa River, New Zealand", (2006). , Published
Bibliography: Eos Trans. AGU, 87(36), Ocean Sci. Meet. Suppl., Abstract OS26Q-03

Alexander, C.R., J.P. Walsh, A.R. Orpin, B.W. Sumners and S.A. Kuehl, "Modern sedimentation on the continental slope seaward of the Waipaoa River, New Zealand", (2006). , Published
Bibliography: Eos Trans. AGU, 87(36), Ocean Sci. Meet. Suppl., Abstract OS11L-06

Gerald, L.E. and S.A. Kuehl, "Recent sediment dispersal and preservation of strom events on the continental shelf off the Waipaoa River, NZ", (2006). , Published
Bibliography: Eos Trans. AGU, 87(36), Ocean Sci. Meet. Suppl., Abstract OS16A-29

Gerber, T., L. Pratson, S. Kuehl, L. Gerald, J. Walsh and C. Alexander, "Late Pleistocene and Holocene seismic stratigraphy of an active forearc basin, Waipaoa continental shelf, New Zealand", (2006). , Published
Bibliography: Eos Trans. AGU, 87(36), Ocean Sci. Meet. Suppl., Abstract OS16A-02

Walsh, J.P., B. Sumners, C. Alexander, A. Orpin, T. Gerber, L. Pratson and S. Kuehl, "Variations in depositional signals across the shelf-slope transition on the Waipaoa River margin, New Zealand", (2006). , Published
Bibliography: Eos Trans. AGU, 87(36), Ocean Sci. Meet. Suppl., Abstract OS11L-05

Kuehl, S., L. Pratson, L. Addington, L. Gerald, T. Gerber, T. Kniskern, A. Miller, P. Liu, L. Carter and A. Orpin, "Contrasting shelf sediment dispersal off small mountainous rivers: The Waipaoa and Waiapu Rivers, NZ", (2006). , Published
Bibliography: Eos Trans. AGU, 87(36), Ocean Sci. Meet. Suppl., Abstract OS22L-02

Alexander, C., J. Walsh, A. Orpin, B. Sumner, T. Gerber, S. Kuehl and L. Pratson, "Preliminary research results indicate modern sedimentation on the continental slope seaward of the Waipaoa River, New Zealand", (2005). , Published
Bibliography: New Zealand Marine Sciences Society Conference Abstracts, p. 10

Gerald, L. and S. Kuehl, "Short-term sediment dispersal patterns and sedimentary environments on the continental shelf off the Waipaoa River, NZ", (2005). , Published
Bibliography: New Zealand Marine Sciences Society Conference Abstracts, p. 44

Kuehl, S., L. Pratson, L. Gerald and T. Gerber, "Preliminary results from the MARGINS program on the Waipaoa shelf", (2005). , Published
Bibliography: New Zealand Marine Sciences Society Conference Abstracts, p. 60.

Gerber, T., L. Pratson, S. Kuehl, L. Gerald, J.P. Walsh and C. Alexander, "Post-glacial seismic stratigraphy of the Waipaoa continental shelf", (2005). Book,
Bibliography: New Zealand Marine Sciences Society Conference Abstracts, p. 133.

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

Preliminary results reveal sediment dispersal patterns and stratigraphic architecture for Waipaoa that contrast markedly with those observed off rivers draining passive continental margins, where tectonic plate motions are more subtle and sediment yields are generally much lower. Typical of small mountainous rivers, the Waipaoa produces episodic high sediment concentrations. Recent depositional patterns appear to be strongly modulated by tectonics, which has partitioned the shelf into distinct depocenters.

