Chapter 3
Conservation Strategy (Section 3.6)

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Acronyms and Abbreviations

BACI	before/after and control/impact
BiOp	biological opinion
Central Valley Water Board	Central Valley Regional Water Quality Control Board
CFR	Code of Federal Regulations
DFG	California Department of Fish and Game
EPA	U.S. Environmental Protection Agency
ESA	federal Endangered Species Act
Fish & Game Code	California Fish and Game Code
FR	*Federal Register*
HCP	habitat conservation plan
IEP	Interagency Ecological Program
Mm	Millilmeters
NCCP	natural community conservation plan
NMFS	National Marine Fisheries Service
NRC	National Research Council
Reclamation	U.S. Bureau of Reclamation
State Water Board	State Water Resources Control Board
UC	University of California
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

Chapter 3

Conservation Strategy (Section 3.6)

3.6 Adaptive Management and Monitoring Program

3.6.1 Introduction

The BDCP Conservation Strategy adopts a set of conservation measures that are designed to achieve the biological goals and objectives. The conservation measures include actions to improve flow conditions, increase food production, restore habitat, and reduce the adverse effects of other stressors. This strategy also recognizes the considerable uncertainty that exists regarding the understanding of the Delta ecosystem and the likely outcomes of implementing the conservation measures, both in terms of the nature and the magnitude of the response of covered species and of ecosystem processes that support the species.

As a component of the BDCP conservation strategy, the BDCP adaptive management and monitoring program is designed to use new information and insight gained during the course of Plan implementation to develop and implement alternative strategies to achieve the biological goals and objectives more effectively. It is possible that the some of the BDCP conservation measures will be unable to achieve the relevant goals and objectives, while others will produce better results than expected. The adaptive management process will afford the flexibility to allow for substantial changes to be made to the conservation measures to improve the effectiveness of the Plan over time. Monitoring and research will be used to measure Plan effectiveness as well as to assess uncertainties and improve understanding of Delta ecosystems. A detailed monitoring and research plan that identifies specific metrics and protocols will be developed during Plan implementation.

To ensure development of a scientifically based BDCP adaptive management and monitoring program, independent science advisors were engaged to provide expert input on best approaches to adaptive management. The results of the deliberations of these scientists are reflected in the *BDCP Independent Science Advisors Report* (Independent Science Advisors 2007). The report set out the following principles for effective adaptive management.

- The scope and degree of reversibility of each conservation measure determines whether active or passive adaptive management[1] should be applied.
- The knowledge base about the ecosystem is key to decisions about what to do and what to monitor, and includes all relevant information, not just that derived from monitoring and analysis within the context of the BDCP.
- Program goals should relate directly to the problems being addressed and provide the intent behind the conservation measures; objectives should correspond to measurable, predicted outcomes.

[1] Active adaptive management is experimental, involving manipulations intended to achieve conservation goals but also to improve knowledge. Passive adaptive management is not experimental, but still uses a scientific perspective to improve knowledge and adapt strategies during project implementation.

- Models should be used to formalize the knowledge base, develop expectations of future conditions and conservation outcomes that can be tested by monitoring and analysis, assess the likelihood of various outcomes, and identify tradeoffs among conservation measures.
- Monitoring should be targeted at specific mechanisms thought to underlie the conservation measures and must be integrated with an explicitly funded program for assessing the resulting data.
- Prioritization and sequencing of conservation measures should be assessed at multiple steps in the adaptive management cycle.
- Specifically targeted institutional arrangements are required to establish effective feedback mechanisms to inform decisions about whether to retain, modify, or replace conservation measures.
- A dedicated, highly skilled agent (person, team, office) is essential to assimilate knowledge from monitoring and technical studies and make recommendations to senior decision makers regarding programmatic changes.

Adaptive management and monitoring will be integrated into one cohesive program. Information obtained from monitoring and research activities will be used by the Implementation Office to make important management decisions on BDCP actions and continually improve the outcomes associated with water resource management and ecological restoration commitments made in this Plan. The adaptive management and monitoring program is directly related to several key components of the BDCP: biological goals and objectives (Section 3.3, *Biological Goals and Objectives*), conservation measures (Section 3.4, *Conservation Measures*), covered activities (Chapter 4, *Covered Activities and Associated Federal Actions*), expected outcomes associated with the effects of the conservation measures and other covered activities (Chapter 5, *Effects Analysis*), Plan implementation (Chapter 6, *Plan Implementation*), and governance structure (Chapter 7, *Implementation Structure*). The remainder of this introduction includes a discussion of the directives, principles, concepts and available information that provide guidance as well as a foundation for development of the BDCP adaptive management and monitoring program. A detailed discussion of the individual components of the adaptive management and monitoring program is provided in Section 3.6.2, *Adaptive Management Process*; Section 3.6.3, *Compliance Monitoring*; Section 3.6.4, *Effectiveness Assessment Guidelines*; Section 3.6.5, *Effectiveness Monitoring*; Section 3.6.6, *Directed Research*; and Section 3.6.7, *Data Management and Reporting*.

3.6.1.1 Regulatory Context

State and federal fish and wildlife agencies use adaptive management as a tool to address the uncertainty associated with conservation of species covered by a habitat conservation plan (HCP) or natural community conservation plan (NCCP). The fish and wildlife agencies consider adaptive management strategies to be necessary in cases where the actions proposed in an HCP/NCCP pose a risk to species due to uncertainty or significant lack of data or information. Within certain constraints, permit holders may be required to bear some responsibility for the risks associated with uncertainty and assume obligations beyond those reflected in the conservation measures set out in the Plan. These additional obligations fall within the limits of the adaptive management and monitoring program and are intended to moderate risk to covered species, increase the likelihood that intended outcomes are achieved, and further ensure that permit issuance criteria are satisfied.

By regulation, an HCP must incorporate monitoring of conservation measures and the response of covered species to these measures (50 Code of Federal Regulations [CFR] 17.22(b)(1)(iii) and 50 CFR 222.22(b)(5)(iii)). An adaptive management strategy is a recommended component of plans with data gaps that would substantively affect how species are managed and monitored in the future (65 *Federal Register* [FR] 3251). The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) Five-Point Policy (65 FR 35241–35257) describes adaptive management as an integrated method for addressing uncertainty in natural resource management and states that management must be linked to measurable biological goals and monitoring. Embedded within the guidance from the five-point policy is the concept that the scale of adaptive management and monitoring should be commensurate with the scope of the effects of the proposed action.

An NCCP must include both a monitoring program and an adaptive management program (California Fish and Game Code [Fish & Game Code] Section 2820-7–8). An NCCP also must integrate adaptive management strategies that are periodically reviewed and modified on the basis of the results of monitoring efforts and other sources of new information (Fish & Game Code Section 2820(a)(2)).

The monitoring and adaptive management program described in this section is intended to meet HCP and NCCP requirements to monitor covered species, natural communities, and species responses to management activities. As such, this program will continually incorporate recommendations for monitoring and adaptive management based on the most recent guidelines provided by the U.S. Geological Survey (USGS), California Department of Fish and Game (DFG), and USFWS for regional HCPs and NCCPs (Atkinson et al. 2004) as well as other relevant policies associated with adaptive management.

3.6.1.2 Goals, Purpose, and Scope

The adaptive management and monitoring program is designed to assess how well the BDCP is fulfilling commitments made in the Plan as well as provide guidance, as appropriate, on how to improve the effectiveness of actions taken to meet those commitments. The goals, purpose, and scope are essential components of the adaptive management and monitoring program that provide a foundation, guidance, and/or a roadmap that help frame the process for attaining those commitments.

3.6.1.2.1 Goals

The goal of the BDCP is to restore and protect water supply, water quality, and ecosystem health within a stable regulatory framework. Biological goals and objectives are the benchmark associated with the BDCP's ecological restoration performance. The BDCP is expected to show progress toward attaining, and ultimately to attain, the biological goals and objectives of this Plan (Section 3.3, *Biological Goals and Objectives*).

As an integral component of implementing the BDCP, the adaptive management and monitoring program will provide a mechanism for attaining those goals along with demonstrating progress toward attaining them. The relationship between goals, conservation measures, and monitoring and research actions within the context of the adaptive management and monitoring program is discussed in detail in Sections 3.6.2, *Adaptive Management Process*, and 3.6.3, *Compliance Monitoring*.

3.6.1.2.2 Purpose

The purpose of the adaptive management and monitoring program is to assist the BDCP Implementation Office in ensuring compliance with the Plan. The program adheres to the following guidelines.

- Use the BDCP organizational framework and decision-making process to incorporate relevant information to adjust, as appropriate, management actions.
- Identify conditions or situations requiring an adaptive management response (decision point), describe the decision-making process (decision), and describe procedures for implementing a response (action).
- Use existing information and, as appropriate, refine that information to describe the baseline condition of biological resources in the Plan Area.
- Use existing conceptual models and, as appropriate, refine those models for natural communities and covered species as a basis for collecting new information, verifying hypotheses, and designing and changing management practices.
- Incorporate hypothesis testing and experimental management, including targeted studies to address key uncertainties and to improve management and monitoring efforts.
- Identify or develop, and implement, scientifically valid monitoring protocols to ensure that data collected will inform management and integrate with other monitoring efforts.
- Implement monitoring actions and processes to ensure program compliance, validate conceptual models, assess progress toward biological objectives, and track the trend of environmental metrics.
- Ensure that monitoring data are collected, analyzed, stored, organized, and reported in such a fashion that the information is accessible to the Implementation Office, regulatory agencies, scientists, and, as appropriate, the public.

3.6.1.2.3 Scope

Designing and implementing a logistically feasible, scientifically sound, and technically effective adaptive management and monitoring program is a complicated task. The National Research Council (NRC) (2010) pointed out that even the most effective ecological restoration actions in the Delta will need time to take effect amid changing environmental conditions, such as multiyear droughts, and other human-caused stresses. Therefore, many effects of the BDCP Conservation Strategy will likely take a long time to detect, they will be difficult to detect because of potential masking by other environmental changes, and there are uncertainties inherent in sampling small populations (National Research Council 2010). The specific adaptive management changes or the magnitude of those changes that may be needed for the BDCP are currently unknown. In this light, the adaptive management and monitoring program has been designed to provide sufficient guidance and direction to ensure that it can be implemented and modified through time both to meet the appropriate regulatory standards and, as appropriate, to take advantage of information obtained from existing and ongoing scientific efforts.

This approach of providing an adaptive management and monitoring/research framework, based on sound scientific guidelines and principles, along with recommendations for monitoring and research

actions is consistent with the general standard associated with issuance of incidental take permits for large-scale HCP/NCCPs as well as the Delta Plan. In some previous NCCPs (e.g., the San Diego County Multi-Species Conservation Plan) that provided extensive details of the monitoring protocols and standards, it was found early in the implementation process that many of the protocols were infeasible or did not produce the right data to evaluate plan success. Incorporating that lesson, this adaptive management and monitoring program provides a framework, guidelines, and principles to design and implement the program early in Plan implementation. Because extensive monitoring has been occurring in the Delta for decades, this adaptive management and monitoring program also incorporates proven monitoring programs and protocols, where appropriate to support Plan goals.

3.6.1.3 Adaptive Management Context

Adaptive management is a structured decision-making process that incorporates uncertainty about the potential responses of resources to management actions, and promotes flexible decision-making that can be adjusted as outcomes from management actions and other events become better understood (Holling 1978; Walters 1986). It requires well-articulated management objectives to guide decisions about what to try, and explicit assumptions about expected outcomes to compare against actual outcomes (Williams et al. 2009). Adaptive management is a science-based process that uses models for developing hypotheses about potential resource responses to management actions, management flexibility, and commitment to carry out monitoring and reevaluation of management goals over time. Adaptive management programs can reduce uncertainty and associated management risks by improving our understanding through monitoring and researching the outcomes of management actions. The challenge in using an adaptive management approach lies in finding the correct balance between gaining knowledge to improve management in the future and achieving the best short-term outcome based on current knowledge (Stankey and Allan 2009). Lindenmayer and Burgman (2005) suggest that an adaptive management process should include the following elements (Figure 3.6-1).

- Explicit definition of management goals.
- Development of plausible alternative management strategies to achieve those goals.
- Implementation of strategies in a comparative experimental framework to spread risks of management failure and improve understanding of system responses to management.
- Monitoring.
- Evaluation of the relative merits and limitations of alternate management strategies.
- Iterative modification of management strategies to improve expected outcomes.

The traditional concept and application of adaptive management as a natural resource management tool has been improving since the 1970s (Holling 1978 Walters 1986; Pahl-Wostl 1995; Lee 1999; Oglethorpe 2002). It has been applied to a wide range of resource management approaches (Walters 1986; Christensen et al. 1996; Stanford and Poole 1996; Oglethorpe 2002; Habron 2003; Kaplan and Norton 2008; Lyons et al. 2008; Williams et al. 2009). Many of these involve water supply management and ecosystem restoration activities: Glen Canyon Dam and the Colorado River ecosystem (National Research Council 1999); the Missouri River ecosystem (National Research Council 2002); U.S. Army Corps of Engineers (USACE) water resource project planning (National Research Council 2004a); Columbia River system (National Research Council 2004b; Vail and Skaggs 2002); and the Everglades ecosystem (Gunderson and Light 2006). Lessons learned from these

applications, as well as advances in other scientific disciplines, have improved the utility of the adaptive management concept. For example, advances in three specific areas are relevant to the BDCP adaptive management and monitoring program.

