The San Francisco Bay Joint Venture Monitoring & Evaluation Plan

MEASURING CONSERVATION DELIVERY EFFECTIVENESS IN AN EVOLVING LANDSCAPE

Phase I - Section III: Waterfowl

Developed by the San Francisco Bay Joint Venture Science Subcommittee

October 2011

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Approved by the SFBJV Management Board: 25 October 2011

Please cite this document as: SFBJV Science-subcommittee. 2011. Measuring Conservation Delivery Effectiveness in an Evolving Landscape: The San Francisco Bay Joint Venture Monitoring & Evaluation Plan. Phase I. San Francisco Bay Joint Venture Office, Fairfax, CA, USA.

Cover photo: Surf Scoters in San Francisco Bay by USGS

Printing: Innovative Print Solutions, 415-507-9040.

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III. Waterfowl Status & Trends

The San Francisco Bay (SFB) is of critical importance to waterfowl along the Pacific Flyway, and is particularly noted as a key wintering area for diving ducks such as Greater and Lesser Scaup, Canvasbacks and Surf Scoters. On average, SFB harbors over 40% of Scaup and Scoters counted in the Flyway each winter (Collins and Trost 2009). San Francisco Bay is also important habitat for a variety of dabbling duck species, including Northern Shovelers and Northern Pintails, which are found in tidal slough channels and in managed ponds. Northern Shovelers are the most common ducks found in low salinity, shallow managed ponds (US Geological Survey (USGS) and San Francisco Bay Bird Observatory (SFBBO), unpubl. data). Northern Pintail were historically the most common dabbling ducks in the SFB but have been declining continent-wide (Goals Project 2000).

Diving ducks such as Greater and Lesser Scaup, and Surf Scoters are in decline across their North American range due to unknown causes. At major wintering areas, such as SFB, food is hypothesized as a primary limiting factor (S. De La Cruz, USGS, pers. com.). The non-native clam *Corbula amurensis*, has become the major prey item for diving ducks in the San Pablo Bay, a northern sub-region of the SFB (De La Cruz 2010, Takekawa et al, pers. com.). Lovvorn et al. (in review) used data from radio-marked birds and intensive benthic sampling to model diving duck use in the subtidal region of San Pablo Bay. This study showed that Scaup and Scoters might leave this area before *Corbula* food resources have been depleted. While additional work is needed, one explanation may be declining profitability as prey becomes patchy and difficult to find. This may cause the birds to leave the area before their absolute threshold of low prey density is reached (Lovvorn et al, in review).

Non-native species invasions are a continual threat to waterfowl given their high rate of occurrence in the SFB (Cohen and Carleton 1995). Invasive prey species can become abundant food resources capable of boosting waterfowl numbers (Custer and Custer 1996, Wormington and Leach 1992), yet may also limit population size or health if they represent lower foraging profitability or an increased risk of contaminant accumulation (De La Cruz 2010, Linville et al 2002). Contaminants may be limiting to some SFB waterfowl as there is evidence that selenium, mercury, and cadmium may influence body condition in Scaup and Canvasbacks (Takekawa et al 2002). Contaminants did not appear to influence proximate measures of condition in Surf Scoters (De La Cruz 2010), but other studies have tied mercury and selenium to oxidative stress in SFB Scoters (Hoffman et al 1998). Such subtle effects on condition may go on to influence survival, migratory timing, and ultimately productivity.

As large-scale restoration of tidal marshes moves forward, including the conversion of former salt production to managed ponds, associated benefits and threats to waterfowl populations must be identified and assessed (Warnock 2002, Athearn 2010, Valoppi 2010). Climate change related sea level rise may alter available subtidal and intertidal habitats for waterfowl throughout the SFB, and may influence prey composition or accessibility. A variety of factors such as subsidence, sediment supply, hydrologic connectivity, and sea level rise influence the restoration trajectory of restored habitats, and the length of time required for tidal marsh characteristics to develop, which also has

implications for habitat availability and suitability for waterfowl. As restored lands accrete and marsh vegetation begins to colonize, conversion of former pond habitat to tidal marsh may reduce habitat for diving ducks and other waterfowl if alternative habitat is not created. One goal of the South Bay Salt Pond Restoration Project (SBSPRP) is to maintain existing ecological value for waterbirds (Trulio et al 2005), but long-term information is key to ensure that habitat requirements of large numbers of waterbirds can be met with reduced managed pond acreage. It is also suspected that human disturbance may influence waterfowl use of certain areas by causing birds to flush from their foraging areas and roosts more frequently, but this has not yet been tied to waterfowl productivity or survival. Given the projected human population growth in the SFB region, the related potential for human disturbance to wildlife as a continued or increasing pressure should be the subject of continuing research.

