Framework for a Unified Monitoring, Assessment and Reporting Program (UMARP) for the Bay-Delta
2010 Report

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Fundamental elements of the UMARP

- **Track implications of major water and environmental management decisions and other potential risks or stressors.** (Have management changes done what we expected them too? Are implications of climate change proceeding as predicted? What benefits from ecosystem restoration).
- **Cut across disciplines and institutions**
- **Coordinate data from existing programs where relevant to Grand Challenges.**
- **Identify (and fill) data gaps.**
- **Assure ongoing interpretation.**
- **Assure regular reporting to the public and policy community on status and trends.**
- **Development and evolution of the strategic plan occurs in collaboration with the wider community.**

Four grand challenges that a UMARP must address

- **To understand how the ecosystem is changing in response to changes in infrastructure and water management actions;**
- **To understand how the ecosystem is changing in response to ecosystem restoration activities and to changes in regulations and rulings to protect the environment;**
- **To understand how the ecosystem is changing in response to external changes in human activities like population growth, changes in land use, changes in agricultural runoff, and inadvertent importation of exotic species;**
- **To understand how the ecosystem is changing in response to exogenous processes (climate change, sea level rise, ocean processes).**

Scope

- UMARP: Performance Measures (PM), targets and explanations: Link science to PMs
- Goals: Monitoring/assessment/reporting plan is different from a recovery plan
- Ecosystem: Structural attributes; Key species & processes; Status, trends of important environmental attributes (IEA's).
- What, when & where: Constrain to a manageable number of indicators, metrics and measurments;
- Indicative of what we expect to change: short term & long term
- Geographic constraints defined by IEA

Coordination

- build a sense of common purpose among the distributed programs
- build a sense of common ownership of monitoring data across the Bay-Delta and its watershed.
- Identifying a unified set of data, of value to all institutions, may help institutions set priorities in their programs and identify data that provide links to other monitoring efforts.
  - Once the unified core of data needs is established it will thereby be in the interest of all programs to sustain that core
- Build communication with the existing programs in a participative atmosphere.

Interpretation

- Interpretation is an annual expectation; change from present *ad hoc* approach
- Questions build from the Grand Challenges.
- Questions can change through time.
- Each metric will be interpreted relative to its history.
- Indicators will be intepreted relative to legal and administrative targets.,
- Indicators geographically comparative where appropriate.
- Interpretations also compared to a predicted value based upon conceptual or quantitative models (e.g. Delta smelt’s geographic distribution at different life stages compared to what is predicted from the model that employs salinity, turbidity and temperature to predict distribution, or habitat area, of delta smelt).
- Ecosystem view attained by intepreting across all IEA’s

Reporting

- Regular reporting to the public and passing information to managers in a way that has value
- Equal priority to data collection and technical interpretation
- Goal: provide a context for understanding environmental change in the Bay-Delta and its implications
- Resources (people, time and money) must be dedicated
- Goals of the UMARP also require addressing broader questions than just those that drive the report cards
- Precedent from elsewhere (Moreton Bay):
  - Accessed via a geographic display; a theme-based display (e.g. a structural aspect of the ecosystem, or a set of key processes) or an attribute-based display developed from the conceptual models…next step

