Proposed Process for Lower Columbia River and Estuary Indicator of Ecosystem Condition

1. Identify goal, objective, actions and assessment questions of interest to resource managers. (*Science Work Group [SWG]*)
2. Identify candidate indicators for each assessment question. (*SWG, April 4-5 workshop of key RME investigators, other working groups for specific indicator portfolio, e.g., indicator species*)
3. Determine relevance of indicators to both assessment questions and to ecological structure/function using screening criteria (*SWG, April 4-5 workshop of key RME investigators*)
4. Determine which are core indicators and provide rationale for each (*SWG and April workshop*)
    a. Does it help answer multiple questions?
    b. Is there a known natural variability (preferred low variability) for the indicator (in order to distinguish extraneous factors from a true environmental signal)? Variability includes measurement error, temporal variability-within the field season, temporal variability-across years, spatial variability and diagnostic capability. Do we need to sample disturbed sites to determine variability?
    c. Long term dataset exist for trends and assess variability/ status
5. Determine population of interest (using Classification) for each core indicator and minimum number of sites (*SWG, Indicator Steering Committee*)
6. Determine what specifically we measure (metrics), frequency of sampling and sampling period (*SWG, Indicator Steering Committee*)
7. Establish analysis methods, quality control and data management (*SWG, Indicator Steering Committee*)
8. Match available funding and projects to list of core indicators (*SWG, Indicator Steering Committee*)
9. Test each indicator for variability (temporal- within season and year, inter-annual, spatial) (*SWG, Indicator Steering Committee*)
10. Determine thresholds for indicators (*SWG, Indicator Steering Committee*)

Human and program dimension portfolios of indicators will be developed by Board of Directors and Science to Policy workshop in 2013.

Process for Puget Sound Partnership's Development of Dashboard of Ecosystem Indicators

1. Established Steering Committee, called Indicators Action Team (IAT).
2. IAT identified objectives and six goals for indicators, which consisted mostly of status and trends type indicators. AEM indicators under separate process.
3. Literature review of ~5 previous indicator systems developed for Puget Sound (>250 indicators in one system alone), combined the systems, eliminated redundancies and organized by six identified goals, focal components and attributes.
4. IAT then categorized candidate indicators by specificity and sensitivity through a screening process, leading to 20 "final" indicators that fall into three portfolios: natural dimension, human dimension and program dimension. Some of these were chosen because they were iconic species (wild Chinook salmon and orcas) or presence of historic data (herring in place of jellyfish).
5. Indicators were based upon best professional judgment of IAT members, and external input was not widely solicited.
6. Next steps involve peer review and more public involvement.

Process followed for NMFS Integrated Ecosystem Assessment for the California Current pilot (2010)

- **Scoping:** Identify management objectives, articulate the ecosystem to be assessed, identify ecosystem attributes of concerns, and identify stressors relevant to the ecosystem being examined.
- **Indicator development:** Researchers must develop and test indicators that reflect the ecosystem attributes and stressors specified in the scoping process. Specific indicators are dictated by the problem at hand and must be linked objectively to decision criteria…etc.

1. Developed an Integrated Ecosystem Assessment (IEA) team that worked with regional managers to identify list of drivers, pressures and components for phase 1. IEA team binned drivers and pressures into 11 broad categories: shipping, freshwater habitat issues, coastal zone development, fishing, invasive species, naval exercises, aquaculture, energy development, marine habitat disturbance, oil spills, and climate change.
2. IEA team binned components into seven categories: wild fisheries, seafood, protected resources, habitat, ecosystem health, vibrant coastal communities, and scientific knowledge and education.
3. For 2010 pilot, IEA team selected subset suite of components: groundfish (representing fisheries), salmon (representing protected resources), green sturgeon, and ecosystem health.
4. The IEA team performed a literature search on marine indicators and developed a set of screening criteria to evaluate candidate attributes and indicators (following Levin et al. 2010):
    a. primary considerations – scientifically sound, relevant to management questions, predictable, etc
    b. data considerations – concrete and numerical, historical data available, operationally simple, broad spatial coverage, etc
    c. other considerations – accessible to public and policy makers, leading or lagging indicator, historically reported, used elsewhere, etc.
5. Indicators were primarily evaluated on the primary considerations and number of evaluation criteria supported by peer-reviewed literature. From these the IEA team then selected a limited set of attributes for each component and then a subset of key indicators (subset of top quartile):

Component	Attribute	Indicator	
Groundfish	Population size, Population condition	Pop size - abundance in bottom trawl surveys, population growth rate, # of species below management thresholds	Pop cond – age structure of populations, spatial structure of populations
Salmon	Population size, Population condition	Pop size – spawning escapement, population growth rate, hatchery contribution	Pop cond – age structure, spatial stock structure, size at age
Green sturgeon	Population size, Population condition	Pop size – spawning escapement, juvenile	Pop cond – age structure, spatial stock structure

		abundance	
Ecosystem health	Community composition (structure), Energetics and material flow (function)	Comm. comp - zooplankton species biomass anomalies, taxonomic distinctness (average and variation), top predator biomass, and seabird annual reproductive output	Energ. Mat. Flow - chlorophyll *a,* inorganic nutrient levels (phosphate, nitrate, silicate).