- **Ecological variability.** Since inception of the original concept, there has been significant advancement in the recognition of the dynamic nature of the natural environment (Oglethorpe 2002). That is, natural systems prove to be variable, nonlinear, complex, rarely predictable, and have the potential for irreversible change (Botkin 1990; Frontier and Pichod-Viale 1993).
- **Ecological economics.** Adaptive management practitioners have recognized that understanding the interactions between natural and social systems is important when making natural resource management decisions (Costanza 1991; Jansson et al. 1994; National Research Council 2005; Pahl-Wostl 2006).
- **Decision making.** The scientific knowledge and understanding of how to identify and quantify preferences when making decisions associated with multiple criteria and objectives has emerged as an important discipline for assisting natural resource managers make difficult decisions (Keeney et al. 1993; Kirkwood 1997; Clement and Reilly 2001; Lyons et al. 2008; International Enclyopedia of the Social and Behavioral Sciences 2001; 76 FR 26089).

Overall, the principles of adaptive management lend themselves to the circumstances surrounding water management and ecological restoration in the Bay-Delta (CALFED Bay-Delta Program 2000; Healey 2008; Delta Stewardship Council 2011). To ensure development of a science-based adaptive management and monitoring program for the BDCP, independent science advisors were engaged early in the process to provide expert advice and guidance (Independent Science Advisors 2007). Guidance from federal and state agencies as well as NRC was also a critical component of developing the adaptive management and monitoring program (see below). The Independent Science Advisors report (2007) also discusses the importance of having a team of people with diverse areas of expertise in both technical science and policy to ensure that decisions and revisions are made with the highest understanding of both technical and policy implications. Additionally, the U.S. Secretaries of Interior and Commerce asked NRC to review the draft BDCP in terms of its use of science and adaptive management. In response, NRC established a panel to review an earlier draft of the BDCP. The panel completed its review and published the results (National Research Council 2011). Among specific recommendations, the panel and the BDCP Independent Science Advisors offered the following overarching observations.

> Numerous attempts have been made to develop and implement adaptive management strategies in environmental management, but many of them have not been successful, for a variety of reasons, including lack of resources; unwillingness of decision makers to admit to and embrace uncertainty; institutional, legal, and political preferences for known and predictable outcomes; the inherent uncertainty and variability of natural systems; the high cost of implementation; and the lack of clear mechanisms for incorporating scientific findings into decision making. Despite all of the above challenges, often there is no better option for implementing management regimes, and thus the panel concludes that the use of adaptive management is appropriate in the BDCP. However, the application of adaptive management to a large-scale problem like the one that exists in California's Bay-Delta will not be easy, quick, or inexpensive. (National Research Council 2011)

> The BDCP must be developed despite great uncertainty about the outcomes of the selected management actions. These uncertainties arise because of lack of knowledge about the current state of the ecosystem, inherent variability, and the likelihood that the future state of the system will differ from the current state as a result of deliberate and unplanned events. Several approaches can be taken in the face of such uncertainty to increase the probability that conservation objectives will be

achieved. First, analyses can be conducted to attempt to minimize the uncertainty about a particular course of action. Exclusive of other measures, such an approach is unlikely to succeed because of the magnitude of the uncertainties discussed above. Second, an initial course of action can be taken with plans to revisit the action in the future and alter it if necessary. This approach is preferable to the first, but it fails to maximize application of the information that can be gained from the response of the system to the actions taken; this approach is essentially static, and passive. An improvement on these approaches is to investigate and learn systematically from the course of action taken using adaptive management, a formal process designed to reduce uncertainties and identify significant negative consequences as they arise (Holling 1978; Walters 1986; Independent Science Advisors 2007).

3.6.1.3.1 Addressing Uncertainty

As mentioned above, adaptive management addresses uncertainty through a structured process that provides for the improvement of relevant knowledge, while seeking to minimize management risks associated with proposed activities (Keith et al. 2011). Successful adaptive management programs reduce the uncertainty of management decisions but recognize that uncertainty and its associated risks will always be a component of ecological systems. It is essential to accept that the consequences of natural events and or management decisions that operate at an ecosystem scale are largely unknown and adjustments to natural resource management actions might entail more than only minor corrective actions. This may require the need for a commitment, most often driven by quantitative models, for identifying and experimentally evaluating alternative hypotheses about responses to resource management actions (Briceño-Linares et al. 2011; Kingsford et al. 2011; Van Wilgen and Biggs 2011).

Most adaptive management programs associated with ecological restoration end up having at least some experimental component (e.g., research, targeted studies) aimed at improving the performance of management actions (Keith et al. 2011). Responses to specific restoration actions are often confounded by responses to other, uncontrolled factors that drive ecological change. Well-defined experiments, supplemented by expert knowledge, are often applied to evaluate the assumptions underlying resource management strategies (Rumpff et al. 2011). Simple experimental designs can go a long way toward separating resource management action effects from other causes of ecological change (Mackenzie and Keith 2009). In some cases, low numbers, small areas and urgent time frames place severe constraints on experimental design. In these situations, a succession of trial-and-error evaluations may offer the only practical insights that adjust management strategies (Briceño-Lenares et al. 2011). The design of targeted studies that address key uncertainties will be driven by hypotheses about key factors for the landscape, natural community, and/or species for which the management action is applied. Adaptive management actions and monitoring will be directed toward confirming or disproving those hypotheses.

3.6.1.3.2 Use of Best Available Science

As noted above, science plays an increasingly important role in contributing to how people perceive and respond to problems in the Delta. Current understanding of the Delta is quite different from that of a few decades ago. Population growth, land subsidence, earthquakes, and climate change assure that the Delta of the future will be very different from today. Chapter 10, *Integration of Independent Science in BDCP Development* provides a summary of how science has been used in BDCP development.

Several federal and state mandates or directives offer insight on the application of best available science. A number of authors have addressed this issue (Doremus 2004; Murphy and Weiland 2010). Murphy and Weiland (2010) reviewed the incorporation of best available science into the federal Endangered Species Act (ESA) compliance process. They noted that the ESA, along with the Marine Mammal Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act, require federal agencies implementing actions to use the best available scientific and commercial data available when making decisions. Under the ESA, USFWS and NMFS must follow the best available scientific data mandate in several situations, such as when making listing decisions, designating critical habitat, and completing the consultation process on proposed federal actions. USFWS and NMFS have not issued regulations that interpret the requirement to use the best scientific and commercial data available. However, they issued a policy statement on information standards under the ESA in 1994 (U.S. Department of the Interior and U.S. Department of Commerce 1994a). This policy and guidance document directs the federal wildlife agencies to meet the following guidelines.

- Evaluate all scientific and other information that will be used to prepare biological opinions (BiOps) and incidental take statements to ensure that such information is reliable, credible, and represents the best scientific and commercial data available.
- Gather and impartially evaluate biological, ecological, and other information that disputes official positions, decisions, and actions proposed or taken by the federal wildlife agencies during their implementation of the act.
- Document their evaluation of information that supports or does not support a position being proposed as an official agency position on a interagency consultation in reliance on the best available comprehensive, technical information regarding the status and habitat requirements for a species throughout its range; and to the extent consistent with the use of the best scientific and commercial data available, use primary and original sources of information as the basis for recommendations to make a determination of whether a federal action is likely to jeopardize a listed species or destroy or adversely modify critical habitat.

Two additional federal statues provide guidance on the use of best available science: the Administrative Procedure Act of 1946 provides parties affected by final agency actions with a means to seek judicial review of those actions. In addition, it requires that a reviewing court set aside an agency action that is ‘‘arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law.’’ Under the Information Quality Act of 2001, Office of Management and Budget issued guidance to federal agencies to ensure the ‘‘quality, objectivity, utility, and integrity’’ of information disseminated by those agencies to the public (Office of Management and Budget 2002). The standards in these statutes emphasize the importance of transparent decision making to allow affected individuals and reviewing courts to determine that federal agencies have considered the full record before them and have made agency determinations based upon the data, analyses, and findings in that record.

The Delta Reform Act also requires a strong science foundation for decisions made by NRC. This includes the ongoing provision of scientific expertise to support NRC and other agencies through the Delta Science Program and Delta Independent Science Board (Water Code 85280). The Delta Reform Act also requires that the Delta Plan be based on and implemented using the best available science (Water Code 85308(a) and (e); 85302(g)) and requires the use of science-based, transparent, and

formal adaptive management strategies for ongoing ecosystem restoration and water management decisions (Water Code section 85308(f)).

3.6.1.4 BDCP Monitoring and Research Actions

As described above, monitoring and research are critical elements of adaptive management, providing the data and analysis structure needed for informed decision making. The goal of implementing BDCP monitoring and research actions is to provide a means by which information necessary to implement the BDCP over time will be collected, compiled, evaluated, and reported to the Implementation Office for use in the adaptive management decision-making process. BDCP monitoring and research actions will be conducted primarily to meet the following objectives.

- Document compliance with terms and conditions of BDCP permits, including limits set by the permits on the incidental take of covered species.
- Increase and refine scientific understanding of the effects of the covered activities on covered species and natural communities.
- Collect data necessary to effectively and successfully implement conservation measures.
- Document and evaluate the effectiveness of conservation measures in achieving BDCP biological goals and objectives.
- Test the scientific hypotheses on which the assessment of effects and effectiveness are based.
- Assess progress toward achieving the biological goals and objectives both specific to discrete conservation measures and programmatic Delta-wide actions.

To obtain these objectives, development, planning and implementation of monitoring and research actions will be organized into the following categories.

- **Compliance monitoring actions**. These actions will provide basic information necessary to track Plan actions and compliance with permit terms and conditions (Section 3.6.3, *Compliance Monitoring*).
- **Effectiveness monitoring actions**. These actions will provide information about the state of the ecosystem. It includes baseline monitoring and status monitoring, and thereby allows determining changes in ecosystem state after conservation measures are implemented, as well as identifying long-term trends in ecosystem condition. The information can be used to assess the response of the ecosystem, natural communities, and covered species, and progress toward achieving the Plan's goals and objectives over time (Section 3.6.4, *Effectiveness Assessment Guidelines*).
- **Research actions.** These actions will address specific scientific questions regarding covered species, natural communities, and landscape-scale processes so that conservation measures can be adaptively implemented to advance biological goals and objectives (Section 3.6.6, *Research*).

As part of Plan implementation, and by the end of each calendar year, the Implementation Office will prepare an annual monitoring and research plan for approval by the Implementation Board. The annual monitoring and research plan will identify actions that will be coordinated with existing programs and data sets that are complementary to, and consistent with, the BDCP conservation strategy. The plan will include the following elements.

- What will be monitored or researched.
- Why the monitoring or research is useful.
- When the effort will occur and at what frequency.
- The conceptual ecological model underlying the selection of the monitoring or research action.
- The geographic area where it will be implemented.
- The specific variables that will be measured and the protocol that will be used, if known at the time (specific metrics or protocols may be developed later).
- Potential management responses to a range of monitoring results.
- The time frame, spatial area and ecological scale over which change is expected to be demonstrated.

As described in Section 3.6.2, *Adaptive Management Process,* the annual monitoring and research plan, as appropriate, would be approved and integrated into the adaptive management process.

3.6.1.5 Integration of Existing Sources of Scientific Information

The reliance on information obtained from existing monitoring and research efforts in the Delta will be critical to the success of the BDCP. Under a variety of statutory mandates and/or cooperative agreements, multiple agencies and organizations are involved in resource management, monitoring, and research in the Delta. Several programs have some overlap with activities proposed by the BDCP. The BDCP Implementation Office will coordinate with the Interagency Ecological Program (IEP), Delta Science Program and other entities involved in monitoring programs and will use data collected through these programs, as appropriate, to support evaluation of the effectiveness of the BDCP Conservation Strategy in achieving the Plan's biological goals and objectives (Appendix 3.E, *Adaptive Management and Monitoring Program*). Details of the relationship between adaptive management and monitoring program and these programs, as well as others, are discussed in Section 3.6.2, *Adaptive Management Process*; Section 3.6.3, *Compliance Monitoring*; Section 3.6.5, *Effectiveness Monitoring; and* Section 3.6.6, *Directed Research*.

The IEP brings state and federal natural resource and regulatory agencies together to monitor and study ecological changes in the Delta. The IEP consists of ten member entities: three state agencies (DWR, DFG, and the State Water Resources Control Board [State Water Board]); six federal agencies (USFWS, U.S. Bureau of Reclamation [Reclamation], USGS, USACE, NMFS, and the U.S. Environmental Protection Agency [EPA]); and one nongovernment organization (The San Francisco Estuary Institute). These program partners work together to develop a better understanding of the estuary's ecology and the effects of the SWP/CVP operations on the physical, chemical, and biological conditions of the San Francisco Bay-Delta estuary.

The IEP has coordinated Delta monitoring and research activities conducted by state and federal agencies and other science partners for 40 years (Table 3.6-1). IEP monitoring activities are generally carried out in compliance with water right decisions and ESA permit and/or BiOp conditions. Most of the monitoring under the IEP focuses on open water areas and the major Delta waterways conveying water to the SWP/CVP facilities in the south Delta. The IEP produces publicly accessible data that include fish status trends, water quality, estuarine hydrodynamics, and foodweb monitoring. Until recently, the IEP maintained and hosted the Bay Delta and Tributaries System or

the HEC-DSS Time-Series Data System. These systems have been archived. In 2012, DWR and IEP will release a standardized and modernized data system. This will make the data more easily accessible.