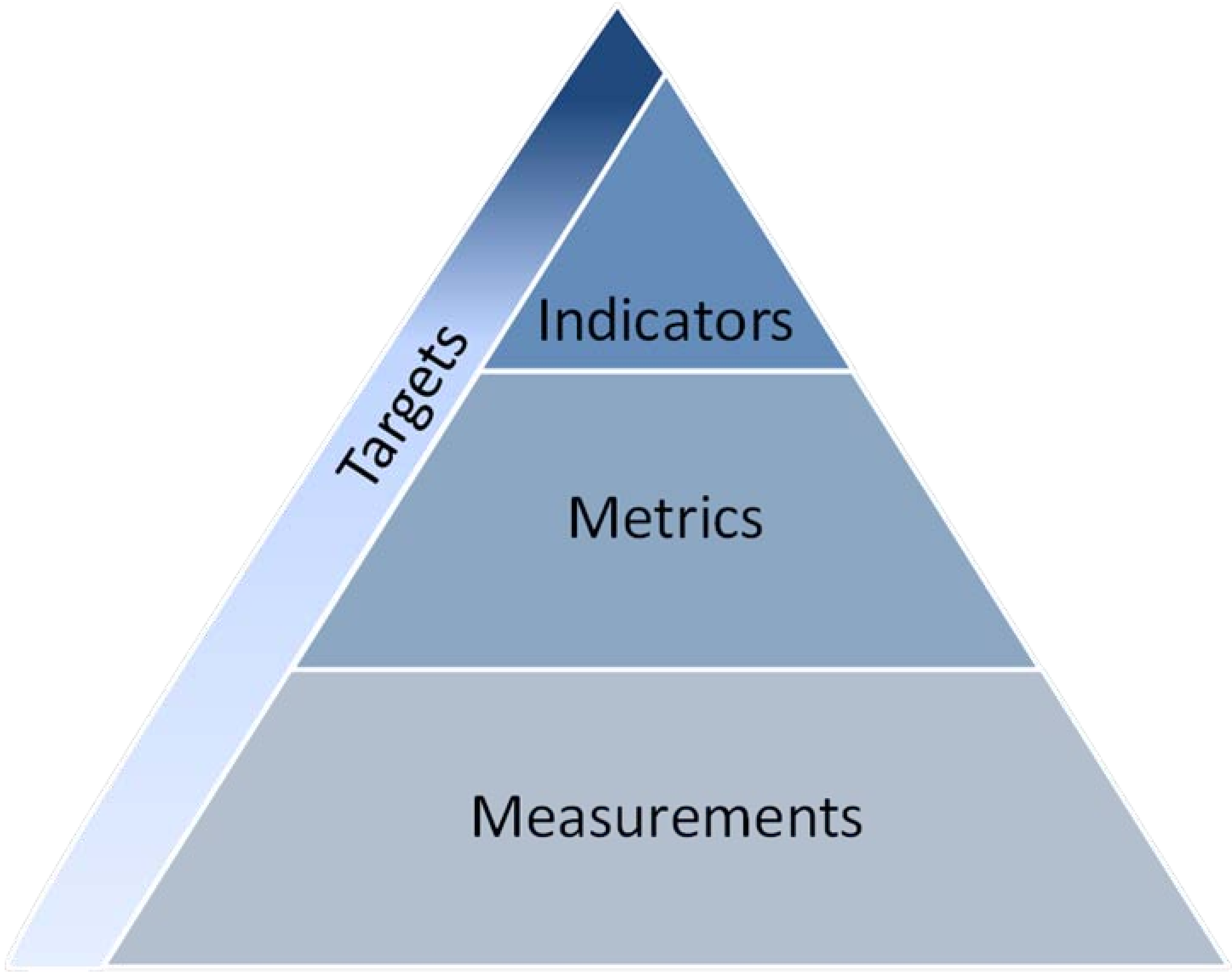


Figure 1. Hierarchy of Indicators, Metrics and Measurements for Important Environmental Attributes (IEAs). Targets can be set for each IEA measure.

Indicators, metrics, variables, [targets]

- *Indicators* are interpretable in policy-relevant terms; the interpretable measure of an important process in the system.
- *Metrics* are status and trends relevant. They are the composite measures that goes into the interpretation.
- *Measurments* are the actual determinations in the field that make up the metric.
- *Targets* are the goals set for an indicator.

Tiered indicator strategy

- Tier 1: Trends in the most important environmental attributes (IEAs) of the system.
  - The few simple IEAs suggested by some of the indicators literature (Florida, Chesapeake Bay)
  - AKA: “performance measures” for policy makers
- Tier 2: Explain trends (e.g. Dennison et al)
  - Tell the “story” for each IEA
  - Larger number of indicators but manageable
  - Capture key processes and key spatial/temporal granularities of ecosystem
  - Tie science to performance measure system

Characteristics of chosen I, M, M

- Responsive to changes in the environment (refer to the grand challenges).
- Amenable to long-term data collection.
- Vary across the environmental gradients of the system or with expected changes in the system.