To ensure that SFB area waterfowl will benefit from habitat conservation and restoration activities as outlined in the San Francisco Bay Joint Venture (SFBJV) Implementation Plan (2001), it is essential to regularly monitor habitat extent (spatially and temporally) and population levels and to evaluate effectiveness of SFBJV conservation delivery. Resulting data, including acreage by habitat type, habitat distribution, and scalable population (abundance or density) or vital rate metrics (body condition [as proxy] or adult survivorship), will also serve to inform flyway or continental scale population objectives set by the North American Waterfowl Management Plan (NAWMP 2004).

Modeling population-habitat relationships for waterfowl during winter has generally been restricted to abundance-based bio-energetic models that calculate the amount of seasonal habitat needed to support a target waterfowl population size within a region, and these have been widely and successfully used over the last two decades to strategically guide conservation planning for waterfowl in wintering areas (Loesch et al. 1994, Central Valley Joint Venture 2006). It has been more challenging to develop models that link waterfowl demographics to changes in spatio-temporal habitat conditions, or models that provide the ability to model predictive scenarios. Remaining key ecological uncertainties include the functional forms of density dependence in waterfowl and other waterbird population dynamics and relationships among vital rates, carrying capacity, and habitat characteristics at multiple scales. The biological models and assessment tools currently used to describe population-habitat relationships for waterfowl during winter and guide conservation planning do not yet address these key uncertainties.

The NAWMP National Science Support Team (NSST) is currently supporting Joint Ventures (JVs) in the development of quantitative habitat objectives that are linked to population or vital rates of target waterfowl populations. The recent NAWMP Continental Progress Assessment Report (NAWMP 2007) states, “to move forward, every JV should develop explicit, biologically-based planning model(s) that predict how on-the-ground habitat actions will affect vital rates or population responses. Such an approach would, minimally, oblige JVs to articulate key assumptions or uncertainties, develop appropriate evaluation plans and provide a basis for further refinement of planning models.”

The goal of the waterfowl module of the SFBJV Monitoring and Evaluation Plan (M&E Plan) is to link habitat delivery actions to target species levels and determine an overall framework for 1) the assessment of

the status and trends of waterfowl taxa in the context of how SFBJV conservation, enhancement, or restoration implementation actions are affecting their status at multiple scales, and 2) the effective and efficient appraisal of the impacts of threats and projected environmental changes to inform future management actions.

This Waterfowl Focus Section Will Provide:

- A framework to assess the effectiveness of wetland habitat focused SFBJV conservation delivery projects, in the context of waterfowl population response (abundance or density) or vital rate (body condition [as proxy] or adult survivorship), at the project and SFBJV regional scales, and set the stage to integrate with flyway or continental scale initiatives;
- A set of prioritized, and an outline of additional, monitoring and evaluation objectives addressing key questions for waterfowl and habitat status at the project and regional scales within the SFBJV region;
- Prioritized and general recommendations for further research needs, monitoring and evaluation metrics, protocols, and data repositories, and for integration with existing monitoring and evaluation programs, as relevant to various target waterfowl species.

Focus Team Process and Participants

In a series of in-person meetings and phone conferences, the waterfowl focus team established focus-specific M&E and research objectives, relevant metrics, protocols, and data repositories, key partners, and existing programs for potential integration. All focus teams convened on May 26, 2011 for a daylong professionally facilitated workshop to vet and identify the top priorities of the identified monitoring, evaluation and research objectives for implementation in the next phase of this planning process. Focus team participants included:

Name	Affiliation
De La Cruz, Susan*	US Geological Survey
Demers, Jill	San Francisco Bay Bird Observatory
Herzog, Mark	US Geological Survey
Huning, Beth*	San Francisco Bay Joint Venture
Oldenburger, Shaun*	California Department of Fish & Game
Sloop, Christina	*Team Coordinator*, San Francisco Bay Joint Venture
Spenst, Renee*	Ducks Unlimited
Strong, Cheryl	US Fish & Wildlife Service - Don Edwards National Wildlife Refuge
Taberski, Karen*	San Francisco Bay Regional Water Quality Control Board

*Participated in prioritization of objectives at May 2011 workshop.

Focal Habitats & Species

There are a variety of SFBJV focal wetland types outlined in Appendix D of the SFBJV Implementation Plan (2001), these include: open water, tidal flats (mudflats), tidal marshes, diked marshes, (production) salt ponds, (managed and/or breached) ponds[1] and lagoons, beaches, and uplands. Table 3.1 below outlines those habitats used by diving duck and dabbling duck species throughout the SFBJV region

Table 3.1: Wetland habitat types used by activity type of diving and dabbling duck species in the SFBJV region.