Research actions are also supported through the Delta Science Program. Their mission is to provide scientific information for water and environmental decision making in the Bay-Delta system. To date, they have done this by funding more than 30 research grants totaling more than $15 million. The Delta Science Program's objectives are listed below.

- Support research. Initiate, evaluate and fund research that will fill critical gaps in the understanding of the current and changing Bay-Delta system.
- Synthesize scientific information. Compile, analyze, and integrate scientific information across disciplines.
- Facilitate independent peer review. Promote and provide independent, scientific peer review of processes, plans, programs and products.
- Coordinate science. Coordinate with agencies to promote science-based adaptive management.
- Communicate science. Interpret and communicate scientific information to policy-and decision-makers, scientists and the public.

The Delta Science Program has particular expertise and experience organizing and facilitating independent scientific reviews.

Several organizations and agencies monitor species and ecosystem conditions that are relevant to the BDCP implementation. For example, a new regional monitoring program intended to coordinate Delta water quality monitoring in compliance with Clean Water Act permit conditions is currently under development by the Central Valley Regional Water Quality Control Board (Central Valley Water Board). A similar regional monitoring program already exists for San Francisco Bay and is carried out by the San Francisco Estuary Institute, a nonprofit research organization. It will be crucial to the success of the adaptive management and monitoring program to regularly communicate with and review the data collected from the other research and monitoring efforts.

1 **Table 3.6-1. Bay-Delta Fish Monitoring Programs Coordinated through the Interagency Ecological Program that are Relevant to the BDCP**

Monitoring Program	Agency	Primary Purpose and Timeframe	Relevant Data for BDCP
Spring Kodiak Trawl Survey	DFG	Monitors spawning adult delta smelt distribution, relative abundance, and reproductive status, January–May, 2002–present.	Delta smelt: Spawning abundance index, distribution, sex ratios, reproductive status (e.g., prespawn, mature, or spent).
Delta Smelt 20 mm Survey (20 mm Survey)	DFG	Monitors post larval-juvenile delta smelt distribution and relative abundance, March–June, 1995–present.	Delta smelt: Post larval and juvenile abundance index, distribution, length frequency.
Summer Townet Survey (Townet Survey)	DFG	Monitors striped bass and delta smelt abundance indices, July–August, 1959 to present.	Delta smelt: juvenile delta smelt abundance index, distribution, and length frequency. Longfin smelt: post larval juvenile longfin smelt abundance index, distribution, and length frequency. Sacramento splittail: young-of-year splittail, distribution, and length frequency.
Fall Midwater Trawl Survey	DFG	Monitors striped bass and delta smelt abundance indices, September-December, 1967–present.	Delta smelt: Preadult delta smelt abundance index. Longfin smelt: Preadult Longfin smelt abundance index. Sacramento splittail: Abundance of all size classes.
Smelt larval study	DFG	Monitors longfin smelt larvae distribution and relative abundance, January 2009–present.	Longfin smelt: Larval abundance index and distribution
San Francisco Bay Study Survey (Bay Study Survey)	DFG	Monitors abundance indices for a variety of species in South San Francisco and Suisun Bays, year-round, 1980–present.	Delta smelt: Juveniles-adult delta smelt abundance index. Longfin smelt: Juveniles-adult Longfin smelt abundance index. Sacramento splittail: young-of-year and older Splittail abundance.
Suisun Marsh Fish Community Survey (Suisun Marsh Survey)	UC Davis	Monitors abundance of all fish species in Suisun Marsh, year-round, 1979–present.	Delta smelt: Juveniles-adult delta smelt abundance, distribution within Suisun Marsh. Longfin smelt: Juveniles-adult Longfin smelt abundance, distribution within Suisun Marsh. Sacramento splittail: Abundance of all size classes, distribution within Suisun Marsh.

Monitoring Program	Agency	Primary Purpose and Timeframe	Relevant Data for BDCP
Fish Salvage Monitoring	DWR, DFG, Reclamation	Monitors entrainment and salvage of all fish species, year-round, 1979–present.	Delta and longfin smelt: 20 mm post larvae-adult smelt abundance. Sacramento splittail: Abundance of all size classes >20 mm and length frequency. Salmonids: >20 mm larvae-adults abundance. Sturgeon: >20 mm juvenile sturgeon abundance.
Chips Island, Mossdale, and Sacramento Trawl Survey	USFWS	Monitors fish abundance and distribution in mid-channel at surface at Chips Island, Moss dale (RM 54), and Sacramento (RM 55), and survival through the Delta, targets Chinook salmon, year-round, 1976-present.	Salmonids: juvenile abundance, distribution, length frequency, survival indices (of hatchery tagged fish) to Chips Island. Delta smelt: >25 mm abundance, distribution, and length frequency. Longfin smelt: >25 mm abundance and distribution, and length frequency. Sacramento splittail: >25 mm abundance and distribution, and length frequency.
Delta Juvenile Fishes Monitoring Beach Seine (Beach Seine Survey)	USFWS	Monitors fish abundance and distribution throughout the Delta, upstream Sacramento River, northern San Francisco and San Pablo Bays, targets Chinook salmon, year-round, 1976–present.	Sacramento splittail: >25 mm young of year Splittail abundance, distribution, and size frequency. Salmonids: juvenile almonds, abundance, distribution, and size frequency.
Chinook salmon escapement estimates (Grand tab database)	DFG, DWR	Grand tab collects all races of Chinook salmon escapement.	Salmonids: adult returns to spawning grounds by race and location.
Suisun March Otter Trawl	UC Davis	Monitors abundance of all fish species in Suisun Marsh, year-round, 1979–present.	Chinook salmon: juvenile abundance and distribution within Suisun Marsh.
Adult Sturgeon Tagging Survey	DFG	Tag-recapture (via creel surveys) of green (prior to being listed) and white sturgeon for abundance and population dynamics.	White and green sturgeon: abundance, distribution, population dynamics, length frequency, annual harvest rates, and migration rates.

Notes:
DFG = California Department of Fish and Game; DWR = California Department of Water Resources; Reclamation = Bureau of Reclamation; USFWS = U.S. Fish and Wildlife Service; UC = University of California; mm = millimeters

1

3.6.2 Adaptive Management Process

The adaptive management and monitoring program is designed to assess how well the BDCP Implementation Office is fulfilling commitments made in the Plan as well as provide guidance, as appropriate, on how to improve the effectiveness of actions taken to meet those commitments. The BDCP conservation measures have been designed to achieve the BDCP biological goals and objectives and are based on the best scientific and commercial information and data available. The relationship between the conservation measures and the biological goals and objectives provides a basis for empirically evaluating the success of the conservation measures.

Under the adaptive management and monitoring program, new data and information developed through monitoring and research will inform the Implementation Office regarding the efficacy of conservation measures, mechanisms underlying the response of the ecosystem and covered species to these measures, synergistic effects of conservation measures, the influence of factors operating outside the BDCP Plan Area (including other conservation planning efforts), and effects of operational criteria on the ecosystem. Monitoring and research conducted under BDCP and by other programs will provide insights into changes in Delta conditions as a result of climate change (e.g., sea level rise, hydrology in the Delta watershed, and increased water temperatures), seismic events, potential large-scale changes in land use, and other parameters outside the scope of the BDCP.

As more is understood about the Delta ecosystem, modifications to the conservation measures may be necessary for several reasons, including the following examples.

- A conservation measure or a suite of conservation measures may prove ineffective, but the root problem is both understood and solvable.
- A conservation measure or a suite of conservation measures may prove initially effective, but changing conditions in the BDCP Plan Area threaten to reverse this initial success.
- A conservation measure or suite of conservation measures may prove ineffective and modifications to the implementation of conservation measures may be necessary.

The adaptive management and monitoring program process will afford the Implementation Office, in coordination with the Implementation Board, the flexibility t to adjust the conservation strategy or specific conservation measures or to revise expectations related to conservation measure outcomes in order to achieve the BDCP goals and objectives.

3.6.2.1 Roles and Responsibilities

3.6.2.1.1 BDCP Implementation Office

As described in Chapter 7, *Implementation Structure*, the BDCP Program Manager will direct a new BDCP Implementation Office. This office, which will be governed by the Implementation Board, will be responsible for implementing and overseeing the Plan, including implementing the monitoring and research actions and the adaptive management process. The BDCP Science Manager, under the direction of the BDCP Program Manager, is the primary Implementation Office staff member responsible for ensuring the proper implementation of these programs (Section 7.1, *Roles and Responsibilities of Entities Involved in BDCP Implementation*). The BDCP Program Manager will facilitate and coordinate discussion and consideration of adaptive management issues among the

various participating entities, including the authorized entities, fish and wildlife agencies, and the Implementation Board to facilitate decision-making regarding changes in Plan implementation.

The Implementation Office will be responsible for the following actions related to the adaptive management and monitoring program.

- Implementing and managing all 10 steps of the adaptive management process.
- Developing annual implementation plans.
- Seeking technical guidance and recommendations.
- Making recommendations to the Proposed and Other Authorized Entities (Section 7.1, *Roles and Responsibilities of Entities Involved in BDCP Implementation*).
- Coordinating with stakeholders and other various parties (Section 7.1, *Roles and Responsibilities of Entities Involved in BDCP Implementation*).
- Keeping the public informed.

3.6.2.1.2 Fish and Wildlife Agencies

As described in Section 7.1, *Roles and Responsibilities of Entities Involved in BDCP Implementation,* the fish and wildlife agencies (USFWS, NMFS, and DFG) will provide technical review, assistance and guidance to the BDCP Implementation Office. Specific to the adaptive management and monitoring program, these agencies will be requested to provide technical guidance associated with implementing all elements of the BDCP adaptive management process (Section 3.6.2.2, *10-Step Process*).

- The USFWS will be requested to provide technical input and recommendations on proposed actions affecting jurisdictional covered species (Table 1-2) and their habitats.
- NMFS will be requested to provide technical input and recommendations on jurisdictional covered species (Table 1-2) and their habitats.
- DFG will be requested to provide technical input and recommendations on jurisdictional covered species (Table 1-2) and their habitat, and on protected natural communities.

In addition to helping implement the adaptive management process, these agencies will provide technical assistance at various stages in the development and implementation of actions under each conservation measure. For natural community protection and restoration (CM2 through CM11), these procedures are described in *CM3 Natural Communities Preservation and Restoration*. For other stressors (CM12 through CM21), these procedures are described in the respective conservation measures.

3.6.2.1.3 BDCP Adaptive Management Team

The *BDCP Independent Science Advisors Report* (Independent Science Advisors 2007) identified the importance of having a team of people with diverse areas of expertise to ensure that decisions and revisions are made with full understanding of both technical and policy implications. Based on this guidance, the Science Manager will create the BDCP Adaptive Management Team and will serve as the chair of and recommend membership for the team to the Program Manager (Section 7.1, *Roles and Responsibilities of Entities Involved in BDCP Implementation*). During the first year of Plan

implementation, membership will be proposed by the BDCP Program Manager and reviewed and approved by the BDCP Implementation Board.

Team membership may change as necessary, depending on specific technical issues that need to be addressed (e.g., fisheries, terrestrial wildlife, habitat restoration, water operations).

The Program Manager will use the Adaptive Management Team to provide internal scientific review (internal to the Implementation Office) on specific technical issues of immediate importance to the success of the adaptive management program and the conservation strategy implementation. The team will also assess on a regular basis the overall efficacy of the adaptive management program, including the results of effectiveness monitoring, selection of research and adaptive management experiments, and relevance of new scientific information developed by others (e.g., universities, Delta Science Program) to determine whether changes in the implementation of the conservation measures and the monitoring program would improve the effectiveness of the BDCP in achieving its biological goals and objectives.

The Science Manager will use the Adaptive Management Team to support the conduct of annual and multiyear reviews including efforts to identify issues that may benefit from independent science advice, consider potential adaptive management actions that may be indicated by the results of monitoring and research efforts, and identify research that may be useful to effectively address uncertainties. The team will make recommendations to the Program Manager for adaptive management changes to the BDCP conservation strategy. The Science Manager may also call on the team to help synthesize and present current scientific knowledge on relevant Delta resources to the Program Manager and BDCP Implementation Board.

Recommendations made by the Adaptive Management Team and by other scientists and experts will be documented in a standard format and will include a description of the recommended change in implementation; the justification for the recommended change; an assessment of any effects the change may have on other elements of BDCP implementation; and any other relevant information to support the recommendation. The rationale for rejecting adaptive management recommendations made during the internal science review process will also be documented.

3.6.2.1.4 Independent Scientific Advisors

Working in coordination with other Delta science programs and the Adaptive Management Team, the Program Manager will periodically seek additional science input on specific issues related to implementation and adaptive management. The Program Manager may convene, at its discretion, experts on selected topics that are not affiliated with the Implementation Office, permit holders, or fish and wildlife agencies. The Program Manager will consult with the Implementation Board regarding the selection of scientists to provide advice on specific matters.

