Sediment Dispersal Offshore Of Small Mountainous Rivers: Insights from Numerical Models

From source to sink: triggers on the inner shelf?

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Waiapu River; 35MT/Yr ± ?
Waipaoa River; 15MT/Yr ± 25%
• High sediment yields.

• River mouth often exposed to oceanographic forces.

• Flood plume might carry sediment directly to mid-shelf depocenters (non-stop delivery).

• Sediment delivery during significant events may overwhelm inner shelf: cross-shelf flux seems limited.

• Sediment trapped, deposited, or somehow remains on inner shelf.

• Eventually something triggers cross-shelf flux (gravity flow induced by waves or currents).
Sediment Transport Model

• Approach:
  • Three-dimensional.
  • Include water column and sediment bed.
  • Coupled sediment transport and physical oceanographic models.

• Account for:
  • Waves and currents.
  • Suspended transport.
  • Bed armoring.
  • Fluvial input.
  • Gravity flows (*).

Grid for ROMS – SWAN Waipaoa shelf model under development by J. Moriarty (VIMS)
OBJECTIVES

- Contrast delivery mechanisms for the nearshore and inner shelf of three small mountainous river systems (the Eel, Waiapu, and Waipaoa Rivers).

- Illustrate capabilities of event- to seasonal-timescale three-dimensional numerical models for evaluating sediment dispersal within the coastal zone of continental margins.
**Eel River shelf**

- Muddy deposits on mid-shelf.
- Flood plume delivers sediment to inner shelf.
- Wave supported gravity flows deliver material to mid-shelf.

- Plan view of model

*Harris et al. 2004, 2005*
Cross-shelf flux offshore of Eel River

- Sediment delivery to mid-shelf determined by wave energy.
- Thickness of mid-shelf flood deposits function of wave energy.

Harris et al. 2004, 2005.
Waiapu River mid-shelf deposit

- $^{210}$Pb from Kniskern et al. 2010.
- Inner shelf storage (Wadman and McNinch, 2008).
- Accumulation rates peak ~80 m isobath.
- Cross-shelf transport mechanisms?

*Figure from Kniskern et al. 2010*
Wave supported gravity flows carry sediment to mid-shelf

- Wave – supported gravity flows: Model estimated flux to 30 – 40 m isobath (Kniskern, 2008).

*Figure from T. Kniskern*
Waiapu River Shelf

- Tripods deployed at 40 and 60 m water depth.
- Current supported gravity flows carry sediment across-shelf (Ma et al. 2008).
- Post-flood turbidity triggered by cross-shelf currents.

Figure from Y. Ma
Cross-shelf flux: strong waves and seaward currents

a) Water Discharge ($m^3/s$, ) and TSS (g/l, )

b) Near-bed Sediment Concentration (g/l)

c) RMS Wave Height (m, ) and Current Speed (m/s, )

d) Across-shelf Velocity (m/s)

Provided by NIWA

From Ma, et al. in prep.
Current supported gravity flows move sediment offshore to 80 m isobath.

From Ma et al. 2010.
Waipaoa River shelf

• Sediment delivered to Poverty Bay.
• Bed stresses relatively low in Poverty Bay.

Miller and Kuehl, 2010

Frequency of Exceedence: $\tau_{cw, \text{max}} > 0.1$ Pa

J. Moriarty’s Poster
Sediment export during flood pulse, and wave resuspension

- ROMS model estimates of suspended sediment flux.

- Top panel: Non-stop to the shelf during flood pulse.

- Bottom panel: Later export to mid-shelf, triggered by energetic swell waves about one week after floods.

From Bever dissertation (2010), in prep. as Bever and Harris.
Three systems considered: each had different triggers for sediment delivery to shelf.

Coherence does not guarantee delivery, dispersal, and deposition to be in phase.

Shallow coastal areas act to modulate sedimentary signals on continental margins.

Currents, as well as waves and fluvial load, can create gravity flows on continental shelves, thereby triggering cross-shelf flux.
References


Ma, Y. 2009. Continental shelf sediment transport and depositional processes on an energetic, active margin: the Waiapu River Shelf, New Zealand. Ph.D. Dissertation, School of Marine Science, College of William and Mary, Gloucester Point, VA, USA. 206 PP.