Radiochemical and sedimentological results confirm the presence of three modern sediment depocenters on the shelf: two on the midshelf, one north and one south of the river mouth; and a third on the outer shelf, seaward of shore parallel anticlines. In each of these depocenters, accumulation rates during the past century are high (1 cm/y) and generally correspond with post-glacial sediment thicknesses measured from high-resolution seismic reflection. Interestingly, the stratigraphic character of the depocenters differs such that the midshelf depocenters preserve physical stratification and terrigenous input signals, whereas the outer shelf depocenter is more homogeneous. Modern sediment is also escaping the shelf to accumulate in some submarine gullies and canyons on the upper slope, at rates similar to those in the shelf depocenters.

Contributions to Other Disciplines:

Significant early progress in the MARGINS program off Waipaoa serves to highlight existing gaps in our current science plan, particularly those related to active tectonics and material transport. For the uplands source, much is already known from previous research about shallow landslide and gullying processes, although the timing and duration of these processes are less well understood. Major issues for source-term researchers and modelers are the character and timing of major landslides û what forces them, how often do they occur, do they provide a pulse or steady perturbation that moves progressively through the system, and how do they affect sediment delivery? This information will become even more critical when extending the timescale of interest to the LGM and beyond, as the climatic conditions have changed significantly. Work has only recently been funded to investigate the floodplain/coastal transition region. The major goals within that sector will be to understand how different modes of sediment delivery and dispersal across the land/sea boundary influences coastal progradation, to determine the effect of natural and human changes in the river geometry and to observe and model transport to better understand the dispersal of material from Poverty Bay onto the shelf during, and following floods. Identification of discrete shelf depocentres, some of which are preserving a terrestrial signal, illustrate the need for longer cores in the three depocenters and an understanding of biological markers in the record (i.e., palynomorphs, microfauna and organic carbon). Additionally, analysis of existing geophysical data needs to be performed to help determine shelf transport pathways. For the slope sector, discovery of significant off-shelf transport to the upper slope highlights the need to understand circulation and transport processes near the shelf break. In addition, with significant material accumulating on the comparatively steep upper slope, the roles of mass movement and transport to the lower slope need to be addressed. For all sectors, a thorough understanding of the detailed tectonic history of the Waipaoa drainage and margin is necessary to unravel the signatures of sediment supply, changing basin geometry and shelf/slope mass wasting. Advances for the upland sector require a synthesis of existing terrace age datasets with other existing paleorecords, the production of river discharge histories in relation to changing climate and landscape and a synthesis modeling effort. For the floodplain/coastal transition, shelf and slope sectors, both observations and modeling of circulation and sediment transport processes at the coast and on the continental margin are needed to decipher the history of sediment dispersal.

Contributions to Human Resource Development:

Graduate and Undergraduate student education.

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Most humans live on and utilize the continental margin, the surface of which changes continually in response to environmental perturbations such as weather, climate change, tectonism, earthquakes, volcanism, sea level, and human settlement and land use. Continental margins span both subaerial and submarine sectors, but these land and seascape components are contiguous, and material transport from source to sink occurs as an episodic but seamless cascade. The margin responds to environmental perturbations by changing the nature and magnitude of a variety of important functions, including: the rate and distribution of weathering, soil formation and erosion; biogeochemical functioning (especially the storage and release of water, limiting nutrients and contaminants); and the morphodynamics of hill slopes, channels, floodplains, the coastal zone, and the continental shelf, slope and rise. While some areas of the margin are eroding, others accumulate sediment and thereby record the history of these surface changes. Active continental margins, such as that associated with the Waipaoa, dominate the terrestrial material flux to the world ocean. Consequently, a mechanistic understanding of the transport and fate of river sediment in these areas is needed to model and predict a wide range of scientifically and socially relevant challenges, such as: the influence of climate and landscape changes on the stratigraphic evolution of the margin; cycling and burial of biogeochemically active constituents such as carbon, nitrogen and iron; sedimentation affects on benthic and pelagic communities, and natural hazards.

Categories for which nothing is reported:

Activities and Findings: Any Outreach Activities

Any Web/Internet Site

Any Product

Contributions: To Any Resources for Research and Education