3.6.2.2 10-Step Process

The BDCP adaptive management framework is a 10-step process based on the recommendations of the *BDCP Independent Science Advisors Report* (Independent Science Advisors 2007), as well as the *5th Staff Draft Delta Plan* (Delta Plan 2011). The process is designed to use new information to inform a systematic and integrated critical review, at regular intervals, of environmental stressors, Plan goals and objectives, analytical methods, predicted outcomes, and conservation measures. Once proposed, the restoration actions are implemented according to a rigorous process of design,

monitoring and research, evaluation, reporting, and decision (Figure 3.6 2). The Implementation Office will solicit early and frequent input and review from the Adaptive Management Team as well as the fish and wildlife agencies for all appropriate steps and elements in this process.

The 10-step process, described in detail below, includes the following steps.

1. Define and/or redefine the problem.
2. Establish biological goals and objectives.
3. Model linkages between objectives and proposed actions.
4. Define program outcomes and performance metrics.
5. Select, prioritize, and evaluate conservation measures/actions.
6. Implement conservation measures/actions.
7. Implement monitoring/research plans.
8. Collect, analyze, synthesize and evaluate data.
9. Communicate current understanding.
10. Make decisions.

3.6.2.2.1 Step 1: Define and/or Redefine the Problem

A problem statement, specifying the issue or concern that conservation measures are intended to solve or mitigate, is used to define the problem. The problem statement links directly to the program's goals and objectives. Problems are defined using the best available science and clearly documented information.

For the BDCP, ecological problems and associated environmental stressors are broadly defined and linked in Appendix 5.A, *Conceptual Foundation and Analytical Framework*, while detailed analyses appear in several chapters of the BDCP and in its many technical appendices. The current information about system function and stressors composes the existing knowledge base.

Environmental stress refers to physical, chemical, and biological constraints on the productivity of species as well as alteration of ecosystem function. Ecological responses result when the exposure to environmental stressors increases or decreases in intensity. Various types of ecological responses occur when the intensity of environmental stress causes significant changes. Resilience is defined as the capacity of species and ecosystems to tolerate some changes in the intensity of environmental stressors. The limits to resilience represent thresholds of tolerance. Substantial ecological changes result when environmental stress causes these thresholds to be exceeded. The resulting effects can include reductions in the abundance of vulnerable species, the elimination of species from particular sites, and replacement by species that are more tolerant of the changed environmental conditions. Other common responses to longer-term increases in stress include of the loss of species and decreased rates of productivity, decomposition, and nutrient cycling. Such changes are called ecological conversions. One example of such a conversion is the pelagic organisms decline that has affected the Bay-Delta aquatic ecosystem since the latter 1990s, largely in response to invasion by two nonnative clams that have greatly altered the phytoplankton community and thus the foodweb (e.g., Jassby et al. 2003; Baxter et al. 2010; Glibert 2010). Chapter 2, *Existing Ecological Conditions*, includes a discussion of the pelagic organisms decline and its effects.

The specific environmental stressors affecting the BDCP covered species are described in Chapter 2, *Existing Ecological Conditions*, and Chapter 3, *Conservation Strategy*, as well as in Chapter 5, *Effects Analysis*, and its associated appendices.

3.6.2.2.2 Step 2: Establish Goals and Objectives

Goals and objectives provide a foundation, guidance, and/or a roadmap that help frame the process for attaining the BDCP commitments.

Biological goals provide broad statements of a desired action's outcome. They are general intentions or visions for some aspect of the system. Goals propose broad solutions and encapsulate desired future conditions.

Biological objectives are specific, often quantitative, statements of outcomes that reflect the intended outcomes of the conservation strategy. Some objectives are stated as quantitative targets for species or locations in a hierarchical arrangement; others characterize desired attributes of ecosystem structure or function. It is not always possible to develop quantitative conservation objectives for many species, communities, or processes. In this case, objectives must be described qualitatively. Nevertheless, as information accumulates, objectives can be refined and made more quantitative. Additionally, predictive models applied in the context of the knowledge base can also assist in developing quantitative objectives.

The BDCP goals and objectives are defined at three ecological scales: landscape, natural community, and species. The goals and objectives are described in detail in Section 3.3, *Biological Goals and Objectives*. The BDCP adaptive management process includes provisions for evaluating progress toward achieving these biological goals and objectives. If the goals or objectives are not being met, conservation measures may be reviewed, evaluated, and adjusted as appropriate. Also, goals or objectives may be modified if new information and understanding shows that they are not achievable or not appropriate as initially stated. Such modifications would require concurrence of the fish and wildlife agencies.

3.6.2.2.3 Step 3: Model Linkages between Objectives and Proposed Actions

Models are used to formalize and apply current scientific understanding, develop expectations, assess the likelihood of success, and identify tradeoffs associated with different management actions. Most models evaluating effects of the conservation strategy and other stressors on BDCP covered species and natural communities are conceptual models (Figure 3.6-3). The role of models in developing, assessing, and implementing the BDCP is detailed in Appendix 5.A, *Conceptual Foundation and Analytical Framework*. Models for individual species and natural communities appear in Section 3.3, *Biological Goals and Objectives*; in Appendix 2.A, *Covered Species Accounts*; and in the some of the appendices supporting Chapter 5, *Effects Analysis* (Appendices 5.B through 5.G).

Conceptual models are especially useful within the context of adaptive management because they clearly show the links between actions and outcomes (i.e., causes and effects), which is useful for decision makers, scientists, and the public. These models provide a road map for testing hypotheses through statements that describe the expected outcome of a conservation measure or other change to a biological system. For a multispecies HCP such as the BDCP, conceptual models provide a useful framework for understanding how individual species react to the same management actions. As

necessary, additional models may be developed as more data become available and as more efficient tools are developed.

3.6.2.2.4 Step 4: Define Program Outcomes and Performance Metrics

The expected outcomes associated with implementing the conservation strategy are described in Chapter 5, *Effects Analysis,* and its associated appendices. Within the context of adaptive management, the expected outcomes of the conservation strategy are linked to the goals and objectives. Objectives are linked directly with expected outcomes and associated performance metrics for several reasons.

- To track progress toward meeting the objectives.
- To document desires and expectations about how the system could function in the future following implementation of conservation measures.
- To identify monitoring actions essential to evaluation of each conservation action.
- To measure performance.

Performance metrics and indicators are described in detail in Section 3.6.4, *Effectiveness Assessment Guidelines*.

3.6.2.2.5 Step 5: Select, Prioritize, and Evaluate Actions

In this step, recommendations are made regarding which conservation actions should be implemented and whether each action should be implemented at full scale (with passive adaptive management) or as a pilot study or research program (with active adaptive management).

Prioritization and sequencing are needed in order to allocate available funding appropriately. Prioritization considers the scale and breadth of the expected outcomes relative to the objective. For example, actions that address multiple objectives often have a higher priority than actions that only address one objective. After the actions are prioritized, they are sequenced in order of implementation. Sequencing criteria may include ease of implementation, independence of measures, feasibility of near-term implementation, funding availability, uncertainty of action implementation and outcomes, and the potential for synergies among actions.

The form of implementation (passive or active adaptive management) is based on the action's geographical and temporal scale, the degree of confidence in its benefit, and the consequences of being wrong. The scale of the action selected should be based on the certainty of the relevant scientific information, the reversibility of the action, and the potential cost of delaying larger-scale actions. A full-scale action is used to solve a large-scale problem when the following conditions apply.

- The action is highly likely to achieve or contribute to one or more key objectives.
- The benefits are expected to outweigh the potential negatives.
- There is minimal benefit to performing new or additional pilot studies or research.

A pilot action is used if there is good reason to think the action will have an effect, but there are uncertainties that can only be resolved through the manipulation of the ecosystem. Research is the most conservative measure and is usually used to address a specific issue key to implementation of

the Plan. When possible, a pilot or research action should test the cause-and-effect relationship in the conceptual model.

3.6.2.2.6 Step 6: Implement Conservation Actions

Design and implementation include clearly describing the specific actions that will occur under the selected conservation measure and how they link to the monitoring plan. These actions are described in Section 3.4, *Conservation Measures*, with the exception of actions implemented under conservation measures for natural community protection and restoration (CM3 through CM11); the design and implementation process for these is described in *CM3 Natural Communities Protection and Restoration*. In general, the design and implementation procedures for each conservation measure include a site assessment for the location or area where an action would be implemented; development of an implementation plan for review by the fish and wildlife agencies; provisions for relevant compliance and effectiveness monitoring (as detailed in Section 3.6.4, *Effectiveness Assessment Guidelines* below); and a funding mechanism (as detailed in Chapter 8, *Implementation Costs and Funding Sources*).

3.6.2.2.7 Step 7: Implement Monitoring and Research Plans

As described above, monitoring and research are critical elements of adaptive management by providing the data and analysis structure needed for informed decision making. The goal of implementing BDCP monitoring and research actions is to provide a means by which information necessary to implement the BDCP over time will be collected, compiled, evaluated, and reported to the Implementation Office for use in the adaptive management decision-making process. Monitoring and research plan implementation is detailed in Sections 3.6.3, *Compliance Monitoring,* and 3.6.5, *Effectiveness Monitoring,* which address compliance monitoring, effectiveness monitoring, and research.

3.6.2.2.8 Step 8: Collect, Analyze, and Synthesize Data

Collection, analysis, synthesis, and evaluation of monitoring data will help determine how conditions have changed in response to actions implemented under the conservation measures, whether the objectives have been met, and why or why not. The analysis should be cumulative, addressing each year's data and conclusions. For example, the analysis should include a discussion of whether the probability of the desired outcome has changed and if so, how this affects the decisions about the action.

3.6.2.2.9 Step 9: Communicate Current Understanding

Communicating the current understanding of the results of each conservation action informs policy makers, managers, stakeholders, and the public so that they can understand and respond as necessary. The information reported should be technically sound, well synthesized, and translated into formats appropriate for the intended audiences.

3.6.2.2.10 Step 10: Make Decisions

As appropriate, the BDCP Implementation Board will reexamine elements of the the preceding 10-step adaptive management process and revise it when needed (Chapter 7, *Implementation Structure*). Revisions may include redefining the problem, modifying the goals and objectives,

modifying the metrics, applying new and modified analytical tools and models, modifying conservation measures, and implementing new or modified monitoring.

The BDCP Implementation Office will assemble, synthesize, and analyze the results of BDCP monitoring and targeted research efforts and integrate the results of new and relevant scientific research and studies conducted by other parties. Based on this information and appropriate scientific review, the Implementation Office may recommend program changes to the BDCP within the adaptive management framework, which will be included as part of the annual implementation plan or as part of periodic program reviews for consideration by the Implementation Board (Chapter 7, *Implementation Structure*). Such modifications vary in their magnitude and content.

Minor Changes

Some decisions do not need to be repeated within the adaptive management process once an initial determination is approved by the Implementation Board. These actions and decisions will be identified through consultation with the appropriate entities. The primary factors in determining whether an action or decision is "minor" are the potential risk that it poses to the conservation strategy or protected resource and the degree of complexity and uncertainty associated with it. The Program Manager will report any such designations to the Implementation Board in the annual workplan.

Significant Conservation Measure Changes

Some decisions will require full consideration as part of the adaptive management process. Such decisions include, but are not limited to, those which call for the following changes.

- Discontinuation of a conservation measure.
- Expansion of a conservation measure.
- Addition of a new conservation measure.
- A decision to reallocate available funding or resources away from ineffective conservation measures and toward more promising ones.

The Program Manager will stay informed of ongoing implementation issues that may require changes in how the plan or specific actions are implemented to determine if they need to be considered as part of the adaptive management process. Changes to the plan would be subject to the parameters and sideboards established for adaptive management, including funding caps established to implement the BDCP conservation strategy.

Significant Ecological Changes

Each year, the Implementation Office and the permitting agencies will check for a significant change in ecosystem condition or decline in the natural abundance or distribution of the covered species. A significant ecological change could also be a failure of a conservation measure to achieve an expected outcome. The principle underlying the significant change is that monitoring results represent significant deviations from the biological expectations. If such deviations have occurred, the Implementation Office, Authorized Entities, and permitting agencies will determine what response actions to take through the adaptive management process (Chapter 7, *Implementation Structure*). The response actions will be implemented as soon as practicable. Concurrent with efforts

to determine what response actions will be taken, the Implementation Office and permitting agencies will initiate an analysis through the adaptive management process to determine potential long-term contingency actions to be recommended to the implementation board.

Changes Outside the Implementing Agreement

Some changes will require amendment of the Implementing Agreement and the permits. The Program Manager will submit any proposed amendments to the permitting agencies for review and approval (Section 6.4, *Permit Duration and Renewal, Plan Changes, Permit Suspension and Revocation*).

3.6.2.3 Water Operations (Adaptive Limits)

To allow for flexible and responsive implementation of the BDCP, *CM1 Water Facilities and Operation* includes a defined adaptive range that establishes the parameters within which measure may be adjusted to improve its effectiveness or respond to changing biological conditions. The use of adaptive ranges in the BDCP is limited to CM1, and they are described in detail in the text of CM1 (Section 3.4.2, *Conservation Measure 1 Water Facilities and Operation)*.

3.6.3 Compliance Monitoring

The purpose of compliance monitoring is to track progress of BDCP implementation in accordance with established timetables and to ensure compliance with terms and conditions of the BDCP and its associated permits. Compliance monitoring will be conducted for all conservation measures, whether implemented directly by the BDCP Implementation Office or by other supporting entities through contracts, memoranda of agreement, or other agreements with the BDCP Implementation Office.

The BDCP Implementation Office will track and ensure compliance monitoring and will provide results to the fish and wildlife agencies. Compliance monitoring will comprise two main categories.

