CoML Scenarios
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Aim: Raise considerations (check-list) for future-oriented thinking in CoML studies and analyses
Major elements of change or Master Trends

Oceans will experience:

• More crowding
• Increasing transparency
• Decreasing anonymity
• Rapid (accelerating) environmental change
Master Trend #1: Ocean Crowding

More uses, more users

Drilling derricks

Wave energy machine (concept)
Crowding: Coastal development, 2002 & 2050
Most coastlines highly developed by 2050
Crowding

A big industry extending down Margins: Offshore Oil & Gas

- Seismic testing
- Drilling
- Subsea Facilities
- Production Platforms
- Subsea Tiebacks
- Many remotely operated vehicles (ROV’s)
Offshore oil & gas: Large scale of subsea areas

Gulf of Mexico
Independence Hub’s subsea reach overlayed on a map of DC

Red circles indicate linked seafloor colonies of square mother hub with surface platform
Offshore oil & gas: Extensive, complex pipeline networks

Gulf of Mexico Pipeline Network
Gas-rich Continental Margins with exaggerated bathymetry – regions of growing exploitation

Source: Census of Marine Life Continental Margins project
Crowding: Growth in maritime transport

Ships > 100 Gross Tons

1960: 36,300
2007: 97,500

Crowding: Maritime Transport
Time lapse tracks of vessels > 300 gross tons, 2009
Busy highways but also areas with few vessels

Note areas of almost no surface shipping in East/South Pacific & Southern Ocean.
International shipping: Port traffic & trade routes - Indo-Pacific has taken lead

The blue lines represent major trade routes and are proportional to the traffic.

Total traffic in thousand tonnes in 2003:
- 50 to 70
- 70 to 100
- 100 to 150
- 150 to 250
- 300 to 350

Crowding: Subsea telecommunications cables
Crucial for domestic & int’l communications
Satellites could pick up <10% of capacity if lost
Crowding: Where? Latent demand for electric power

- Increases in light flux if everyone outside the USA lit like USA
- Red indicates increases in demand

Demand will grow steeply in Indo-Pacific

Source: Nadja Makarova Victor & Jesse Ausubel, 2004
Master Trend #2: Decreasing Anonymity
Automatic ID System (AIS) Vessel Tracking

Partly required, partly voluntary by operators, freely available on-line
Decreasing Anonymity:
Can zoom from basin to vessel info

Systems likely to become ever more complete, now
Focused mainly on vessels > 300 GT
Decreasing Anonymity:
For illicit activities like piracy or smuggling drugs & human cargoes, the cops & robbers game rises to more sophisticated levels.

Vessel tracklines over time near the Straights of Gibraltar.
Decreasing Anonymity: 
Google Earth / Oceans 
Whales lose privacy too
Master Trend #3: Transparency - but today most of ocean is still unobserved

Red indicates high density of reliable, documented observations of marine life at the species level in the largest what/where database on marine life (20 million records)
Especially unobserved: The South and Eastern Pacific

Red indicates dense archived records, white no archived records of marine life

5 & 1 degree scales – at fine scales, even more empty boxes

Notes:
The es(50) example shows how many areas are inadequately sampled, but at the same time shows that these are areas just next to areas where the estimated biodiversity is very high. Both are done with ArcView, with the projection 'View from Space', centred on -30, -150.
Master Trend 3: Increasing Transparency
Economic & environmental concerns increase ocean monitoring with a multitude of sensors & platforms

Proliferating undersea webcams with ever better resolution already show sea life and whatever is in view on the Internet
Transparency:
Sea floor observatories with power supplies

$0.5$ billion US National Science Foundation “Ocean Observatories Initiative”, comparable efforts outside USA will put in place dozens of facilities…
Transparency: Drifting floats
~1200 buoys report sea temperatures
Transparency: Ocean gliders
part of movement to unmanned vehicles

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The Mission

On April 27, 2009, students and scientists from Rutgers University launched a small underwater robotic glider off the coast of New Jersey. The glider was christened The Scarlet Knight by Zdenka Willis, director of the U.S. Integrated Ocean Observing System. While previous explorers like Columbus and Lindbergh used boats or planes to cross the Atlantic, The Scarlet Knight will attempt to be the first underwater robot to cross the Atlantic Ocean. With help from a number of international partners, students from the Coastal Ocean Observation Lab will pilot The Scarlet Knight Glider on its eight-month voyage.

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Where is The Scarlet Knight Today?