Indicator: Feasibility

- Indicators/metrics for which data already exists are attractive, but new opportunities also recognized…categorize choices
- ***Type one:***
  - **Long-term database exists for the variable(s).**
  - **Metrics have been calculated and trends established**
- ***Type two:***
  - **Methodologies are established and data are just beginning to be collected?**
- ***Type three***
  - **Monitoring methods would require additional development, although research has demonstrated feasibility.**
  - **Interpretations of metric expected but no experience.**
  - **e.g. Acoustics; otolith; fish flux if to do better**
- ***Type four***
  - **Research necessary to establish feasibility for monitoring.**

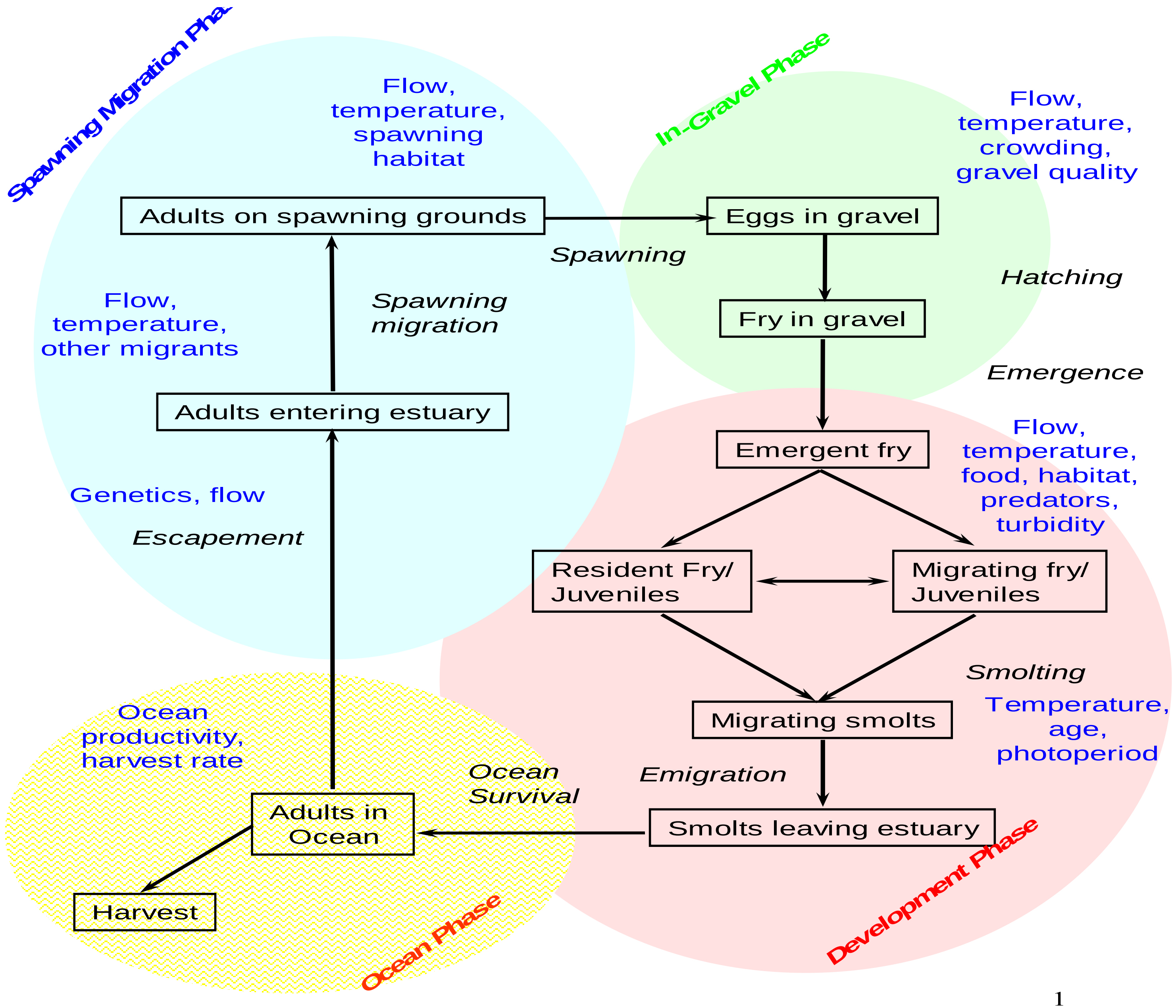
Indicator relevance?

- Obviously fits monitoring goals as defined above
- Think might be useful but need to know more about how it fits into attributes of system; model available so don’t need continuous monitoring.
- Don’t need to monitor because not directly related; indirect relationship can get at in another way.
- Would be nice if we had all money in the world but is either not a sufficiently important environmental attribute or is technically or economically infeasible.

Performance Measures: Tier 1

- ***Important Environmental Attributes* (IEA),**
  - **Key ecosystem attributes**
    - key assemblages (e.g. zooplankton), invasive species, primary producers, water quality, hydrology.
  - **Species central to policies**
    - Anadromous salmonids;
    - Native and commercially valuable fishes: represented by delta smelt, longfin smelt and Sacramento splittail (plus striped bass)
    - Sturgeon – Benthic food web
  - **Combined IEAs: ecosystem attributes (PMs) that are integrative and relevant to policy**
  - **Explanatory aspects for each IEA status and trend: Tier 2?**
    - **Essential to establishing policy choices**

IEA: Anadromous Salmonids



Tier 1: Important Environmental Attribute of the Delta: Anadromous Salmonid fishes @ Ecosystem scale

Issues: All salmonids	***Assessment: Indicators***	***Evaluation: Metrics***	***Measurements***
1. Population trends in streams: each ESU	Annual production[1]	Size of spawning population	a. Numer of redds; (weekly counts) b. Carcass surveys
2. Migration corridor: Reach specific survival	Fish flux[3]	*a.* Number of fish passing a selected location per day; b. progressive counts landward-to-seaward; c. Survival between sampling points.	a.Rotary screw traps (Tribs & Red Bluff-Winter run); b. Trawling (Sacramento, Freeport; Yolo Bypass;Mossdale, Chipps Is.) c. Acoustic tag experiments[2] d. pattern recognition[5]
3. Movement of salmonids through the Delta	Run and reach contribution to migrating salmonid populations at different times Fall run access to Bay: Sacramento R. Adult migration corridor: SJR	a. Number & size at date; b. Genetic analysis[5] c. Survival through Delta Sacto R.: % time OMR is negative 10 d with inflows >1/3 of exports in Sept. & Oct.?	a. Counts & size of fish in traps and trawls; b. Otolith microchemsitry Sac R. flows at Rio Vista; Delta Cross channel,; OMR flow; Exports relative to inflows at Vernalis
4. Suitability of Estuarine Nursery	a. Delta rearing; Delta mortality	*a. Fish per unit time* migrating seaward at Chipps Island compared to fish entering the Delta (mortality). **Once per year:** . *Otoliths to characterize growth & identify % fish that reared in Delta.*	a. Chipps Island salmon numbers by race and origin; b.Mossdale (Sacto R.) outgoing numbers; c. Outmigrants from Red Bluff; Acoustic tag experiments e. Otoliths: Sr/Ca, growth, how long in Delta
5. Ocean factors	Ocean conditions Ocean Harvest	Stage of PDO; El Niño; all ocean climate indices	Ocean factors used to calculate Pacific Decadal Oscillation and other major

UMARP for each tributary

Purpose	**ASSESSMENT**	**EVALUATION**	**MONITORING**	**Feasibility & Relevance**
	INDICATORS	**METRICS**	**MEASUREMENTS**	
Salmonid abundance in each tributary**	**Escapement: trend through time**	**Size of spawning population (annual)**	**Number of redds (weekly counts); Carcass surveys**	**1, 1**
Fecundity	Egg production; Reproductive potential	a.Number of spawning females b.Fecundity c.sex ratio	Abundance, size, age, gender, condition	1, 1
	Hatchery contribution	Hatchery releases	Number of hatchery fish released	1
Reproductive success	Outmigration	a.Juvenile outmigration b. hatchery fish/total juvenile pop.	Number of outmigrating juveniles (e.g. screwtrap number or index)	1
Population projections	Future population size	Calculate from number of two year old “jacks” fish	Adult: abundance, size, age, condition	1

Ecosystem Attributes: Tributaries

IEA	**Indicator**
Hydrology	Precipitation
	Contribution of snow pack
Flows	Internal role of reservoir storage
	Extent and duration of inundation below reservoirs
	Dewatering
	Temperature
	Diversions and impediments
	Biological suitability & habitat
Suitability of habitat	How much habitat suitable for spawning
	Stream habitat (adequacy for salmonids)
Stressor: Hatcheries	Influence of hatcheries
Stressor: Contaminants	Pesticide inputs

Important Environmental Attributes: Stream Ecosystem

IEA	ASSESSMENT	EVALUATION	MONITORING	Feasibility & Relevance
	INDICATORS	METRICS	MEASUREMENT	
Hydrology	Precipitation	Cumulative daily totals	Areal over watershed (DWR)	1
	Contribution of snow pack	Annual cumulative total snowfall Water content of snow	Regular snow measurements from DWR	1
Flows	Internal role of reservoir storage	Low points in reservoir storage. When & how often below a certain level.	DWR & BR data	**1**
	Extent and duration of inundation below reservoirs	Reservoir discharge.	DWR & BR data plus USGS downstream gage data	1
	Dewatering	a.Days stream is below critical minimum passage threshold during critical season. b. Flood frequency	Streamflow from gages Studies on adequacy for passage.	1

IEA: Salmonids in Delta

Critical Habitat	*Assessment: Indicators*
Migration corridor: Rivers and Delta	Fish flux toward the sea (juveniles), determined by reach specific survival[3]
	Run and reach contribution to migrating salmonid populations at different times
	Fall run access to Bay: SJR
	Fall run access to Bay: Sacramento
	Adult migration corridor: Connect Bay to SJR
Suitability of Estuarine Nursery	a. Delta rearing
Ocean factors	Ocean conditions

Ecosystem Attributes: Examples Delta

IEA	**Indicator**
Hydrology	Exports: Zone of influence as defined by hydrologic metrics & measurements
Delta Habitat	Turbidity, temperature, salinity
	Carbon exports and balances
	Macrophyte habitat area
	Nutrients/phytoplankton including *Microcystis*
Predation	Indices of predator abundance
Contaminants	Condition index, biomarkers, concentration thresholds

Tier 2: Explanatory: Stressors for Salmonid fishes

Issues: All salmonids	*Assessment: Indicators*	*Evaluation: Metrics*	*Monitoring: Measurements*
7. Hatcheries	Percentage wild fish (compared to hatchery fish)	a. Population hatchery fish. b. Population of wild fish. Ratio: b/a. c.	Coded wire tag in: a. hatchery returns, b. carcasses c. ocean fishery[6]. d. Genetics on samples from salvage, trap/trawl
8. Genetic impacts of management practices	Genetic baseline for each major run.	a. Number of fish in each race identified by genetics. b. genetics of hatchery vs. wild fish	Genetic analysis on archived salvaged, trawl captured or screw-trapped fish: Sampling design needed
8.Exports: Direct	Take at Delta facilities	Take at export facilities/Juvenile production	a.Salvage[7] b. Carcass survey for production c. Fecundity estimates based on size.
8a. Exports: Zone of influence & indirect	Zone of influence of facilities	a.Percent time OMR flows are above negative threshold.	Flows in Old and Middle River
9. Delta access and habitat	Suitable delta habitat	a. Transport and habitat: Flows, turbidity and temperature, when and where salmon are in Delta….Metric is average for Apr, May, June. b. Salmon counts in specific habitats.[8]	**** Network: temperature; salinity, turbidity, instantaneous flows (IF), suspended sediments, ammonia, oxygen : Sutter, Cache slough, Steamboat, Freeport, below Freeport, Delta Cross Channel gates or PC, Georgiana slough flows.
10. Predation	Estimate of predator populations	Large mouth bass, Striped bass, pike minnow	Abundance of predators (when and where?).
11. Impact of harvest	Ocean harvest	a. harvest vs. abundance (% population). b. annual allowable harvest c.Predicted population size at year +1.	a. Commercial harvest. b. Party boat catch data. c. Total salmon production d. Expected ESA escapement
Contaminants	a. Exposure b. Contaminant stress	Exposure metric Health metrics	Concentrations in surrogate biomonitors Biomarkers

Explanation of each choice

Abundance

Why. Track trends in population size through time.
Target: Targets are run-specific and, in some cases, tributary specific. Adequate numbers to open ocean fishery.
How and Where collected: Redds, carcass surveys, screw traps, snorkel surveys. All tributaries, but some differences in methods.

Fedundity and reproduction success

What. Inputs from reproduction and hatcheries, outputs measured by outmigrating juveniles, characteristics of immigrating fish.
Why. Data show trajectory of population. Used in regulating ocean fishery.
Target. None established
How and Where. Keswick and Red Bluff screw traps for juvenile outmigrating Winter Run; screw traps on some tributaries provide data on Fall Run. Hatcheries provide number of hatchery fish returned to the system, carcass surveys provide data on individuals. Future population from number of two year old jacks.

UMARP Framework for Delta Smelt (1 of 2)			
Goal	**ASSESSMENT**	**EVALUATION**	**MONITORING**
	INDICATORS **Running average**	**METRICS** **annual**	**Measurements** **Monthly/individual trawl**
Delta smelt Abundance	Presence in regions over 5 years	Presence in subsets of stations in any of 4 months	Presence in catch of FMWT at 100 stations each of 4 months
Abundance	Average Fall Abundance	Cumulative index from all four months at all stations; Running average over five years	Abundance in catch of FMWT at 100 stations each of 4 months **(BRUCE)**
Life cycle	Larval, juvenile and adult health in different season.	Growth, condition, indices of stress, trophic level = a health metric .	*Length, weight & age from otoliths (= growth rate), condition (histopathology), C & N isotopes on individual fish (use fish captured by all programs).
Life cycle	Larval and juvenile abundance and health distribution	a. Distribution of health metric. B. Number of juveniles + larvae that were lost (fish flux & what proportion of population) from different locations across the zone of entrainment (using probability of loss) . c. Index relative to expected habitat.	20 mm survey…**Wim write-up. Check on success of larval survey and incorporate data if successful or as modified. (WIM)**
Life cycle	Health of juveniles; Stock recruitment; survival through summer. Reduced entrainment risk	Summer index of abundance. Index relative to expected habitat.	Summer Tow net ; adjust sampling to be more smelt specific and cross-calibrate. **(WIM & Bruce)**
Life cycle	Population size.	Index of abundance.	Fall midwater trawl. **(WIM & Bruce)**

UMARP Framework for Delta Smelt (2 of 2)			
Goal	**ASSESSMENT**	**EVALUATION**	**MONITORING**
	INDICATORS **Running average**	**METRICS** **annual**	**VARIABLES** **Monthly/individual trawl**
Life cycle	Reproductive health	Distribution. Fecundity. Intersex.	Spring Kodiak trawl **(WIM & Bruce)**
Physical habitat	turbidity	Habitat area summer and winter	Continuous monitoring of turbidity, salinity, temperature
Physical habitat	Temperature	Habitat area spring	
Physical habitat	salinity	Habitat area fall	Monitoring network
Habitat	Zooplankton Food abundance	Copepod abundance and biomass in Delta smelt habitat as defined above	Zooplankton abundance by species
Take Stressor	Direct mortality at export facilities	Adult salvage Juvenile salvage Salvage relative to fall mid-water trawl and spring 20 mm survey, respectively.	Federal salvage; State salvage **(BRUCE)**
Stressor	Expected take	Expected salvage (adult and Juvenile); interpret salvage metrics above compared to this.	OMR flow; SJR flows. Turbidity (use OMR/turbidity for adults) **(BRUCE)**
Contaminant Stressors	Multi-Contaminant stress	Up and down regulation of sensitive genes	Gene expression profiles. **(MIKE)**

Data management

- Data management is an important part of a UMARP.
- Improved data management, alone, is not sufficient to achieve the desired level of coordination.
- Data management requires decisions on the goals, the audience and the structure of the data management system.
  - The goal: Provide an accessible home for all the monitoring data relevant to the UMARP goals.
  - Audience for the ***raw database of variables and metrics*** is the technical community, although access to the public will also be important.
  - Audience: For the public the most important goal is to provide interpretations of data relevant to answering the Grand Challenges (e.g. “reporting” changes in an indicator over time, and it implications).
- Requires a commitment to good data mgt. by all participants
- Data management systems that are under design provide a precedent for the structure needed to address this need.
- Details will be designed by a committee of experts as the framework and strategic plan are being completed.

Unified Monitoring Assessment and Reporting Program (UMARP): Framework

The framework includes a *description of a core of monitoring* that tracks environmental changes as they occur in the Bay-Delta and its watershed.

Identify the most important attributes of the ecosystem around which we want to focus the UMARP. Develop high priority indicators, metrics and measurements to follow change through time in response to Grand Challenges.

Interpretation of monitoring data (assessment), as well as *reporting* out to the public and passing information to multiple audiences will *have equal priority with data collection*.

The ultimate purpose is a monitoring environment that links a set of performance measures to the science.

S*ufficiently comprehensive* to detect major surprises early in their development and *sufficiently flexible* to serve California's diverse and evolving water management needs.

Identifying a unified set of data, of value to all institutions, may help institutions set priorities in their programs and identify data that provide links to other monitoring efforts. Once the unified core of data needs is established it will thereby be in the interest of all programs to sustain that core.

Next steps

- UMARP Committee
  - Expand depth: ecosystem attributes, other IEA’s, address grand challenges: restoration, climate
  - Incorporate expertise: Nobriga-ecosystem; Cloern-climate change
  - Peer reviewed paper on framework
- Pilot interpretive/reporting approach: postdoc
  - Watershed(s)?