- **Construction Monitoring**. This includes verification that constructed features and structures as well as the avoidance and minimization measures are completed and implemented to plan specifications, consistent with the guidelines laid out by the BDCP Implementation Office.
- **Conservation Measure Implementation Monitoring**. The BDCP Implementation Office will prepare planning documents and implementation records that demonstrate compliance with the BDCP and its associated authorizations and to facilitate interagency coordination. Annual Progress Reports will include a description and accounting of compliance with water operations criteria and land acquisitions and habitat restoration requirements. The compliance monitoring program will also allow for operational decisions to be assessed by the federal and state fish and wildlife agencies on a real time and transparent basis to ensure that the criteria and biological performance requirements established for water operations are being met, as required under the Delta Reform Act (Water Code Section XXX).These activities are further described in Section 3.6.7, *Data Management and Reporting*, and in Chapter 6, *Plan Implementation* (Section 6.2, *Compliance and Progress Reporting*).

3.6.3.1 Construction Monitoring

Monitoring of construction activities will be conducted during the construction of various proposed facilities (both covered activities and conservation measures), including habitat restoration projects. Construction monitoring is required to ensure that avoidance and minimization measures are properly implemented. The Implementation Office will monitor implementation of covered activities to ensure that applicable avoidance and/or minimization measures (*CM22 Avoidance and Minimization Measures*) are properly implemented. It also will ensure that conservation measures are constructed in accordance with specifications and plans. Construction compliance monitoring will include the following potential actions.

- Appropriate avoidance of sensitive species/features.
- Documenting compliance with design criteria for construction of project features, including Pipeline/Tunnel Conveyance Facility, Fremont Weir modifications, experimental sturgeon ramps, Tule Canal/Toe Drain improvements, Sacramento Weir fish passage modifications, modifications to berms, levees and water control structures, and the realignment of Lower Putah Creek.
- Documenting enhancement of inundated floodplains for covered species (*CM5 Seasonally Inundated Floodplain Restoration*), channel margin enhancement for covered species (*CM6 Channel Margin Enhancement*), and riparian natural community restoration (*7 Riparian Natural Community Restoration*).
- Documenting compliance with BMPs associated with construction activities (*CM1 Water Facilities and Operation* and *CM2 Yolo Bypass Fisheries Enhancement*).

Relevant monitoring protocols are presented in Appendix 3.E, *Adaptive Management and Monitoring Program*.

3.6.3.2 Conservation Measure Implementation Monitoring

Compliance monitoring for the implementation of conservation measures will be conducted during the implementation phase and throughout the permit duration of the Plan. Compliance monitoring is required to ensure that conservation measures and their associated actions are properly carried out within the specifications and timeframe of the Plan. The Implementation Office will be responsible for implementing compliance monitoring. Compliance monitoring actions also will address some measures that are currently being performed under other Delta programs as well as new measures that will need to be implemented. These potential actions are listed in Table 3.6-2, *Compliance Monitoring Actions*; more detailed information appears in Appendix 3.E, *Adaptive Management and Monitoring Program*.

1 **Table 3.6-2. Compliance Monitoring Actions**

Conservation Measure	Compliance Monitoring Action
CM1 Water Facilities and Operation	Document operation of the water diversion facilities in compliance with operational criteria and adaptive operational limits. Ensure that monitoring provides for real time assessment of compliance with operational criteria and performance requirements, as set out in the Delta Reform Act.
CM1 Water Facilities and Operation	Document compliance of diversion operations with flow requirements in Old and Middle Rivers.
CM1 Water Facilities and Operation	Document compliance with the minimum flow requirements at Rio Vista.
CM2 Yolo Bypass Fisheries Enhancement	Document the operation of modified Fremont Weir.
CM4 Tidal Natural Communities Restoration	Document restoration of tidal habitat suitable for covered fish species.
CM 5 Seasonally Inundated Floodplain Restoration	Document acreage of functional habitat restored.
CM6 Channel Margin Enhancement	Show extent of channel margin enhancement.
CM7 Riparian Natural Community Restoration	Document restoration of riparian habitat.
CM8 Grassland Natural Community Restoration	Document the extent of grassland habitat restoration.
CM9 Vernal Pool Complex Restoration	Document the extent of restoration.
CM10 Nontidal Marsh Restoration	Document the extent of nontidal marsh habitat restoration.
CM11 Natural Communities Enhancement and Management	[placeholder]
CM12 Methylmercury Management	[placeholder]
CM13 Invasive Aquatic Vegetation Control	[placeholder]
CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels	Operate and maintain an oxygen aeration facility in the Stockton Deep Water Ship Channel (DWSC) to increase dissolved oxygen concentrations between Turner Cut and Stockton to meet Total Maximum Daily Load (TMDL) objectives.
CM15 Predator Control	Document removal of predators on covered fish species.
CM16 Nonphysical Fish Barriers	Document the installation of nonphysical fish barriers.
CM17 Illegal Harvest Reduction	Determine compliance ratios in routine enforcement activities.
CM18 Conservation Hatcheries	[placeholder]
CM19 Urban Stormwater Treatment	[placeholder]
CM20 Recreational Users Invasive Species Program	[placeholder]
CM21 Nonproject Diversions	[placeholder]
CM22 Avoidance and Minimization Measures	[placeholder]

2

3.6.4 Effectiveness Assessment Guidelines

The general purposes of an effects assessment are to evaluate whether or not the modification of a stressor has changed the environment, to determine which components are adversely affected, and to estimate the magnitude of the effects. Evaluating change in environmental conditions is often difficult, due to several factors. It is often not clear which environmental component will be affected by the stressor, what type of change will occur and what the exposure will be. Choices must be made about where and when the potential effect will occur (i.e., define the spatial and temporal extent), what organisms will be affected (e.g., fish, plants), what the exposure will be (magnitude, duration), what any mitigating factors could be (what affects distribution of exposure) and how may these factors alter exposure and effect. Change in the environment is natural and variation due to natural effects may be great.

Because the biological outcome of many BDCP conservation measures is uncertain, the adaptive management and monitoring program is based on scientific principles that guide continual refinement of conservation efforts in order to effectively implement the conservation strategy. The most basic monitoring involves simply assessing effects once a management action has occurred without any replication, controls, or comparison of management treatments. More complex investigations may test hypotheses using combinations of experimentation, model evaluation, or statistical inference. BDCP monitoring and research will, whenever practicable, comply with all scientific guidelines listed below.

- Monitoring and research actions will be designed to test hypotheses about species' ecological relationships and responses to management actions.
- Monitoring and research actions will incorporate scientific principles of replication, control, and pre- and post-treatment monitoring to measure effects of management actions.
- Targeted studies will refine monitoring protocols and resolve key management uncertainties.
- Directed studies will include an experimental design with sufficient statistical power to detect effects.
- Trend analysis and before-and-after studies will be used to test for long-term, large-scale, or ecosystem-process-based changes associated with BDCP implementation.

Monitoring actions and the design of targeted studies will be driven by hypotheses about key factors for the landscape, natural community, and/or species for which the management is applied. Monitoring and research actions will be directed toward confirming or disproving those hypotheses. Directed studies will be conducted on a small scale using an experimental design that will yield statistically valid results to address critical uncertainties.

In addition to the scientific guidelines described above, the following steps will be included in the experimental design.

- **Define the question**. Monitoring strategies will be designed to address specific hypotheses. Conceptual, statistical, or spatially explicit models will define those hypotheses.
- **Determine what to measure**. Establish the attributes or variables that the monitoring action will measure to answer the question defined above. This step includes the development of measurable success criteria for evaluating creation, restoration and enhancement actions.

- **Use indicators, if appropriate**. In some cases, groups of species, indicator species, or other forms of indicators will streamline monitoring. Indicators are selected because they are easy to survey and provide usable information on the species or system in question. Guidelines for selecting and using indicators are described in detail below in Section 3.6.4.1, *Indicators*.
-
- **Define monitoring protocols**. Questions to be answered by the monitoring program will be at the species, natural community, and ecological landscape scale. Monitoring protocols will vary with scale and with specific monitoring targets. Established monitoring protocols will be used where possible; any new monitoring protocols will be developed in accordance with the guidelines provided in Section 3.6.4.2, *Protocols*.
- **Statistical and sampling design**. Define statistical structure of the experiment and determine appropriate sampling design and sample size requirements. Statistical and sampling design are described in Section 3.6.4.3, *Statistical and Sampling Design*.

3.6.4.1 Indicators

Indicators can be used in many ways: to predict species richness (MacNally and Fleishman 2004), estimate biodiversity (Kati et al. 2004; Chase et al. 2000), assess levels of disturbance, or provide targeted information on a system or species (Caro and O'Doherty 1999; Carignan and Villard 2004). In general, indicators demonstrate changes or trends that are quantifiable. Landres et al. (1988) defined an indicator species as an organism whose characteristics are used as an index of attributes too difficult, inconvenient, or expensive to measure for other species or environmental conditions of interest. Indicators may be species or physical, chemical, or ecological attributes (e.g., water velocity, dissolved oxygen level, or percent shrub cover). For the purposes of this Plan, indicators are selected to facilitate monitoring of systems or species that are otherwise difficult to examine. Effective indicators have some or all of the following characteristics (Carignan and Villard 2002; Atkinson et al. 2004).

- They are relevant to program goals and objectives and can be used to assess program performance at appropriate spatial and temporal scales.
- They are sensitive to changes in the ecosystem, providing early warning of response to environmental or management effects.
- They indicate the cause of change, not just the existence of change.
- They provide a continuum of responses to a range of stressors such that the indicator will not quickly reach a minimum or maximum threshold.
- They have known statistical properties, with baseline data, references, or benchmarks available.
- They are technically feasible, easily understood, and cost effective to measure by all personnel involved in the monitoring.

Plan indicators may be used to provide information on ecosystem function, natural community health, covered species performance, and other components that are difficult to survey. In some cases, indicators may be used to determine the availability of habitat for a species. In cases where an indicator is used to monitor an ecosystem or natural community, conceptual models will be used to help identify an appropriate indicator species or variable.

The annual monitoring plans will clearly present the rationale for using selected indicators. Indicators must be applicable and appropriate measures of the biological goals and objectives. For example, the monitoring plan will specify why monitoring the presence of egg masses for covered amphibians is an appropriate indicator of population-based goals and objectives. The recommendations of the science advisors will also help guide the selection of indicators, and the Implementation Office will work with the fish and wildlife agencies to develop appropriate indicators.

3.6.4.2 Protocols

When available, existing and accepted monitoring protocols will be adopted to facilitate data comparison with other studies. In cases where standardized protocols are not yet available, protocols will be developed and proposed with reference to relevant guidance, such as the National Park Service's Inventory and Monitoring Program guidelines for monitoring protocols (Oakley et al. 2003) or the Bureau of Land Management's monitoring guidelines for plants (Elzinga et al. 1998). Proposed protocols will be subject to review and approval by the fish and wildlife agencies. Designated monitoring protocols will be appropriate to the task, implemented precisely, and as cost-effective as possible. BDCP will participate as a cooperating entity in efforts to standardize monitoring protocols for consistency with protocols used in neighboring and regional HCPs, NCCPs, and other conservation and environmental monitoring programs. Ongoing training by the BDCP Implementation Office or their contractors will ensure consistent protocol implementation.

3.6.4.3 Statistical and Sampling Design

Statistical and sampling design will vary with the goals and phases of monitoring. Baseline surveys may require a less rigorous sampling design, relying, for example, on visual surveys for detecting presence or absence. Rapid assessment techniques may also be used. As on-the-ground monitoring progresses, site selection and replication merit increased attention based on the goals of the monitoring at that time.

Sampling design seeks to minimize extraneous variance in the measured values of indicators or variables. Selection of variables will be guided by a thorough knowledge of the ecological relationships that drive natural communities. Sampling intensity and probability of detection will be considered to ensure that all covered species are adequately inventoried and monitored. Methods of data analysis will be established prior to study design, and a statistician or biologist with sufficient statistical expertise will be consulted. Some of the issues to consider in the experimental design are listed below (Scheiner and Gurevitch 1993).

- Availability of sites on which treatments can be applied.
- Availability of reference sites.
- Site selection design (e.g., random, stratified random, non-random).
- Choice of systematic versus opportunistic sampling.
- Detection probability of the sampling protocol.
- Avoiding pseudo-replication (Hurlbert 1984).
- Sufficient statistical power to identify changes or differences of concern.

3.6.4.4 Before-and-After Assessments

The Delta reflects a highly altered ecosystem with a limited number reference sites that provide long-term information on historic conditions (e.g., Suisun tidal marsh, Liberty Island). As such, the evaluation framework will rely heavily on the Before/After and Control/Impact (BACI) design approaches to assess ecosystem change (Green 1979; Underwood 1992; Underwood 1994). The BACI approach is typically presented as a means for testing if an effect on the system has occurred. The study design may also be used to evaluate conservation and restoration projects (Michener 1997; Lincoln-Smith et al. 2006) and test whether conditions are improving. This type of monitoring approach is commonly used in restoration ecology, particularly where numerous natural and anthropogenic disturbances represent unplanned, uncontrollable events that cannot be replicated or studied using traditional experimental approaches and statistical analyses.

