Breakout 4. Observations Group A

1. **Promising observational advances**
   a. Hyperspectral satellites to study surface e.g. PACE, SWOT
   b. Automated, in-situ sampling
      i. Drones, AUVs e.g. CLIO, ESP, EVPs / flow cytometry, omics
      ii. Self-coordinating and self-localizing underwater swarms
   c. Ocean observatories and LTER networks → generate consistent and prolonged datasets
2. **Prospects for measuring desirable variables**
   a. Subsurface samples (e.g. Chl max, bottom temperature)
   b. Tradeoff between depth and breadth of sampling (temporal and spatial scales)
   c. Targeting physical variables that have predictive skill to inform bgc + ecological forecasts
   d. Shallow (estuaries, intertidal) and benthic habitats
   e. Understanding of lags in physical + bgc processes can be predictive of current state
3. **Leveraging coupled reanalysis products**
   a. Construct physical relationships from reanalysis products we trust and test those in the field
   b. Observations can verify model and models can guide observation efforts
   c. M/Statistical Learning + Process knowledge can fill in gaps in models and observations
4. **Best Strategies for promoting data Sharing and Creation of Integrated Archives**
   a. Short-term: Effective data mining techniques with ML/AI to minimize human time (e.g., NCAR climate data guide)
   b. Long-term/sustainable: Invest in positions/institutions between observationalist and modelers to oversee data standardization and availability → to support coastal re-analysis
   c. Create community standards that can be embraced by existing databases, and enforced by agencies/journals

Breakout 4. Observations Group B

1. **What do you see as the most promising observational advances (technological /programmatic) that can facilitate progress in physical/biogeochemical/ecological forecasting?**

Building coverage in strategic ways (e.g. GoME). Excited about BGC ARGO, expansion to sea gliders; buoys in coastal ecosystems collecting continuous data on temperature, salinity, chla etc.

Satellite observations (e.g., PACE and GLIMR) with different retrieval algorithms (e.g. empirical relation) regionally designed.

Diagnostic variables (e.g., radiative transfer to get surface color) can be coded in models for more direct comparison with observations.

2. **Which variables would be most desirable and what are the prospects for measuring them?**

Benthic flux data (nutrient, oxygen, carbon) in the coastal/continental shelf

Environmental DNA measurements (from water samples) can help to estimate community composition for ecosystem forecasting and the BIO part of biogeochemical whether microbe taxa or functional groups (a gene itself like nitrogen reductase)

3. **Leverage coupled physical/biogeochemical reanalysis products for process understanding, forecast initializations?**

Challenge and improve reanalyses, e.g., GLORYS and ECCO-Darwin, in the regions. In addition to state, want estimates of skill.

Take advantage of renalysis to reconstruct past conditions when we don't have enough observations.

4. **Best strategy for promoting data sharing and the creation of integrated archives across regions and disciplines, with consistent data quality and format requirements?**

Scientist cannot do DAAC, but DAACs need to be infinitely more responsive to scientists needs and not just go off on their imaginary pursuits. Learn the 'ingredients' from the (very few) DAACs success stories. We want easy access to complete, curated data sets, not just individual locations and regions.

Breakout 4. Observations Group C

How can we leverage coupled physical/biogeochemical reanalysis products for process understanding and forecast initializations?

- Comparisons of ocean reanalysis products can be very informative; even though they are assimilating the same data, they can differ substantially.
- Provide information about data uncertainty (and if appropriate potential bias) from the reanalysis ensemble.
- Higher resolution reanalysis products can be helpful in the coastal regions, but it remains a challenge since a lot of coastal data is not assimilated into global models. Intercomparisons between reanalyses can be helpful. Regional reanalyses also useful.

What do you see as the most promising observational advances (technological /programmatic) that can facilitate progress in physical/biogeochemical/ecological forecasting? Which variables would be most desirable and what are the prospects for measuring them?

- BGC-ARGO oxygen and pH data exciting; biases worrisome: need good and standardized methods for correcting for biases in the data.
- Gliders: promising for routine monitoring. Challenging on east coast due to Gulf Stream and more event-focused applications.
- Grazing rates and benthic fluxes needed, but very difficult and expensive to do.
- Real time data critical for initializing nowcasts and short term forecasts.

What would be the best strategy for promoting data sharing and the creation of integrated archives across regions and disciplines, with consistent data quality and format requirements?

- Data access is a problem but it's better than it used to be, especially in the open ocean. Data still hard to find in coastal regions.
- Make data available by APIs that enable reproducible workflows. Copernicus is a good example of how this can be done.
- When possible, standardize measurement methods and units.
- Organize databases with properties that are relevant to end users, such as by variable, rather than properties like project number.
- Can QC and serving data be facilitated by the RAs?

Breakout 4. Observations Group D

- **What do you see as the most promising observational advances (technological /programmatic) that can facilitate progress in physical/biogeochemical/ecological forecasting?**
  - Numerous prospects for improved spatiotemporal perspective on coastal ocean/BGC conditions (gliders, sail drones, drones), though still cost, reliability & coordination challenges to meet..
  - Leveraging industry partnerships (commercial fishing, offshore wind, ships of opportunity)
- **Which variables would be most desirable and what are the prospects for measuring them?**
  - A physical/BGC baseline is a good starting point and tractable
  - Need to take some bold leaps to provide similar spatiotemporal perspective across food web and/or for target organisms (i.e., tags, optics, targeted acoustics, eDNA) but solutions at scale are not yet clear.
  - Need to identify a core set of ecological forecasting variables
- **Leverage coupled physical/biogeochemical reanalysis products for process understanding, forecast initializations?**
  - Ocean will always be data sparse, integration of models and data a critical way forward
  - Difficult to access data sets required to build and evaluate reanalyses locally
  - Contributes to mechanistic understanding challenges, could provide a basis for machine & deep learning approaches.
- **Best strategy for promoting data sharing and the creation of integrated archives across regions and disciplines, with consistent data quality and format requirements?**
  - A big issue - need entities to pull together disparate regional datasets/approaches nationally
  - Not “who should do it?” but “how do we come together to do it?”.
  - A role for Climate Observations and Monitoring program for initial steps toward long-term solutions?

Breakout 4. Observations Group E - online

1. **Most promising observational advances for physical/biogeochemical/ecological forecasting?**
   - Wire-walkers, pop-up buoys, various autonomous instrumentation, *in situ* optical imaging, eDNA/metabarcoding
   - Data management - making data more available on shorter, more immediate timescales (portals, etc.). Storing data on the cloud and reproducible work flows.
   - Issues: scalability of technologies → expense, requirements for "manual knowledge"

2. **Which variables would be most desirable and what are the prospects for measuring them?**
   - Near-bottom variables - esp in estuaries, shelf / coastal zones, fluxes into these regions
     - E.g., oxygen, salinity, respiration and mineralization rates, $CaCO_3$ precip rates, fluxes of carbonate variables
   - Mechanisms & processes in subsurface ocean
     - E.g., Alongshore currents, subsurface profiles / information (physical, BGC, biological) back in time, nutrients, oxygen
   - Dark data recovery - possibilities to use these data to validate reanalysis products, desirable variables
   - Multi-trophic-level measurements

3. **Leverage coupled physical/biogeochemical reanalysis products for process understanding, forecast initializations?**
   - Adjusted temperature tendency due to data assimilation would be useful for heat budget
   - Use parameter changes during calibration of reanalysis products and the variation in parameters in space or time to infer processes that may be driving the need for the variation.

4. **Best strategy for promoting data sharing, creation of integrated archives across regions and disciplines?**
   - Some data repositories do exist (but data are still scattered): NCEI (NOAA), BCO-DMO, LTER sites - EDI (NSF), KNB
   - Across community (agencies, scientists) → need more conversations about interoperability, standardization - lots of work has been done on ontologies, but researchers all structure their datasets differently
   - Accountability for data documentation (metadata creation) throughout collection/curation process → not just initial data mgmt plans, and final data publication efforts