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READ MORE

Track The Scarlet Knight on your own computer in Google Earth

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Toggle Ocean Temperatures

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Fish E-Z Pass: Detailed plans now exist for many regions...
Master Trend 3: Transparency ties to Wide-open access to information (Google-Wiki-Napster)

• General Movement to Universal Access to Recorded Information
• Environmental concerns press for real-time access to much environmental info
• Lots of “free-lance” bottom-up distribution of sensors, linked through internet, analyzed by crowd-sourcing (“Galaxy Zoo” for oceans)
• Lots of homemade hardware enters the seas
Transparency: More freelancers - Home-made subs

Self-propelled Semi-submersibles proliferate
Master Trend 4: Rapid Environmental Change

• Physical and chemical
• Biological
• --more frequent & severe storms
• --circulations patterns change
• --acoustic properties change
• --sea level gradually rising 0.5 meters
• --ice-free seasons in Arctic
Physical & chemical changes

- Circulation patterns (currents, oscillations)
- Water temperatures
- Ocean stratification
- Coastal upwelling (anoxic zones)
- Storm intensity or frequency
- Acidity (which also changes sound properties)
- Sea level
- Salinity
- Fertilization alterations (intentional and unintentional)
- River outflow and sedimentation
- Pollution
- Ice cover
- Human additions of noise in ocean
- Urbanization of coast lines and coastal development
- Sediment transport and accumulation
- Recovery time from man-made or natural damage
Physical change example: More noise added

- Continuing human additions of sound 3db/decade (2x power)
- Affects animal behavior
- “Acoustic daylight” allows discovery of many phenomena, especially at close range (50-100 meters)

Swimming Diver

Source: Buckingham
Physical change example:
Storm surge vulnerability and Sea level rise
East Asia

[Map showing inundated areas in East Asia with a legend indicating 6 Meter Inundation]
Physical change example:
Sea level rise, storm surge vulnerability:
Southeast US and Gulf of Mexico
Physical change example - Arctic Ice Loss: International Shipping: New Polar Trade Routes?

Arctic ice melt is opening up the Northwest Passage to potential commercial sea traffic.

(This satellite view from above the North Pole illustrates where the routes would travel.)
Rapid Environmental Change: Biological Aspects

- Declining wild fish catches
- Increasing aquaculture
- Changes in harvesting of specific species
- Changes in harvested areas
- Food web changes, trophic cascades
- Shifts in diversity at population, species, genetic levels
- Species extinction, population extirpation
- Species distribution: contraction, expansion, range shifts
- Changed traffic patterns of animals, migrations
- Invasion of alien species, introduction of exotic species
- Changes in nutrient cycles
- Changes in habitat provision
- Changes in surface primary productivity and carbon fluxes to the seafloor
- Increased variation in ecosystems (due to range shifts, altered food webs, invasive species, over-harvesting…)
- New species discoveries—1 million still to be discovered?
Example: Environmental changes from fishing

Reduced size of catch by recreational fishermen in Key West, an emblem of the fast-changing oceans

Source: McLenahan, 2009
Rapid Environmental Change: Societal aspects

- Technologies used for fishing (e.g., trawling, nets)
- Technologies used for marine transport (possibility of quieter propulsion, faster dispersal of fouling species)
- Offshore development: Wind farms, offshore oil and gas platforms, wave energy facilities (increases or decreases in offshore structures, aggregating devices, artificial reefs)
- Seabed mining
- Night-time illumination at sea (from offshore structures, etc.)
- Marine cargoes (more or less oil transport and spills, etc.)
- Marine debris
- Human diet (more sushi or less seafood?)
- Changes in centers of consumption (associated with differential population and economic growth)
- Urbanization of coastlines—sedimentation, sewage, contaminants, hypoxia, habitat destruction
- Changes in tourism (including cruise ships, ecotourism)
- Accuracy of forecasting ocean conditions
- Public concern about the oceans
- Effectiveness of national ocean governance
- Effectiveness of international ocean governance (including High Seas)
- Changes in marine protected areas, more marine reserves
- Installation of ocean observing systems Scientific collaboration on marine biodiversity research (increased?)
- Support of ocean sciences and particularly biodiversity research
- Open-access to primary and secondary data online as normal practice
But...uncoordinated, complex ocean governance, e.g., USA

Uncoordinated sectoral ocean governance. A cacophony of activities, most regulated by separate federal agencies, crowd ocean waters in the Gulf of Maine. A federal public trust doctrine extended to all U.S. ocean waters would identify these agencies as trustees of the U.S. ocean public trust, unifying them for the first time under a common mandate to manage marine resources sustainably. LNG, liquified natural gas; OPAREA, Operating areas.
More enclosure & complex jurisdiction – including Exclusive Economic Zones (EEZs)

- United States: 11.3
- France: 11.0
- Australia: 8.1
- Russia: 7.5
- Indonesia: 6.1
- Canada: 5.6
- Japan: 4.5
- New Zealand: 4.0
- UK: 3.9
- China: 3.8
- Chile: 3.7
- Brazil: 3.6
- Kiribati: 3.4
- Mexico: 3.1
- India: 2.6
- Denmark: 2.5
- Norway: 2.3
Ocean real estate with unsure sovereignty

Expanded “EEZ’s” possible (in blue) under provisions of the UN Convention on the Law of the Sea
The top of Earth could get hot.
Collective impact of all master trends:
Majority of surface oceans now experience high impact from mix of coastal & maritime activities; impact likely to spread, deepen

http://www.nceas.ucsb.edu/GlobalMarine