	Diving Ducks	Dabbling Ducks
Foraging	• Tidal flats (when inundated) • Production salt ponds • Managed and/or breached ponds • Open Bay/Coastal Estuaries[2] • Tidal sloughs • Lagoons • Coastal ocean • Freshwater marsh, ponds, creeks	• Tidal flats (mainly at low tide) • Production salt ponds • Managed and/or breached ponds • Open Bay/Coastal Estuaries[2] • Tidal sloughs • Lagoons • Freshwater marshes, ponds, creeks
Roosting	• Tidal flats (when inundated) • Production salt ponds • Managed ponds • Open Bay/Coastal Estuaries[2] • Lagoons • Coastal ocean • Freshwater marsh, ponds, creeks	• Upland vegetation • Levees and islands within ponds • Tidal marshes • Freshwater marshes • Production salt ponds • Managed ponds • Open Bay (uncommon)
Nesting	• Do not nest in SFB	• Upland vegetation • Levees and islands within ponds

[1] Former salt ponds; typically circulation ponds, some recently breached, some managed, others not.
[2] For example SFB & Tomales Bay, including vegetated subtidal areas such as eelgrass, widgeon grass, etc.

Performance Targets

Ideally, performance targets are to be used in assessing the amount of habitat available to desired seasonal population targets with habitat objectives based on bio-energetics model outputs. Given uncontrollable phenomena that affect local abundances, such as environmental variation, weather, and occurrences outside of the SFBJV boundary, metrics based on habitat objectives derived from bio-energetic models should be provided in the form of managed and unmanaged habitat availability. This way population targets primarily become "inputs" to population-habitat models that result in estimated habitat objectives. Updated population targets will become available as a result of ongoing research and modeling activities and as an outcome of the implementation of monitoring and evaluation objectives and research needs outlined in this M&E Plan. These targets will be integrated with NAWMP goals in the 2012 revision, and incorporated in a future update of the SFBJV Implementation Plan (2001). They will serve to improve the efficacy in evaluation of past and future habitat conservation delivery accomplishments.

Acreage performance targets respective to the protection, restoration, and enhancement of wetland habitat types benefiting waterfowl are outlined in the SFBJV Implementation Plan (2001). Performance targets for select waterfowl species specified in the SFBJV Implementation Plan (2001) are outlined here.

Current SFBJV Waterfowl Performance Targets (SFBJV 2001):

- Provide enough high quality open bay (subtidal), intertidal, and pond habitat throughout the SFBJV region to consistently support wintering populations of **key SFB waterfowl species** (*Canvasback, Scaup (Greater and Lesser), and Surf Scoters*) at recent peak population levels

  Sustain populations in every year at the peak levels recorded in midwinter 1989-90 (Accurso 1992, SFBJV 2001)

  - *Canvasback* – 29,818
  - *Surf Scoter* – 61,248
  - *Greater & Lesser Scaup* – 139,214

- Provide enough habitat to consistently support wintering populations of other SFB **indicator waterfowl species** (*Mallard, Northern Pintail, Northern Shoveler, Ruddy Duck*) at recent peak population levels (SFBJV 2001).

  ii. Sustain populations in every year at the peak levels recorded in midwinter 1989–90 (Accurso 1992, SFBJV 2001)
  - *Mallard* – 702
  - *Northern Pintail* – 8,771
  - *Northern Shoveler* – 48,079
  - *Ruddy Duck* – 24,073

Monitoring and Evaluation Objectives

Priority M&E Objectives and Associated Metrics & Protocols

Summarized below are the highest priority M&E objectives the waterfowl focus group identified based on several criteria:

1) Ease of implementation
2) Long-term importance;
3) A natural "early" step;
4) Usefulness for managing or modeling;
5) Ability to help manage JV "effectiveness"; and
6) Cost-effectiveness.

These criteria were assigned scores from 1-5 (lowest to highest value) by each participant. Final scores were averaged across participants and the top three priority objectives are listed here:

Priority M&E Objective 1[3]**:** *Habitat Quantity & SFBJV Contribution.*

Every five years, evaluate the net change in the extent and distribution of diving and dabbling duck habitats throughout the SFBJV region, and evaluate the regional contribution and effect of SFBJV projects and habitat restoration/enhancement to suitable habitat use by diving and dabbling ducks, respectively.

- *Metric 1:* Change in area of waterfowl habitat types to complement available and future energetic analyses (i.e., potential Duck Use Days - DUDs) in order to evaluate the regional contributions of SFBJV projects and habitat restoration/enhancements.
  - *Protocol 1:* Net Landscape Change analysis (GIS, bathymetry, BAARI)
- *Metric 2:* Waterfowl population density (abundance per unit area)
  - *Protocol 2:* FWS midwinter waterfowl surveys, to be flown consistently and with GPS software that marks actual geographic locations of birds seen.
  - *Potential challenges:* GPS software funding, re-evaluation of current transects needed to better align with SFB geography, coordination with FWS/California Department of Fish and Game (DFG), survey cost, need for trained observers.

