Defining Goals and Requirements for Sampling and Modelling Programs

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Typical sequence of steps in a spill/disaster
(based on conversations with Richard Carson)

- Try to contain spill (deploy floating barriers, etc) – Coast Guard, Navy, etc
- Collect evidence of spill and impact (sample the contaminants at the source, collect oiled fish and seabirds, take areal images, etc)
- Initialize models which predict path of contaminants
- Try to protect sensitive areas (barriers), deploy mitigation/remediation efforts
- Monitor for changes in ecosystem, fish catch, tourism etc
- Economic damage assessment

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Need to have defendable evidence

- Need to prove disaster did happen and had a major impact (photos, dead animals)
- Need to prove contaminants actually came from the ship (fingerprinting)
- Need to prove that pre-existing contaminants were not at a similar level
- Need to prove that changes to ecosystem could not be a natural/typical variation
- Need to prove adequate data quality, methods, documentation, preservation, etc- both for **baseline data** and for **post-disaster monitoring**

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Sampling aspects

- Need to assure “spatial representativeness”, i.e. how do we know that a sample at one location is representative of the “area” ?
- Need to assure “temporal representativeness”, i.e. how do we know that a sample at a fixed time is represenative of the day or phase of the event ?
- Need to know what level of a parameter is “unusual” or “extreme” and unlikely to occur naturally
- Need to be able to attach uncertainty (or confidence) to samples (or products derived from sample, like average or integrated amount of a quantity)

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These will be addressed in Monday afternoon session

Modelling aspects

- Circulation model needs to be real-time and have some fore-casting range
- Must be ready to run at 1 day notice, and with model particles released.
  That means it must be running all the time (for spin-up).
- Ideally can also do statistics with years of saved model output (ensembles)
- Need realistic/validated simulations:
  - boundary conditions from widely accepted global models (HYCOM, CMEMS)
  - atmospheric forcing from good local weather product
  - some established confidence in current speed and direction (on what scales ??)
- Consider using regional models from India
- HYCOM creator is willing to assist Sri Lanka

Parameters to sample

- **Physical state:**
  - *currents* advect wreck/pollution
  - *stratification* determines mixing
  - *temperature* affects chemical reactions
  - *wave state* affects dispersal (and may prevent burn-off of contaminants)

- **Chemistry:**
  - released *contaminants* (oil, acid, toxic chemicals, plastic)
  - *oxygen, pH, nitrate* may be affected through chemical reactions, and are crucial for ecosystem functioning

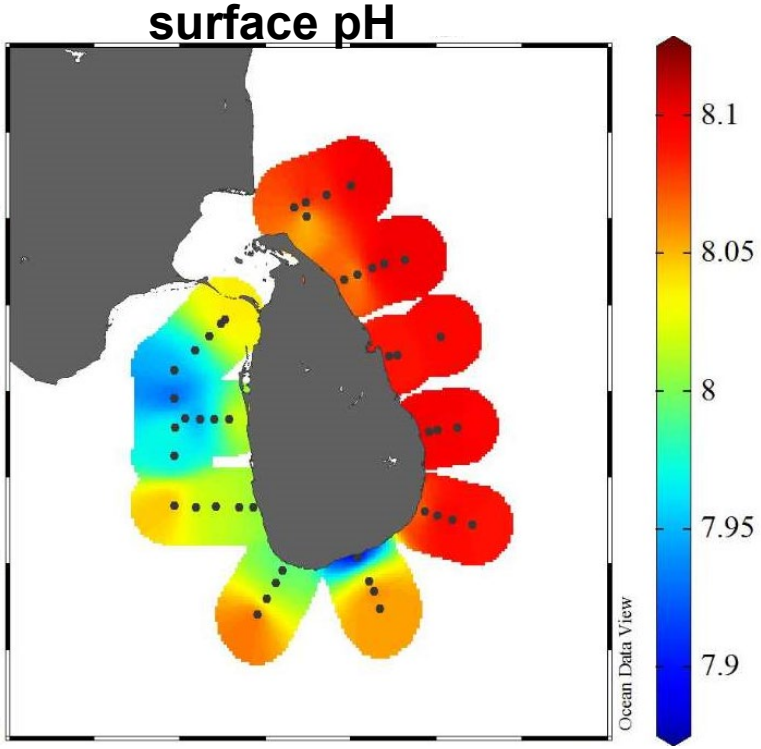
- **Biology:**
  - *chlorophyll* concentration (phytoplankton) can be affected by changes in O_2, pH, or toxic compounds, or by lack of grazing if zooplankton/fish are affected
  - *zooplankton* (prey for many commercial fish species), can be affected by any of the above
  - *fish abundance*
  - *mammals, turtles*
  - *coral reef* ecosystems
  - shallow ecosystems (*mangroves, lagoons*, etc)

For all these parameters, need to know

- Past typical conditions and variability
- Disaster Nowcast: what are the likely conditions right now (build a climatology from existing data, remote sensing, model)
- Disaster “Now-state”: what are the observed conditions right now
- Anomalous conditions resulting from the disaster in subsequent period

All these need to be easily findable (accessible to everyone) and with documented/verifiable data quality

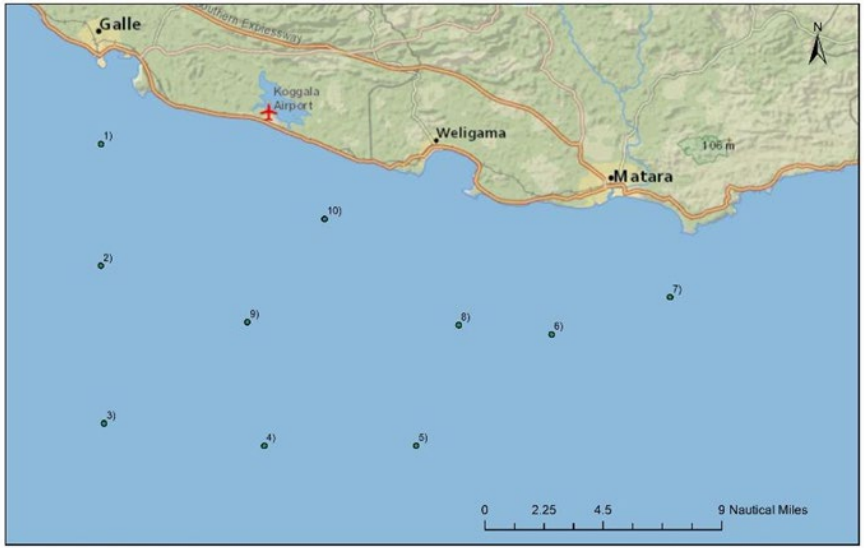
Examples



- Freidjof Nansen measurement (June- July, 2018)
- very valuable measurements
- How typical are these values, how do they vary in time ?
- How does pH change after a disaster ?

Examples

old (?) NARA sampling locations off Galle/Dondra

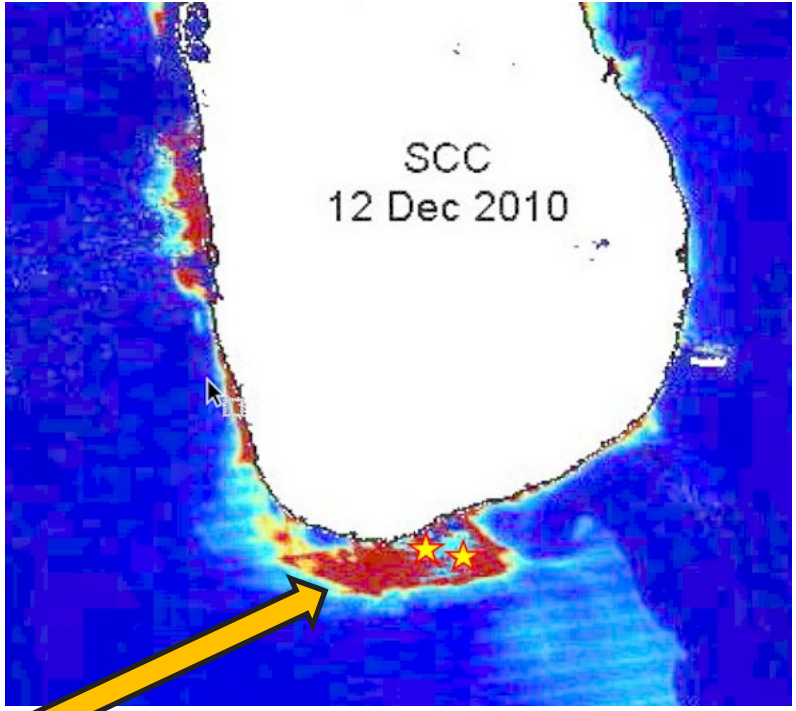


- How frequent ? Does it capture variability ?
- What is sampled ?
- Are the data available right now ?
- Probably only occupied in half of the seasons – what if a disaster occurs in season without data ?
- What does NARA know about the currents there (transport of contaminants) ?

It might be good to build a climatology of typical currents, drift trajectories, etc

Examples

- Complicated natural spatial patterns
- Need to detect impacts from disasters against this background
- Routine monitoring and scientific understanding of the processes is important for that



Chlorophyll satellite image showing upwelling regions

Shipping lane, productive upwelling, fisheries, whales, vulnerable ecosystems ?
(Scripps is now funded for a mooring there)

Method from “Systems Engineering”

1. Specify objectives or “use cases”
2. Derive requirements such that the system satisfies objectives or use cases

Example:

“If an oil spill occurs, we want to predict where the oil will go over the next few days.”

Requires:

- We make observations where the oil presently is.
- We have a numerical model running that predicts ocean currents.
- Model can receive present oil position as input, and use its currents to generate future positions as output.
- …

Example objectives (use cases) for this project

“We want to assess the damage done by a maritime accident (here: pollution).”

- Requires baseline/reference observations to document the “before” situation
- Requires observations of the damaged areas “after” the event
- Observations need to be comparable and with uncertainties documented/understood, so that before/after differences stand out from observational uncertainties

“We want to limit/reduce the damage done by this accident.”

- Requires observing the pollution plume to direct response efforts
- Requires short-term predictions about the spread of pollution
  - Requires a numerical model to simulate and predict currents
    - Requires observations of currents, temperature, salinity as well as external observational data (satellite altimetry, Argo, …) to initiate the model runs
  - Requires communicating the predictions to stakeholders (e.g. fisheries) so that they can avoid the area

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Round-table discussion: potential goals for NARA

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