3.6.4.4.1 Baseline Conditions

Baseline and monitoring survey results will be used as the basis for BACI designs intended to evaluate program effectiveness. In some cases baseline monitoring may involve monitoring at reference (control) sites inside or outside the BDCP area (e.g., habitat use in unaffected habitat areas). Surveys to establish existing baseline conditions are used to compare biological and physical conditions before and after implementation of conservation actions and to evaluate the effectiveness of those conservation actions. The BDCP monitoring program will be conducting sufficient baseline monitoring to establish the "before" condition against which change can be compared. This will entail both assessing existing databases and determining what new measurements will be useful prior to the implementation of a conservation measure. Most of these baseline surveys were needed in order to develop the Plan and have already been completed, but more local-scale surveys are likely to be needed in association with individual actions (e.g., restoration projects or predaceous fish control plans) needed to implement conservation measures. Baseline surveys will be performed prior to implementation of conservation actions with sufficient lead time to allow future detection of changes in trajectories for the expected outcomes after implementation.

As described above (Section 3.6.1, *Introduction*), a substantial number of monitoring programs currently exist in the Delta area, and some current and historic data can be used to aid in establishing baseline conditions. Existing data and monitoring programs include data that are collected Delta-wide and local-scale datasets pertaining to specific natural communities or locations within the Delta.

Depending on the conservation action being planned, documenting baseline conditions may include the following types of tasks.

- Inventory and document resources and improve mapping. The results of the assessments for land acquisition will be the first source of baseline data. Data-collection methods and nomenclature will be standardized to facilitate sharing of information.
- Conduct baseline surveys for plants in areas where covered activities may affect plant occurrences.
- Research and document historical data and trends, as appropriate.
- Use aerial photos and ground surveys, as needed, to assess quality and location of local and regional landscape linkages between unprotected natural areas and adjacent protected lands.

- Collect additional baseline data needed to refine conceptual models.

3.6.4.4.2 Preacquisition Surveys and Natural Community and Habitat Suitability Assessments

Pre-acquisition surveys and natural community and habitat suitability assessment are described in *CM3 Natural Communities Protection and Restoration*. These surveys and assessments typically address the following factors.

- The extent and quality of existing covered species habitats.
- Connectivity with other habitat areas.
- Presence of covered species (based on existing data).
- Infrastructure supporting existing habitats or needed to restore habitats.
- Potential constraints to long-term management and maintenance of habitats.
- Other conservation-related opportunities and constraints.

3.6.5 Effectiveness Monitoring

Evaluating changes in environmental conditions can be difficult. It is often unclear which environmental component will be affected by a stressor manipulation and what type of change will occur. A changing environment is natural, and variation due to natural effects may be great (Smith 2002). To account for this uncertainty and variation, BDCP monitoring designs will be based on where and when effects are expected to occur (both spatially and temporally), what organisms are expected to be affected (fish, wildlife, plants, aquatic invertebrates, etc.), what the expected benefits are (magnitude, duration), potential mitigating factors (including distribution and exposure), and how various factors may alter exposure and effect (Chapter 5, *Effects Analysis,* and its associated appendices).

Effectiveness monitoring will be performed for the permit's duration and in perpetuity per the terms of the Plan. Specific metrics and protocols for effectiveness monitoring will be developed early in Plan implementation and periodically revised in response to factors such as improvements in scientific understanding, improved technology, and the needs of integrated regional programs. It is anticipated that the extent of effectiveness monitoring will be reduced over time as causal relationships between the conservation measures and the responses of covered species and natural communities are better understood. For example, if relationships between tidal marsh restoration and zooplankton production are established through monitoring and research on restored tidal marshes, then effectiveness monitoring for assessing the production of zooplankton associated with subsequent restoration of tidal marsh may be reduced or performed more efficiently. However, effectiveness monitoring will have to continue in order to establish the effectiveness of the conservation measures in each conservation zone or ecologically relevant portions of the Plan Area, and the need for effectiveness monitoring will be periodically renewed as new techniques for conservation action implementation are tried via the adaptive management process.

As described above, research and monitoring plans associated with specific goals and objectives and associated conservation measures will be prepared as part of the adaptive management and monitoring program implementation process. These plans will be reviewed on a regular basis and

adjustments made in response to new information or identified research needs. Plan implementation, monitoring, analysis, and research are all part of the overall adaptive management process described earlier.

Potential effectiveness monitoring actions are described below, and the metrics for each action are presented in Appendix 3.E, *Adaptive Management and Monitoring Program*. This appendix also contains a description of programs that are currently implementing a portion or all of the monitoring action and an explanation of how the monitoring information is expected to inform adaptive management decision making. The Implementation Office will determine the specific methods for gathering monitoring information and may change monitoring actions and metrics through the adaptive management process. In some cases, data will be used to monitor effectiveness in multiple analytical scales. As a result, some monitoring actions and metrics may occur in one or more analytical scales (i.e., at landscape, natural community, and/or species scale).

3.6.5.1 Landscape Scale

Landscape-scale monitoring will be directed at tracking large areas, ecosystem processes, and regional issues that affect the Plan Area, and most actions are intended to ascertain the effectiveness of landscape-scale biological goals and objectives. Monitoring of ecosystem processes and conditions will provide the Implementation Office with information necessary to track long-term changes affecting the Delta ecosystem and to document the contribution of the BDCP toward maintaining and improving ecosystem attributes in support of the covered species and natural communities.

The BDCP Implementation Office will use the best available scientific understanding and data to set markers from which to assess future changes in ecosystem processes, structure, and function. Depending on the type and extent of data gaps, the BDCP Implementation Office will collect additional information at the outset of Plan implementation to gain a better understanding of existing conditions. Potential monitoring actions, their associated landscape objectives, and relevant conservation measures are summarized in Table 3.6-3. Specific metrics and approaches are provided in Appendix 3.E, *Adaptive Management and Monitoring Program.*

*[**Note to Reviewers:** Monitoring actions are still in review. This is an example of an action for one landscape-scale objective, one natural community objective (valley/foothill riparian natural community), and one species objective (riparian brush rabbit). A complete table will be released as soon as it is available.]*

Table 3.6-3. Effectiveness Monitoring Actions

Monitoring Actions[1,2]	Related Conservation Measures[3]	Related Biological Objectives[4]
GIS Analyses		
Perform GIS analysis of aerial photos to determine the relative increase in flooded acres.	CM3, CM5, CM11	L2.1
GIS analysis of digitized aerial photos to determine the relative cover and distribution of native riparian habitat types such as scrub, mid-successional forest, and mature canopy forest in restored areas.	CM3, CM5, CM11	L2.1
GIS analysis of digitized aerial photos to determine the relative cover and distribution of native riparian habitat types such as scrub, mid-successional forest, and mature canopy forest in restored areas.	CM7, CM11	VFRNC2.1
GIS analysis of digitized aerial photos to determine the relative cover and distribution of native riparian habitat types such as scrub, mid-successional forest, and mature canopy forest in restored areas.	CM3, CM7, CM11	RBR1.2
Field Surveys		
On the ground visual surveys for rare and covered plant species that have returned to newly flooded habitat from a persistent seedbank.	CM3, CM5, CM11	L2.1
On the ground visual surveys to determine use of newly created riparian habitat by riparian brush rabbit.	CM3, CM7, CM11	RBR1.2

Notes

1 Actual monitoring actions and protocols will be determined during BDCP implementation.

2 Appendix 3.E, *Adaptive Management and Monitoring Program*, describes potential monitoring protocols and metrics for each proposed monitoring action.

3 See Section 3.4, *Conservation Measures*, for detailed descriptions of conservation measures.

4 See Section 3.3, *Biological Goals and Objectives*, for detailed descriptions of biological goals and objectives.

3.6.5.1.1 Landscapes and Ecological Gradients

A goal of the Plan is to protect and restore large landscapes representing a range of physical and biological attributes (e.g., hydrology, soil, and plant associations) necessary to sustain viable populations of covered species and to preserve native species biodiversity. *CM3 Natural Communities Protection and Restoration* provides the mechanism and guidance for the acquisition of lands and the establishment of a system of conservation lands in the Plan Area necessary to meet natural community and species habitat protection objectives under the above goal.

Plan actions also have the potential to affect water quality important for covered species. Low levels of dissolved oxygen in the San Joaquin River near the Stockton Deep Ship Channel have been linked to delayed or impaired passage by Chinook salmon using the San Joaquin River basin. *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels* will maintain a dissolved oxygen aeration facility in the Stockton Deep Ship Channel. Hydrodynamic conditions, water quality, and movement of native fish are also addressed under *CM2 Yolo Bypass Fisheries Enhancement*, *CM4 Tidal Natural Communities Restoration*, and *CM5 Seasonally Inundated Floodplain Restoration*.

Monitoring actions to address ecosystem processes include the following types of activity.

- Measuring dissolved oxygen in the San Joaquin river to determine whether *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels* has effectively removed the passage barrier created by seasonally low dissolved oxygen levels.
- Conducting before-and-after sediment testing to detect methylmercury levels, as discussed in *CM12 Methylmercury Managment*.
- Monitoring to assess the effectiveness of natural community restoration actions in meeting goals and objectives related to environmental gradients.

3.6.5.1.2 Connectivity

One goal of the conservation strategy is to sustain and enhance the effective movement and genetic exchange of native organisms within and between natural communities inside and outside the study area. Connectivity is addressed under *CM3 Natural Communities Protection and Restoration*, but also through other conservation measures, such as *CM7 Riparian Natural Community Restoration* and *CM8 Grassland Natural Community Restoration*. The Implementation Office will employ effectiveness monitoring to ensure that covered species use conservation reserve network linkages effectively and that management actions to increase permeability or improve connectivity are successful.

3.6.5.1.3 Ecosystem Processes

The variability and range of ecosystem processes have been altered in the Plan Area by the modification of ecosystem hydrology, the conversion of natural habitat to agricultural systems, residential and commercial development, and other effects of human activity. These ecosystem processes drive biological processes that characterize natural communities and sustain viable populations of covered species. For example, hydrologic processes are an important driver for aquatic ecosystem function, and their key attributes include timing (seasonal, tidal), magnitude, frequency, duration, volume and depth.

Monitoring actions to address ecosystem processes include the following types of activity.

- Actions to determine the effectiveness of habitat restoration achieved under *CM4 Tidal Natural Communities Restoration, CM6 Channel Margin Enhancement, CM7 Riparian Natural Community Restoration, CM8 Grassland Natural Community Restoration, CM9 Vernal Pool Complex Restoration*, and *CM10 Nontidal Marsh Restoration*.
- Actions to determine the effectiveness of management actions implemented under *CM11 Natural Communities Enhancement and Management*.
- Actions to measure productivity improvements expected from implementing *CM2 Yolo Bypass Fisheries Enhancement* and *CM5 Seasonally Inundated Floodplain Restoration*.
- Actions to determine the effectiveness of various predatory fish control actions taken under *CM15 Predator Control* and to evaluate the spatial distribution of those control actions in order to identify and prioritize control sites through the adaptive management process. *CM5 Seasonally Inundated Floodplain Restoration* and *CM6 Channel Margin Enhancem*ent also have actions that examine habitat use by predators.

- Actions to determine the effectiveness of various invasive aquatic vegetation actions taken under *CM13 Invasive Aquatic Vegetation Control*.
- Besides trend analysis of other landscape monitoring actions, there are likely to be additional actions to evaluate biological processes related to climate change. These are likely to be developed through the adaptive management process in relation to emerging.

3.6.5.2 Natural Communities

The Implementation Office will monitor the extent and distribution of natural communities within the BDCP conservation lands and within the Plan Area at appropriate intervals over the term of the BDCP. This monitoring will provide the Implementation Office with information sufficient to track long-term changes in the distribution and extent of covered natural communities. These monitoring data will also help to document the BDCP's contribution toward maintaining and improving the extent, distribution, and continuity of natural communities and covered species. The baseline conditions from which changes in the range and distribution of natural communities and covered species will be assessed are the conditions described in Chapter 2, *Existing Ecological Conditions,* and Appendix 2.A, *Covered Species Accounts,* and in baseline data collected by the Implementation Office early in the implementation period.

Where protection of biological diversity is a goal, natural community monitoring is needed to evaluate success. Effectiveness monitoring at the natural-community scale will provide the information necessary to verify progress toward achieving the Plan's biological goals and objectives described in Section 3.3.4, *Natural Community Biological Goals and Objectives*. The monitoring plan will focus on the degree of progress in the following areas.

- Effectiveness of habitat protection, preservation, and restoration that contribute to the conservation of associated covered and other native species.
- Maintenance and enhancement of habitat functions to increase the abundance and distribution of associated covered and other native species.
- The benefit of covered species and native plants.
- The promotion of native biological diversity (e.g., species richness, presence or abundance, biomass) through restoration or creation of natural communities to increase the extent and availability of covered and other native species habitat.

The sections below provide an overview of the types of monitoring actions that the BDCP will carry out to track progress toward meeting biological goals and objectives at the natural-community scale. Monitoring will be performed for the permit's duration and in perpetuity per the terms of the Plan. Specific metrics and protocols for effectiveness monitoring of natural communities will be developed during Plan implementation. Table 3.6-3 summarizes potential monitoring actions, associated landscape objectives, and relevant conservation measures. Specific metrics and approaches are provided in Appendix 3.E, *Adaptive Management and Monitoring Program*.

3.6.5.2.1 Tidal Natural Communities

Tidal natural communities include tidal perennial aquatic, tidal mudflat, tidal brackish emergent wetland, and tidal freshwater emergent wetland. Tidal natural communities support many covered species; they are used as foraging, refuge and spawning or migration habitat by covered fish species;

they provide reproduction, feeding, and resting habitat for many covered wildlife species; and they include occurrences of several covered plant species. Preservation and restoration of tidal natural communities will occur in conjunction with C*M3 Natural Communities Protection and Restoration* and *CM4 Tidal Natural Communities Restoration* and to a lesser degree through *CM6 Channel Margin Enhancement*. Monitoring actions will focus on effectiveness of management to improve habitat quality and connectivity for covered species (e.g., by restoring tidal marsh channel network appropriate to the Plan Area), enhance or restore tidal habitat (e.g., by restoring tidal action and reversing subsidence), decrease the spread of nonnative species, and increase the extent and diversity of native plants and wildlife (e.g., by promoting establishment of native vegetation).

3.6.5.2.2 Seasonally Inundated Floodplains

Floodplains are generally shallow, flat areas adjoining rivers and sloughs that are inundated when flows exceed the capacity of the stream channel. In the Plan Area, they occur in association with a variety of natural communities, including areas of tidal brackish emergent wetland, tidal freshwater emergent wetland, valley/foothill riparian, nontidal freshwater perennial emergent wetland, managed wetland, other natural seasonal wetland, grassland, and cultivated lands. Restoration of this natural community represents an opportunity to improve landscape function and connectivity. When inundated, floodplains benefit species that can access these aquatic habitats by supporting invertebrates that are a food source for waterfowl, shorebirds, and many covered fish species and by providing spawning habitat for some fishes and refuge habitat along migration corridors (Moyle et al. 2007; Silveira 1998).

Monitoring actions will focus on effectiveness of management to improve habitat quality and connectivity for covered species (e.g., by increasing the frequency and duration of inundation within the Yolo Bypass), enhance or restore floodplain habitat (e.g., by removing existing levees or sections of existing levees), to decrease the spread of nonnative species, and to increase the extent and diversity of native plants (e.g., slough thistle) and wildlife (e.g., migrating juvenile salmonids).

3.6.5.2.3 Channel Margins

Channel margins are the transition zone between open water and adjacent wetland or upland natural communities; most channel margins that would be restored under the BDCP are adjoined by valley/foothill riparian natural community or cultivated land. Channel margins provide high-value rearing habitat for several covered fishes including juvenile salmonids and delta smelt.

Monitoring actions evaluating channel margin areas will focus on effectiveness of management to improve habitat quality and connectivity for covered species, enhance or restore channel margins, and track the response of target species to habitat management activities.

3.6.5.2.4 Valley/Foothill Riparian Natural Community

Riparian natural community tends to be distributed across the landscape as narrow corridors along watercourses or as isolated remnant patches associated with streams and permanent and intermittent water sources. The natural community is dominated by cottonwood, willow and oak trees and willow/blackberry scrub, and provides habitat for several covered species, including riparian brush rabbit, Swainson's hawk, western pond turtle, and valley elderberry longhorn beetle. Debris, terrestrial insects, and shade provided by the natural community affect adjacent channels

and channel margins by providing forage, cover, and water quality benefits to covered fish species, especially juvenile salmonids.

Monitoring actions will focus on effectiveness of management to restore the riparian natural community, improve habitat quality and connectivity for covered species, enhance or restore riparian forest, decrease the spread of nonnative species, and increase the extent and diversity of native plants and wildlife.

3.6.5.2.5 Grassland Natural Community

Grassland natural community is dominated by both introduced and native annual and perennial grasses and forbs. The grassland natural community provides habitat for several BDCP covered species, including San Joaquin kit fox, Townsend's big-eared bat, tricolored blackbird, giant garter snake, California tiger salamander, serpentine plants, and San Joaquin spearscale.

Monitoring actions will focus on the effectiveness of management to reduce the presence of nonnative plants, increase the extent and diversity of native plants, and promote keystone species (e.g., California ground squirrel) within the natural community for the benefit of native plants and wildlife.

3.6.5.2.6 Vernal Pool Complex Natural Community

Vernal pool complex natural community is characterized by interconnected and isolated groups of vernal pools and seasonal swales, which are generally found within a matrix of grassland or alkali seasonal wetland natural community. The natural community is rare in the Plan Area, but there are large areas of vernal pool complex to the east and west of the Plan Area. Vernal pools provide habitat for a number of endemic, native plants and wildlife including covered species such as alkali milk-vetch, Boggs Lake hedge-hyssop, vernal pool tadpole shrimp, vernal pool fairy shrimp, giant garter snake, and western burrowing owl.

Monitoring actions will focus on effectiveness of management to improve habitat quality and connectivity for covered species, enhance or restore vernal pool habitat, decrease the spread of nonnative species (e.g., ryegrass and pepperweed), and increase the extent and diversity of native plants and wildlife.

3.6.5.2.7 Nontidal Freshwater Perennial Emergent Wetland Natural Community

The nontidal freshwater perennial emergent wetland natural community is characterized by emergent soft-stemmed aquatic plants, a shallow water regime, and generally shallow peat deposits (Mitsch and Gosselink 1993). This natural community occurs in highly fragmented patches within the Plan area. This natural community provides breeding habitat for California red-legged frog and is a primary habitat for giant garter snake and western pond turtle. Benefits from restoring this natural community include reestablishing ecological gradients and connectivity with other native habitats, including grassland, riparian, and permanent aquatic habitats; improving genetic interchange among native freshwater emergent wetland species' populations; and contributing to the long-term conservation of giant garter snake (U.S. Fish and Wildlife Service 2006).

Monitoring actions will evaluate the effectiveness of management to improve habitat quality and connectivity for covered species, enhance or restore nontidal freshwater marsh habitat to support native wildlife functions, decrease the spread of nonnative species, and increase the extent and diversity of native marsh vegetation. Monitoring actions will also track the response of target species (e.g., tricolored blackbird, giant garter snake, western pond turtle, and Townsend's big-eared bat) to habitat management activities.

3.6.5.2.8 Covered Species

The status and distribution of covered fish, wildlife, and plant species will be monitored in the Plan Area over the term of the BDCP. This monitoring will provide the Implementation Office with information sufficient to track long-term changes attributable to factors such as covered activities, physical and chemical changes, climate change, and other factors that may affect covered species. The results of these monitoring efforts will document the contribution of the BDCP to the conservation of covered species and inform system-level assessments of status, trends, and distribution. The baseline conditions from which changes in the range and distribution of covered species will be assessed are the conditions described in Chapter 2, *Existing Ecological Conditions,* and Appendix 2.A, *Covered Species Accounts,* and in baseline data collected by the Implementation Office early in the implementation period.

As part of the covered species monitoring, the Implementation Office will also review relevant scientific information documenting improved knowledge of covered species biology, including such topics as behavior, habitat needs, and ecological interactions. Review of this information will further inform assessments of the status of covered species within the Plan Area and decisions concerning whether to modify species management and monitoring through the adaptive management process. Monitoring will be performed for the permit's duration and in perpetuity per the terms of the Plan. Specific metrics and protocols for species effectiveness monitoring will be developed during Plan implementation.

This section provides an overview of the monitoring actions that the Implementation Office will conduct to assess the status of covered species and to determine the extent to which the conservation strategy, described in Chapter 3, *Conservation Strategy*, is being implemented and the extent to which biological goals and objectives for species are being met (Section 3.3, *Biological Goals and Objectives*). Species-specific monitoring will address the following issues.

- Perform field surveys and database coordination to document and monitor species status.
- Evaluate covered species response to flow management implemented per *CM1 Water Facilities and Operation*.
- Evaluate covered species response to habitat restoration actions implemented under conservation measures *CM3 Natural Communities Protection and Restoration* through *CM11 Natural Communities Enhancement and Management*.
- Evaluate covered fish species response to stressor reduction actions implemented under *CM12 Methylmercury Managment*, *CM13 Invasive Aquatic Vegetation Control*, *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, *CM15 Predator Control*, *CM16 Nonphysical Fish Barriers*, *CM17 Illegal Harvest Reduction*, *CM19 Urban Stormwater Treatment,* and *CM21 Nonproject Diversions*.

- Evaluate covered fish species response to conservation hatchery programs implemented under *CM18 Conservation Hatcheries*.

In some cases conservation for covered species is addressed primarily through monitoring actions at the landscape scale and the natural-community scale. In such cases, the responses of covered species will serve to measure the success of management actions at the landscape or natural-community level. Monitoring is described in Sections 3.6.5.1, *Landscape Scale*, and 3.6.5.2, *Natural Communities*, above. For some species, additional species-specific goals and objectives were deemed necessary for conservation, and the monitoring actions are described below. Table 3.6-3 summarizes potential monitoring actions. Specific metrics and approaches are provided in Appendix 3.E, *Adaptive Management and Monitoring Program*.

3.6.5.2.9 Fish Species

Populations of covered fish species, and native fish in general, in the Bay Delta and Central Valley have dramatically declined in recent decades, leading to the listing (or proposed listing) of several as threatened or endangered under the federal and/or California endangered species act(s), or as California species of special concern. A variety of stressors have been implicated in the declines, among which are declining physical habitat quality and availability, impaired water quality, reduced ecosystem productivity, increased predation, and general effects related to ecological interactions with a wide variety of nonnative organisms (Chapter 5, *Effects Analysis,* and its associated appendices). Biological goals and objectives for the covered fish species focus on aquatic environmental stressors and their effects on fish populations. The principal conservation measures that address those stressors are listed below.

- *CM1 Water Facilities and Operation*
- *CM13 Invasive Aquatic Vegetation Control*
- *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*
- *CM15 Predator Control*
- *CM16 Nonphysical Fish Barriers*
- *CM17 Illegal Harvest Reduction*
- *CM19 Urban Stormwater Treatment*
- *CM20 Recreational Users Invasive Species Program*
- *CM21 Nonproject Diversions*

Most of these conservation measures are evaluated by monitoring actions at the landscape and natural community levels Monitoring actions specific to covered fish species will evaluate progress towards achieving the fish species biological objectives by tracking population status indicators such as midwater trawls and screw trap collections, counts of entrained and salvaged fish, or counts of stranded fish.

3.6.5.2.10 Wildlife Species

As with the covered fishes, populations of covered wildlife species in the Bay Delta and Central Valley have dramatically declined in recent decades, leading to the listing (or proposed listing) of

several as threatened or endangered under the federal and/or California endangered species act(s), or as California species of special concern. Primary causes of declines can are continuing habitat loss and fragmentation, and negative interactions with nonnative species.

Conservation of covered wildlife species is addressed primarily through conservation measures that receive effectiveness monitoring at the landscape and natural community scales (Sections 3.6.5.1, *Landscape Scale,* and 3.6.5.2, *Natural Communities*). For some species, additional species-specific goals and objectives have been designated, and monitoring actions will be required to evaluate effectiveness of management actions in attaining these objectives. Additionally, monitoring will be used to periodically re-evaluate species status within the Plan Area and identify trends in covered species use of habitat associated with protected and restored natural communities.

3.6.5.2.11 Plant Species

Covered plant species in the Plan Area occur in a variety of natural communities, chiefly vernal pools, grasslands, and fresh to brackish wetlands. Occurrences of covered plant species in the Bay Delta and Central Valley region have declined resulting in listing by federal and state agencies and by the California Native Plant Society. Primary causes of decline are habitat loss, clearing, dredged material disposal, and negative interactions with nonnative species.

Similarly to wildlife species, conservation of covered plant species is addressed primarily through ecosystem and natural community goals and objectives (Sections 3.6.5.1, *Landscape Scale,* and 3.6.5.2, *Natural Communities*). For some species, additional species-specific goals and objectives have been designated, and monitoring actions will be required to evaluate effectiveness of management actions in attaining these objectives. Additionally, monitoring will be used to periodically re-evaluate species status within the Plan Area and identify trends in covered species use of habitat associated with protected and restored natural communities.

3.6.5.3 Using Information from Existing and Ongoing Programs

Numerous monitoring programs currently exist in the Delta area, and some current and historic data can aid in establishing baseline conditions. Existing data and monitoring programs include data that are collected Delta-wide and local-scale datasets pertaining to specific natural communities or locations within the Delta.

Delta-wide monitoring data will be used to establish the overall condition of the Delta area. Existing Delta-wide data include distribution of land cover and natural communities, land use, water quality, and water quantity. These data are presented in the Plan, particularly in the following locations.

- Distributions of natural communities and covered species: Chapter 2, *Existing Ecological Conditions*, and sources cited therein.
- Baseline information on covered species: Appendix 2.A, *Covered Species Accounts*, and sources cited therein.
- Land ownership: Partially presented in Chapter 2, *Existing Ecological Conditions,* and Chapter 3, *Conservation Strategy*; DWR has a complete GIS database.
- Long-term trend and baseline water quality monitoring: Database of the Delta Water Quality – Comprehensive Monitoring Program.

- Streamflow monitoring: multiple programs, including the following ones.
  - Continuous Recorder Sites (DWR, Reclamation).
  - Delta Flows Network and National Water Quality Assessment Program (USGS).
  - DWR, SRCSD, SWAMP, Central Valley Water Board, State Water Board, San Francisco Estuary Institute, and other programs.
- Phytoplankton and zooplankton productivity and abundance and Delta microcystis abundance data: the IEP Environmental Monitoring Program.
- Bird distribution and abundance: the USFWS midwinter waterfowl surveys.
- Fish distribution and abundance: programs administered under IEP and some other sources.

3.6.6 Directed Research

Research actions are generally not a requirement of HCPs and NCCPs. Given the ecological complexity of the Delta and the level of uncertainty regarding anticipated beneficial outcomes from the conservation strategy, there is a need for research to address key uncertainties. Adaptive management addresses these uncertainties through a structured process that provides for the improvement of relevant knowledge, while seeking to minimize management risks associated with proposed activities (Keith et al. 2011). Active adaptive management explicitly incorporates learning as part of the objective function, making decisions that improve learning (Holling 1978; Walters 1986). As described in Section 3.6.4, *Effectiveness Assessment Guidelines*, the Implementation Office will follow strict scientific guidelines when implementing directed research activities. Directed research conducted under BDCP will have the following attributes.

- Be directly relevant to uncertainties associated with BDCP implementation.
- Have clear goals, hypotheses, methods, analytical approaches, and deliverable schedules.
- Make results available to the fish and wildlife agencies and to the public.

Existing research programs in the Delta have produced a broad range of valuable research results and conclusions. Many of these efforts are ongoing under the IEP and Delta Science Program (Section 3.6.1, *Introduction*). The BDCP will consider these efforts when identifying and prioritizing key research needs to fill data gaps and address uncertainty relevant to the BDCP.

3.6.6.1 Critical Uncertainties

Critical uncertainties are key questions that, when answered, modify the conceptual model of an ecological system. Some of the key uncertainties are expected to be resolved using directed research, and others may only be resolved over time as the system changes. It is expected that new data and information will be developed during implementation that will increase knowledge and help reduce uncertainties regarding implementation and outcomes of the conservation measures.

Many key uncertainties have been identified for individual conservation measures (Section 3.4, *Conservation Measures,* Section 3.5, *Important Regional Actions,* and Chapter 5, *Effects Analysis*). Some of them are expected to be resolved by directed research and others may be resolved by studies outside BDCP. Directed research principally involves the following approaches.

- Developing new and more sensitive indicators and metrics.
- Modeling and assessing responses of ecosystems and covered species to stressors addressed by conservation measures.
- Determining causal relationships between ecological stressors and changes in natural communities and covered species.
- Identifying and evaluating tradeoffs among conservation measures.
- Developing more detailed life-history models for all covered fish species to facilitate Plan implementation and guide adaptive management.

3.6.6.2 Directed Studies

Directed studies will be used to reduce uncertainty related to how the Delta ecosystem and its components function. Directed studies will also be used to reduce uncertainty related to achieving biological goals and objectives. Results of studies conducted under the Plan will inform management and will improve the likelihood of achieving BDCP biological goals and objectives.

Chapter 5, *Effects Analysis,* and its associated appendices outline the use of various analytical tools that provide a framework for evaluating the effects of the conservation measures. The Implementation Office will use and maintain these analytical tools and may also develop, or support development and refinement of, models and other analytical tools to enhance the adaptive management process. To refine these analytical tools or develop new analytical tools, the BDCP Implementation Office will conduct directed studies to collect necessary information. All proposed studies will be prioritized and will be carried out according to their priority ranking. Results of research would be used to help direct and prioritize subsequent implementation of conservation measures through the adaptive management process. Table 3.6-4 lists potential research actions.

3.6.6.2.1 Pilot Studies

Pilot projects will be used to ascertain, on a small scale, which management actions may ultimately yield conservation benefits prior to initiating a long-term project. Pilot projects are a cost-effective way to test management actions. Pilot projects are designed to evaluate alternative monitoring protocols and sampling designs and to select the best technique for obtaining information.

The Implementation Office may also conduct pilot projects to develop, test, and refine monitoring protocols for ecosystems, natural communities, and species. The purpose of this testing is to identify the best and most cost-effective monitoring methodologies to derive the desired information.

Various management techniques may also be implemented and evaluated as pilot projects. In some cases, restoration, enhancement, and monitoring methods are not known or have not been successfully reproduced on a large scale by land managers or the scientific community. Before restoration or enhancement through management can occur successfully, these methodologies need to be tested on a smaller scale. These pilot projects, designed to test the effectiveness of restoration and enhancement, are necessarily long-term (i.e., 5- to 15-year) endeavors. They will inform long-term management and can be included as part of the long-term management program. This feedback will increase the efficiency with which reserve lands can be managed and the overall success rate of management activities. Similar pilot projects will be developed in the targeted studies phase when multiple techniques are intended to achieve a desired outcome and are

appropriate for monitoring habitat function within Plan Area. Testing the use of indicators for natural communities or covered species, refining monitoring protocols, establishing control plots for long-term management, and reviewing the literature for guidance on sampling, experimental design, and management will all be a part of the targeted studies phase of implementation.

3.6.6.2.2 Implementation

As part of Plan implementation, and by the end of each calendar year, the Implementation Office will prepare an annual monitoring and research plan for approval by the Implementation Board. The plan will identify actions that are complementary to, and consistent with, the BDCP conservation strategy. BDCP will prioritize and provide funding for research to support more effective implementation of BDCP's conservation strategy.

Additional research needs will be identified by the Implementation Office over the term of Plan implementation. BDCP research activities will be refined as proposed actions associated with conservation measures are implemented and site-specific designs, including experimental designs, are developed. Research will be coordinated with monitoring to ensure that it functions as one program where the research is designed specifically to address key uncertainties in the information being gathered and to establish causal links to the conservation measures and BDCP biological goals and objectives. Results of research would also be used to help direct and prioritize subsequent implementation of conservation measures though the adaptive management process.

1 **Table 3.6-4. Conservation Measures, Key Uncertainties, and Potential Research Actions**

Conservation Measure	Key Uncertainty[1]	Potential Research Actions[2]
CM1 Water Facilities and Operation	Relationship between Delta Cross channel operation, covered fish survival and transport, and tidal flows.	Document fish migration changes resulting from altered Delta Cross Channel operations.
	Overall effects of new water facilities and operation on predation.	Characterize predation (timing, frequency, site-scale influences, predator and prey characteristics) at North Delta intakes.
		Determine the change in Central Delta predation due to altered flow downstream of the new north Delta diversions.
CM2 Yolo Bypass Fisheries Enhancement	Response to implemented modifications.	Evaluate growth rates of juvenile salmonids entering the Yolo Bypass during periods of Fremont Weir operation.
		Evaluate passage success of juvenile covered salmonids, sturgeon, Sacramento splittail, and lamprey from the Yolo Bypass during periods of Fremont Weir operation.
		Document Sacramento splittail spawning and spawning success in the Yolo Bypass during periods of Fremont Weir operation.
		Evaluate the extent of covered fish species loss due to predators as a result of changing flows or habitat conditions.
CM4 Tidal Natural Communities Restoration	Causal relationship between tidal marsh restoration and food production and exports.	Quantify the primary production exported from restored tidal marsh plain into adjacent restored subtidal aquatic habitat areas.
	Hydrodynamic effects on export rates of organic carbon.	Document the export of organic carbon produced in restored tidal marsh plain into existing Plan Area channels.
	Causal relationships between tidal marsh restoration and benthic invertebrate communities.	Determine the extent and patterns of establishment of nonnative clams in restored subtidal aquatic habitats.
CM12 Methylmercury Management	Relationship between tidal habitat restoration locations and export of methylmercury into adjacent channels.	Assess levels of bioaccumulation of methylmercury in sediments, foodweb of covered and other native species, and sportfish.
CM13 Invasive Aquatic Vegetation Control	Relationships between tidal habitat restoration design and the establishment and spread of nonnative aquatic vegetation.	Evaluate the effect of tidal habitat restoration on the establishment of nonnative aquatic vegetation in subtidal aquatic habitats.
	Effects of herbicide on the relationship between phytoplankton and Microcystis.	Determine effects of water flow and temperature on Microcystis bloom and its effects on phytoplankton.

Conservation Measure	Key Uncertainty[1]	Potential Research Actions[2]
CM15 Predator Control	Predator removal hotspot priorities.	Document the locations, predation intensities, and prospects for effective control at fish predation hotspots within the Delta.
	Effectiveness and durability of predator control in improving survival of covered species.	Conduct before-and-after studies evaluating the density and abundance of predators at removal location and nearby sites (are fish numbers reduced or simply redistributed?)
	Population-level and community-level response of predators and covered species to localized predator removals.	Determine abundance, age classes, and distribution of predators, including striped bass, largemouth bass and other smaller piscivorous fish.
CM16 Nonphysical Fish Barriers	Barrier effectiveness for non-salmonid covered species.	Evaluate effectiveness of deterrents on green sturgeon, white sturgeon, and smelts.
	Predator response to nonphysical barrier.	Determine abundance of predators within the area of the nonphysical barriers, both before and after installation, and evaluate the effect of the barriers on the survival of outmigrating juvenile salmonids.
		Evaluate predator response to operation of nonphysical barriers.
CM18 Conservation Hatcheries	Risks associated with the release of hatchery stock to enhance natural populations.	Evaluate effects of introduced hatchery-raised delta smelt on longfin smelt on wild populations.
CM21 Nonproject Diversions	Diversion prioritization for all covered fish species (not just salmonids).	Develop techniques to assess entrainment risks for juvenile sturgeon and the smelts.
		Implement evaluation techniques at diversions that are being evaluated for effects on salmonids, and use results to develop an integrated prioritization strategy that benefits multiple covered fish species.

[1] Preliminary identified BDCP uncertainties based upon current understanding (see Chapter 5, *Effects Analysis*, and its associated appendices). Additional uncertainties will likely arise and be identified during implementation of the BDCP.

[2] Preliminary identified potential research actions (see Chapter 5, *Effects Analysis*, and its associated appendicles). Actual research actions will be determined during implementation of the BDCP.

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3.6.7 Data Management and Reporting

3.6.7.1 Data Management and Maintenance

Data management is an essential function of the BDCP Implementation Office. Developing and maintaining a comprehensive database of BDCP actions and decisions is important to document permit compliance and the progress of the Plan toward meeting the biological goals and objectives. Maintaining an organized and accessible database is also important for regular reporting of BDCP progress to the Implementation Office member entities, the fish and wildlife agencies, and the public.

The BDCP Implementation Office will develop and maintain a spatially linked database to track Plan implementation. The database will be structured to allow for future expansion and integration with external databases (e.g., linkage to the databases of the Delta Science Program, and California Water Quality Monitoring Council). The database will look to other well-recognized database management examples, such as the new IEP database (estimated reveal date of 2012).

The following functions are expected to be supported by the BDCP database.

- Data documentation such that future users can determine why, how, and where data were collected (i.e., metadata).
- Quality assurance and quality control methods for data entry.
- Access to and use of the most current information for analysis and decision making.
- Corrections and improvements in the data.

The database is expected to maintain the following information.

- Monitoring, research, and adaptive management experiment data and results.
- Modeling inputs, outputs, and results.
- Status of covered activities, including implementation and effects.
- Implementation status of conservation measures.
- Implementation status of research and adaptive management experiments.
- Adopted changes to BDCP implementation through the adaptive management process.
- All reports and documents generated by the Implementation Office and relevant data and reports generated by other entities.
- The BDCP Implementation Office may choose to develop a web-linked database to facilitate controlled transfer of information into and out of the database by other entities. If the BDCP Implementation Office chooses to allow access to the database by others, the database will incorporate controls and monitoring to ensure database integrity.

The BDCP Implementation Office will ensure quality control of all monitoring data and will adopt procedures to maintain high standards of quality. Steps will be instituted to maintain the accuracy and functionality of gages, meters, and other devices, and protocols will be established to govern the collection, transcription, and storage of data. All monitoring data will be entered into database software and will be made available online once quality control analyses have been conducted.

The BDCP Implementation Office will use standard analytical procedures where such procedures exist. Particular analyses would be specific to individual monitoring parameters and would consist of classical parametric or nonparametric hypothesis testing and statistical models to the extent practicable. The BDCP Implementation Office will consult with professional statisticians as necessary to ensure correct experimental and data collection program design.

3.6.7.2 Reporting Requirements

To demonstrate permittee compliance with BDCP permit requirements, an annual report will be prepared by the Implementation Office and submitted to the fish and wildlife agencies (Chapter 6, *Plan Implementation*, Section 6.2, *Compliance and Progress Reporting*). The highlights of the report will be presented at a BDCP public workshop, and the report will be made available to the public.

Chapter 6, *Plan Implementation*, presents the implementation schedule for the BDCP. To ensure successful implementation, the Implementation Office may need to adjust the schedule to address new information or changed or unforeseen circumstances (Chapter 6, *Plan Implementation*). More detailed and specific monitoring schedules will be developed for each BDCP conservation action.

Throughout the course of BDCP implementation, the Implementation Office will prepare and submit to the fish and wildlife agencies the following documents, described in Chapter 6, *Plan Implementation*.

- Annual Work Plan and Budget
- Annual Water Operations Strategy
- Annual Progress Report
- Annual Water Operations Report
- Five-Year Comprehensive Review
- Five-Year Implementation Plan

These documents will enable the range of interested public and private stakeholders, and the general public, to assess the progress and performance of the BDCP toward meeting its biological goals and objectives and make informed recommendations to the Implementation Office regarding matters relating to Plan implementation. These reports will be available to the public and posted on the BDCP website.

3.6.8 References

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