Priority M&E Objective 2: *Waterfowl Distribution and Abundance.*

Every three years, map and evaluate the winter habitat utilization, species composition, distribution and abundance status and trends of diving and dabbling ducks by habitat type throughout the SFBJV region. To do so, continue to support and expand existing, and implement new abundance surveys of wintering waterfowl as appropriate.

- *Metric:* Waterfowl population density (abundance per unit area) – fine scale
- *Protocol 1:* FWS annual midwinter waterfowl surveys, to be flown with GPS software that marks actual geographic locations of birds seen.
  - *Potential challenges:* GPS software funding, re-evaluation of current transects needed to better align with Bay, coordination with FWS/DFG, survey cost, need for trained observers.
- *Protocol 2:* Ground (or boat) surveys within restored, managed, and production salt ponds (i.e. South Bay Salt Pond Restoration Project, Napa Sonoma Marshes, etc.) to assess change over time (repeated measures) as restoration and management proceeds.

[3] This objective links directly with prioritized objectives in the net landscape change section module.

Priority M&E Objective 3: *Human Disturbance.*

Annually (for first five years, then every three or five years) evaluate the levels of anthropogenic disturbance in spatially representative high value areas for diving and dabbling ducks where public access occurs; evaluate impacts to roosting & foraging from disturbance and frequency by watercraft, trail use, noise, etc.

- *Metric:* Disturbance type and frequency (i.e. acute vs. chronic disturbance), pre and post disturbance behavior, foraging behavior, movements and body condition of birds in disturbed and undisturbed areas
- *Protocol:* Ground surveys, radio-telemetry, condition measurements over time and space

Additional M&E Objectives

In addition to the priority objectives listed above, here is a non-ranked listing of other objectives for monitoring and evaluation of SFBJV program effectiveness. These address remaining key questions for waterfowl status and habitat management at the project and regional scales within the SFBJV region.

HABITAT FUNCTION - TARGET ORGANISM STATUS & TRENDS

- Demographic Monitoring; Regional Scale – For target waterfowl species, carry out baseline demographic surveys to determine the ratio of juveniles to adults using SFB and coastal areas. Repeat every 5 to 10 years to monitor for changes in age ratios.
- Food Resources; Project & Regional Scale - In locations determined as important for diving and dabbling ducks throughout the SFBJV region, survey the availability of key food resources (i.e. abundance & distribution of: benthic invertebrates[4], herring (and other) roe; aquatic vegetation – algae, eelgrass, etc.) at a given frequency and spatial resolution (e.g. every 10 years in rotating regions of the SFB or as appropriate), and link this with associated waterfowl time-activity surveys. This should include an estimation of seasonal potential Duck Use Days (DUDs) for priority species.
- Environmental Context; Project & Regional Scale – In locations determined as important for waterfowl throughout the SFBJV region, evaluate the environmental context (i.e. shelter, predators, natural/un-natural disturbance levels), and wetland habitat structure and function both spatially and temporally.

ENVIRONMENTAL CHALLENGES

- Contaminants in Food; Project & Regional Scale – Expand existing bivalve contaminant monitoring programs to intertidal and subtidal habitat locations determined as important for diving ducks throughout the SFBJV region.

[4] http://www.werc.usgs.gov/Project.aspx?ProjectID=210

- Contaminant Bioaccumulation; Regional Scale - Continue periodic monitoring of key contaminants of concern (mainly selenium but also mercury and cadmium, and other emerging contaminants) for 5-10 years or as appropriate for target diving and dabbling ducks to establish body burden/health safety thresholds[5] and learn about effects as appropriate, as water regimes and habitat changes occur.
- Climate Change; Regional Scale[6] - Contribute diving and dabbling duck population and habitat status monitoring data to online repositories (e.g., Migratory Bird Data Center, California Avian Data Center and Avian Knowledge Network), which may be further linked with other programs to enable larger-scale assessment of local changes across a broader climatic gradient.
- Climate Change – Sea Level Rise; Regional Scale – Model potential waterfowl distribution and foraging areas in light of predicted sea level rise as well as scenarios of salinity and sediment change
- Climate Change – Phenology; Regional Scale[7] - Implement high frequency surveys during the migratory periods (fall arrivals and spring departures) to provide much needed data on waterfowl phenology, that over-time would be helpful for climate change analyses.

Recommended Metrics

Listed below are recommendations for monitoring metrics. As outlined above, selected indicator target species to represent the SFBJV area's diverse waterfowl community in the range of habitats used include: Mallard, Northern Pintail, Northern Shoveler, Canvasback, Greater and Lesser Scaup, Surf Scoter, and Ruddy Duck.

Recommended monitoring and evaluation metrics for these species are:

POPULATION STATUS & TRENDS

- