DRAFT

Framework for indicators for science, management and adaptive management in the CALFED Bay-Delta Program

Purpose:
Indicators will be used by the CALFED Bay Delta Program to:

- Inform progress towards program goals
- Help understand cause and effect relationships between actions and outcomes

Indicators will be used to help answer questions such as:

- Is CALFED meeting program goals?
- Is the system working the way that was expected? (e.g. are the outcomes what were expected?)
- Is CALFED doing the right actions – and the highest priority actions?
- Are their other factors influencing the system that can't be controlled, or hadn't been considered?

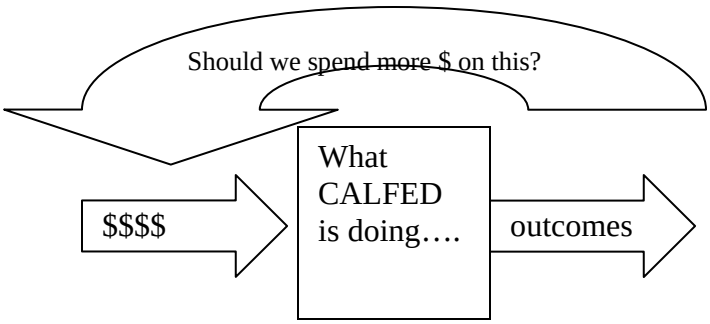
Indicators for different purposes:
In order to effectively manage the system, indicators should be closely linked with conceptual models that describe and document our current scientific knowledge of how drivers and outcomes are related [and program goals??]. A more comprehensive set of indicators at different scales is needed for this purpose. Given the limited resources and the complexity of the issues, a lot of thought will need to go into the selection of these indicators in order to best understand the underlying mechanisms at work in the region, and to provide support for diagnostic capabilities. This more comprehensive and detailed set of indicators (often at different scales) are intended for a technical audience and will assist in making management decisions and doing adaptive management.

A subset of indicators can be used to assess progress and be selected to answer questions directly related to the goals and objectives of the program. This smaller set of indicators should be derived from the more technically detailed indicators and include discussion about factors that are mostly likely affecting the outcome of the system. For example, adult salmon escapement may be used as an indicator to report progress towards recovering salmon populations. To understand the "why" behind this outcome, a much broader suite of indicators is needed, such as proportion of hatchery escapement, age structure of spawning adults, conditions during spawning, rearing and migration, ocean conditions, abundance of juveniles, ocean and inland harvest.

The terms "performance measures" and "indicators" have often been used interchangeably – but this can be misleading. Performance measures are also a subset of indicators that can be used to measure the performance of a particular project, program or agency. One difficulty in choosing performance measures, is that an outcome of particular interest (for example, returning salmon populations) may be affected by many different factors: some that may be influenced by management actions, and some that may not.

Basic Framework: Types of indicators and how they can be used:

In the very simplest sense – we are being asked – what are we getting for the money? An extremely simple diagram is:



Although this diagram may be appealing to the layperson, it is not very useful for determining how to achieve the outcomes, explaining results, or determining more effective means of achieving program goals. A slightly expanded conceptual model would be more useful for explaining the actions taken, and what is happening in the system to affect the outcomes. An expanded conceptual model would also be useful for troubleshooting – identifying barriers and finding more effective ways to achieve outcomes. Below is a description of some general classes of indicators, and a conceptual model of how indicators relate to management, science and adaptive management. This basic framework or approach can be used by the program elements in the development of appropriate indicators.

Types of indicators:
The basic framework includes 3 general "classes" of indicators:

1: **Administrative indicators**: These describe what resources (funds, programs, projects) are being implemented (or plan to be implemented).
Example: Dollars spent, number of projects implemented

2: **Driver indicators** (can also be called "pressures", "management actions" and "other factors"): This class of indicators describe the factors that may be influencing outcomes and may include on-the-ground implementation of management actions (acres of habitat restored) or other factors not directly related to management actions (population growth, weather and hydrologic fluctuations, climate change).

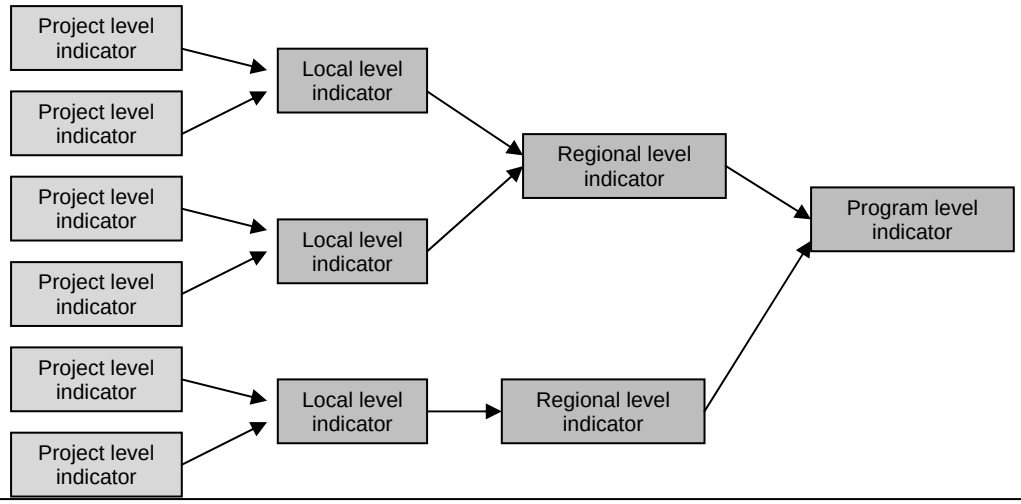
3. **Outcome indicators** (can also be called "response", "ecosystem status" or "results" indicators): This class of indicators describe measurements related to the ultimate outcome of the drivers – and should be closely related to the goals and objectives of the program.

Examples: For water quality, indicators may include measures of public health protection for tap water and cost of treatment. For water supply reliability, indicators may be related to the ability of supply to meet demand. For ecosystem restoration, indicators can be population level of key species, diversity indices, or other indicators of ecosystem status and processes.

These categories are flexible so that the framework can be more easily adapted to the different program elements within CALFED. The distinctions between the categories are not rigid. In some cases, an "outcome indicator" for one purpose, may become a "driver indicator" for another purpose.

These classes of indicators can be used at many different scales. In developing indicators, it is important to consider how indicators at smaller scales can be combined or aggregated to inform larger scale decision making. This will be a challenge for all of the program elements to consider. Figure 1 is a basic diagram depicting indicators at different scales and how they relate to one another.

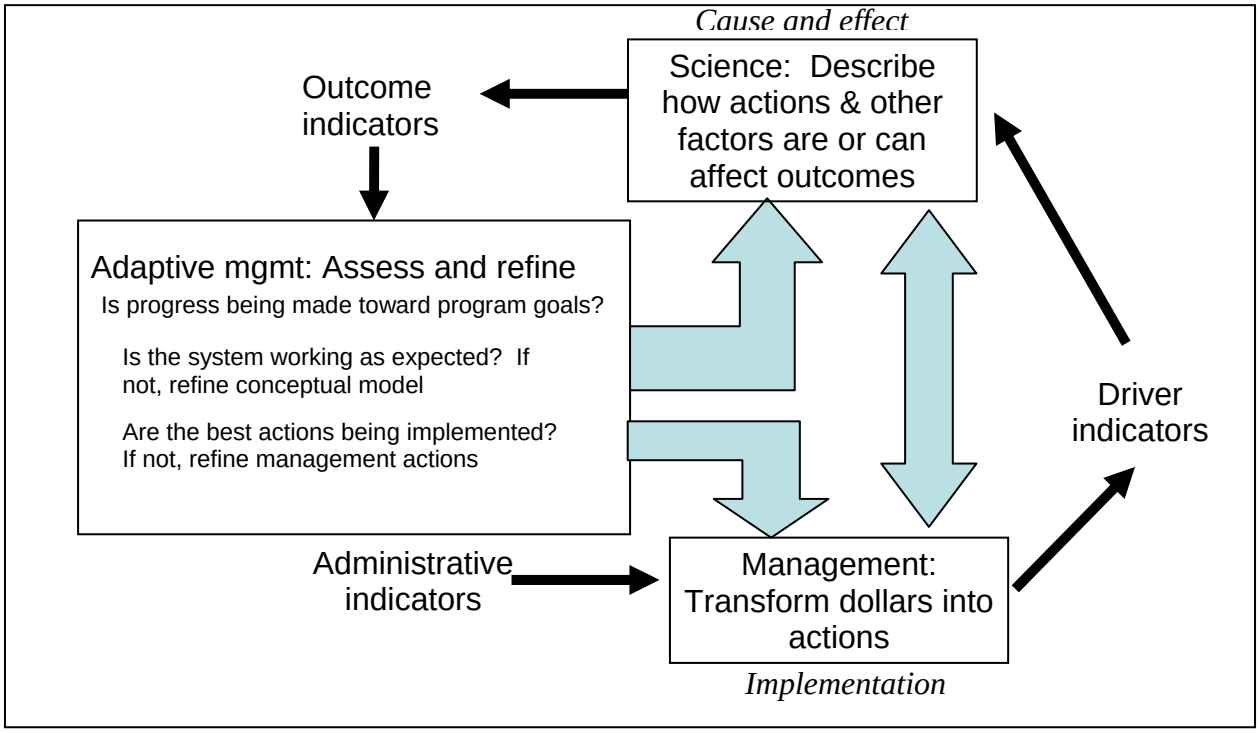
Figure 1: Indicators and conceptual models need to be appropriate for the scale being studied – and be able to "roll up" to inform larger scales.



How indicators can be used to link science, management and adaptive management

The activities of management and the state of scientific knowledge are what links the different levels of indicators. Implementation links administrative indicators to driver indicators, that is money and projects are implemented to achieve certain actions, and indicators can be used to measure what is being accomplished. Actions are taken on the assumption of having a certain effect on an outcome of interest. The relationship between the action (cause) and outcome (effect) provide the link between driver indicators and outcome indicators. Outcomes can be affected by many drivers, including management actions (such as controlled flows) and uncontrollable factors (such as precipitation and runoff). Monitoring of indicators and scientific research play a critical role in understanding the "cause and effect" relationships. Conceptual models can be

used to describe the current understanding of relationships between drivers and outcomes. Explicit conceptual models, quantitative models, and data assimilation tools can be very useful for documenting our knowledge of "cause and effect", identifying areas of uncertainty, and attempting to predict outcomes of management actions. Outcome indicators are essential for adaptively managing the system – they are the basis for assessing progress toward goals, and evaluating whether we need refinement of management actions or conceptual models.



Management decides on implementation actions

Management entities essentially make decisions about how to use administrative resources (funds, staff, etc) to implement management actions. Hence management is the linkage between administrative indicators (such as dollars) and driver indicators (implemented management actions). These implementation activities might include:

- allocation of funds
- selecting program priorities and developing solicitations for proposals
- selecting projects and contract administration
- project implementation and performance

When making decisions, management base their decisions on either implied or explicit "conceptual models" of how the system behaves and what expected outcome the management actions will have. Explicit conceptual models can be beneficial for management decision making for the following reasons:

- documents the rationale for making a specific decision related to the expected outcome

- allows multi-disciplinary review and discussion of the conceptual model, which allows a more comprehensive understanding and reduces the chances of faulty reasoning or unintended consequences
- provides a basis for incorporating new information and continually improving our understanding of how the system works

It is also important to realize that there is a time lag in order to carry out implementation. A typical time frame for implementation, from fund allocation to project completion, is probably 5 to 6 years. It may be much longer for multi-phase projects, such as a restoration project that includes acquisition, planning, environmental review, and construction. Following construction, it may take many more years before the ecosystem responds with a measurable outcome (for example it may take years to decades before salmon spawning habitat has a measurable effect on returning adult salmon populations.)

Science describes cause and effect

The relationship between management actions (measured by driver indicators) and the outcome of the actions is based on assumptions or understanding about "cause and effect" between drivers and outcomes, which is informed by science (the term "cause and effect" is used very broadly here and does not infer that there is a specific documented causal relationship, in a scientific sense). In choosing to take an action, there is an expectation or assumption of an expected outcome. These choices are based on a current understanding of how the system works or might respond to some controlling factor. Conceptual models are a graphic and/or visual description of how we believe the system works and how the outcome or response might be affected by the controlling factors. These "conceptual models" may also be quantitative or predictive models. Research and monitoring activities are essential to develop and refine conceptual models.

To optimize the linkage between drivers and outcomes, the conceptual model should be:

- as explicit and complete as possible, or as needed for the situation
- based upon the best available science
- consider all of the controlling factors, including potential management actions and other environmental or uncontrollable factors that may influence the outcome
- be a basis for discussion of expected outcomes from different management scenarios, including acknowledgement of uncertainty (lack of understanding) and unpredictability (uncontrollable and unpredictable factors such as weather)

Some typical frameworks for conceptual models that describe environmental outcomes include the pressure-state-response model, or the driver-linkage-outcome model. Either type of conceptual model may be appropriate for linking drivers and outcomes, as may other frameworks. The Driver-Linkage-Outcome (DLO) framework for conceptual models includes an analysis of all of the drivers, their interrelationship, and how they are likely to affect the outcome. The Pressure-State-Response (PSR) framework for conceptual models is similar but is a simplified and more linear version that focuses on one driver (pressure) and its relationship to an outcome (state). PSR conceptual models may be more appropriate for simple linkages between drivers and outcomes, or where one is interested in the effects of a specific management action. DLO conceptual models

are necessary to understand outcomes affected by many factors (such as adult salmon returning to spawn), or can provide a broader context for a number of PSR sub-models.

Adaptive management:
Indicators can be useful tools for facilitating adaptive management, by helping to answer the questions:

- Are we meeting program goals?
- Is the system working like we expected?
- Are we doing the right (and highest priority) management actions?

It is critical to monitor and evaluate the response of the system to management actions, as well as other controlling factors that may be affecting the outcome. This evaluation can help identify the need for refinement of the conceptual model, or underlying assumptions in taking management actions, as well as identify a changing system where new and uncontrollable factors may suddenly emerge and affect the desired outcome. If the outcome of management actions (or inaction) is different than expected, there is a need to evaluate the assumptions (i.e. underlying conceptual model) that the decision was based upon and refine future management decisions, which may include additional resources for research and monitoring to refine the conceptual model. One consideration in this process is the time lag between a management decision, its implementation and the anticipated response of the system. This would give weight to the argument that a fairly comprehensive set of indicators would need to be monitored and quickly analyzed to allow a timely management response to changes in the system.

Using indicators for program assessment:
Indicators are useful and necessary tools for doing program assessment, and can be used as "performance measures". Not all indicators should be considered "performance measures" for the program, since many may be measuring factors that are beyond the control of the program, but are nonetheless affecting the outcome and progress towards goals. Program assessment should also consider whether the program is being effective in implementing actions, and if there are processes being used to evaluate outcomes and do adaptive management (revise conceptual models, revise management actions). Program assessment should consider whether decisions are being made on the basis of explicit conceptual models – and whether those models utilize the latest scientific understanding. In summary, a program assessment should include:

- Evaluation of "performance measures" – indicators at all levels and scales that are relevant to program goals and reflect program activities. There may be some value in identifying quantitative targets or goals associated with specific performance measures.
- Evaluation of whether management actions taken are based on explicit conceptual models of expected outcomes, based on the most current technical knowledge or scientific information. (Are we doing the right things?)
- Evaluation of effectiveness of implementation of management actions (Are we doing things right?)
- Are adaptive management processes working to refine conceptual models and refine management actions in a timely manner?