Nutrients Component, from Global NEWS.
TWAP LMEs

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TWAP LME Nutrients Component

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Also leading Nutrients contribution to TWAP Rivers and BOB (Bay of Bengal) LME Level 2 project

**Summary:**

- Ecosystem state and trends based on indicators (Nutrients, Eutrophication Potential)
- Projections to 2030 & 2050, based on a Millennium Ecosystem Assessment scenario
- Ranking of LME's based on nutrients
- Human drivers
Global NEWS 2 Model

**Nutrient Export from Watersheds**

**Nutrient Sources**
- **Natural**
  - N$_2$-Fixation
  - P Weathering
- **Anthropogenic**
  - Non-Point
    - Fertilizer (by crop type)
    - N$_2$-fixation - crops
    - Manure (by animal species)
    - Atmos. Dep. N
  - Point
    - Sewage (pop.; treatment level)

**Hydrology & Physical Factors**
- Global Watersheds
- Water Runoff
- Precip. Intensity
- Land-use
- Slope

**In-River Nutrient Removal**
- Rivers & Reservoirs
  - Consumptive Water Use

**Nutrient Loading to Coastal Waters**

Seitzinger et al. 2005, 2010; Mayorga et al. 2010
Global NEWS 2, Integrated Scenario Development

1. MEA Scenarios
- MEA Storylines
- MEA Population
- MEA GDP
- MEA Crop-livestock production

Global Chemistry-transport models ensemble

Integrated Assessment Model (IMAGE)

- Hydropower Production
- Monthly Temp. and Prec.
- Land Cover Irrigated/Rainfed

2. IMAGE:
- Land Use, Climate, Nutrient Management, Energy, Wastewater

3. WBM$_{plus}$: Hydrology and River Discharge
- Water Balance Model (WBM$_{plus}$)
- Dam Construction
- Consumptive Water Use
- Wastewater N + P Effluent
- N + P Fertilizer Inputs
- N + P Manure Inputs
- Biological N$_2$ Fixation Natural, Agriculture
- N + P in Harvested Crop/Grass Products

NEWS models
- In-stream retention, retention in reservoirs
- DIN, DON, DIP, DOP, DOC, POC, PN, PP, DSi

Seitzinger et al. 2010
Global NEWS 2 output, basin yields for Year 2000

Exports normalized by basin area

Nitrogen (kg N km\(^{-2}\) yr\(^{-1}\))
0   15   40   70   110   190   350   570   880   > 1220

Phosphorus (kg P km\(^{-2}\) yr\(^{-1}\))
0    1    2    5   10    20    50    100   500   > 2000

Carbon (kg C km\(^{-2}\) yr\(^{-1}\))
0   50   100   250   500   1000   2000   4000   8000   > 20000

Mayorga et al., 2010
Nutrient (N, P, DSi) loads to LME's

Total DIN load (Tg N/yr) to LMEs from land-based sources based on NEWS2 model for approx. year 2000 conditions. LME number is indicated.

Also DIP, DOP, PP, TP, DSi

Increases in nutrient loads generally indicative of eutrophication concerns. But depends on nutrient form, nutrient ratios, baseline.
Positive ICEP indicative of eutrophication problems resulting from production of nonsiliceous algae sustained by river inputs of N and/or P in excess over Si, limiting conditions for diatom growth. (ICEP is based on Redfield ratios)

Garnier et al., 2010
Nutrients: Preliminary LME Rankings

LME's ranked in the top 10 largest loading of DIN, DIP, TN, or TP, or largest combined ICEP. Number indicates LME numbering system.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>DIN load</th>
<th>DIP load</th>
<th>TN load</th>
<th>TP load</th>
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</table>

10 individual LME's in the Top 5 rankings:
5 (Gulf of Mexico), 12 (Caribbean Sea), 17 (North Brazil Shelf), 26 (Mediterranean Sea), 28 (Guinea Current), 34 (Bay of Bengal), 36 (South China Sea), 44 (West Central Australian Shelf), 47 (East China Sea), 48 (Yellow Sea)
Challenges: Pacific Warm Pool and River Inputs?

Unlike LME’s, Pacific Warm Pool is defined as starting far offshore. Should river inputs from Papua New Guinea be assigned to it?

All LME's included in assessment, except 3 high-latitude ones with no clear rivers: 61 (Antarctica), 64 (Central Arctic), 65 (Aleutian Islands)
Challenges: Accounting for nutrient ratios AND loads, and LME characteristics

ICEP captures only one aspect of eutrophication potential (nutrient ratios). LME's with similar ICEP values may have very large differences in river loads.

Left side of each plot:
LME 12 (Caribbean Sea) vs.
LME 59 (Iceland Shelf and Sea)

Right side of each plot:
LME 26 (Mediterranean Sea) vs.
LME 44 (West Central Australian Shelf)

Also, normalize loads by LME shelf area or coastal length?
Challenges: Sub-LME regional variability?

LME's are large areas.
Addressing sub-LME river basin export variability – Some possibilities.
Examples from **LME 26** (Mediterranean) vs **LME 44** (W. Central Australian Shelf)

(1) Relative dominance by discharge from a single river

% Largest river / Total LME discharge (parenthesis: LME discharge)
LME 26: 50% (699 km³/yr)
LME 44: 50% (11 km³/yr)

(2) Distribution of river basin ICEP among 3 categories

(3) River basin ICEP (and loads?) histograms
Nutrients: Follow-up work for completion

1. Final, slightly revised year-2000 results
2. Millennium Ecosystem Assessment (MEA) results for 2030 & 2050, Global Orchestration scenario (similar to 2000)
3. Assessment of change trajectories by LME, and hot-spot LME's

1. Pacific Warm Pool results?
2. Development of indicator(s) addressing nutrient loads, nutrient ratios (ICEP), and LME characteristics
3. Indicators and trends based on DIN & DIP (more bioavailable) vs TN & TP
4. Normalization or clustering of indicators for comparability to indicators from other TWAP LME components?

1. Assessment of sub-LME variability?
Nutrients: Interactions with TWAP Rivers

- Consistency: All results derived from the same Global NEWS contemporary and scenario outputs (scenario results available shortly)
- Risk Categories (indicators) derived from published N & P concentration thresholds
  - Not directly applicable to LME work, when based on river exports
  - TWAP Rivers currently analyzing indicators used across components, to come up with common, well founded recommendations

- TWAP LME project includes **all** LME's, including ones associated with single nations (e.g., in Australia, New Zealand). But Rivers TWAP project is limited to basins that are multi-national, strictly speaking.