In-situ measurements of environmental variables at three Hawaiian deep sea coral patches

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What are deep corals

- Azooxanthellate
- 50-2000+ m
- Suspension feeders
- Slow growing
- Long lived
- Independent colonies found in patches (not reef building)
Patchy nature of deep corals

- The product of the right environmental conditions over substrate suitable for coral settlement and growth.
- Can we use a comparative approach to discern the relative importance of some of these variables?
Precious coral fishery

- Corals harvested
  - Pink, gold, and black

- Fishing (all in the main islands)
  - Since 1950’s Diver collection of black coral
  - 1966-69 dredging pink & gold
  - 1972-79 submersible collection pink & gold
  - 1999-2001 Submersible collection pink & gold
Makapuu Precious coral bed

- **Precious corals**
  - Gold coral, *Kulamanamana haumeaeae* (325-624 m)
  - Bamboo, *Acanella dispar* (275-575 m)
  - Red coral, *Hemicorallium laauense* (275-575 m)
  - **Pink coral, *pleurocorallium secundum*** (225-575 m)

Local hydrography may have significant influence at small spatial scales  
(Long and Baco 2013)
## Physiography of coral beds

<table>
<thead>
<tr>
<th>Patch size</th>
<th>Common precious coral taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 square km</td>
<td>Gold coral: Kulamanamana haumeaae, Bamboo: Acanella dispar</td>
</tr>
<tr>
<td>2.7 square kms</td>
<td>Gold coral: Kulamanamana haumeaae, Bamboo: Acanella dispar, Red coral: Hemicorallium laauense</td>
</tr>
<tr>
<td>12.5 square kms</td>
<td>Gold coral: Kulamanamana haumeaae, Bamboo: Acanella dispar, Red coral: Hemicorallium laauense, Pink coral: Pleurocorallium secundum</td>
</tr>
</tbody>
</table>
Temperature
Flow rate
Current direction
Turbidity

Temperature
Flow rate
Center (in) and edge (out) placement
### Study site sampling

<table>
<thead>
<tr>
<th>Site</th>
<th>Year</th>
<th>Duration</th>
<th>Depth m</th>
<th>Mean °C (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Makapuu</td>
<td>2007</td>
<td>6 months Nov - Apr</td>
<td>415</td>
<td>8.3 (0.77)</td>
</tr>
<tr>
<td>Barbers Pinn.</td>
<td>2013</td>
<td>7 months, Dec-July</td>
<td>330</td>
<td>10.3 (1.5)</td>
</tr>
<tr>
<td>Keahole</td>
<td>2012</td>
<td><strong>2.5 years</strong></td>
<td>379</td>
<td>8.2 (0.39)</td>
</tr>
</tbody>
</table>

### Multi year at Keahole

- **Keahole Anderra**

  - Time: 2012-07 to 2015-01
  - Data includes: Alt Speed, North, East values over the years.
Flow speed Barbers Pinnacle

Range 0.05-68.67
Mean 12.74
Sd 7.44

$R^2=0.56$
Flow speed Makapuu

Range 0.13-50.1
Mean 13.6
Sd 7.79

R² = 0.35
Flow speed Keahole

Range 0.01-44.44
Mean 4.56
Sd 4.08

\[ R^2 = 0.63 \]
Flow speed

Frequency Plots

Barbers
Makapuu
Keahole

Speed cm/s
Flow and temperature Makapuu

At this scale correlations between flow and temperature were weak

◊ But the temporal spectral signals match up well at all sites
Flow and temperature – spectral plot

Changes in temperature and flow (regardless of direction) controlled by tide cycle
Tidal direction of flow
Lagged tidal effects

- Compared with Honolulu tide station
- Hourly rate of change in tidal height compared with flow speed.
- Reason for the different slopes?
  - Local oceanographic features
  - Bottom topography influencing tidal flow speed?
- Seasonal feature at Keahole?
Flow in relation to tidal height
Makapuu

- Only Makapuu looks like it is correlated with an hourly change in tide level.
- Makapuu has the least topography to effect tidal influences.
**Flow (cm/s) across the patch**

<table>
<thead>
<tr>
<th>Patch</th>
<th>“center”</th>
<th>mid patch</th>
<th>edge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Makapuu</td>
<td>12.6</td>
<td>14.7</td>
<td>?</td>
</tr>
<tr>
<td>Barbers Pt.</td>
<td>9.6</td>
<td>13.5</td>
<td>&gt;8.4</td>
</tr>
<tr>
<td>Keahole</td>
<td>4.8</td>
<td>2.78</td>
<td>0.54</td>
</tr>
</tbody>
</table>
Consistent flow across the patch

- The flow spectra is consistent within and among sites.
- No consistent difference between center (in) and edge (out) of the coral patch.
Pot 41
Pot 42
Flowmeter 2
Flowmeter 1
#16 South current meter
#15 West current meter
#13 East current meter
#14 East current meter
Turbidity differs between sites
Comparing the 3 sites

- The Makapuu and Barbers sites had appreciably higher flow environments.
- At this scale temp does change with the tide but does not correlate well with flow rate.
- **Direction of flow at Makapuu site is most consistent of the three sites and also had the best correlation between tide and flow rate.**
- Flowmeters placed across the coral patch indicate variability in the flow rate but were generally consistent across temporal spectra.
- **Turbidity was 2-3 times greater at the Barber Pt. site which is close to the Makapuu site.**
Localized recruitment?
WW I S-19 scuttled 75 yrs ago
11 bamboo colonies
Mean ht 25 cm (sd 12.4)
Max 50 cm, settled 55 yrs ago
No golds, no midas
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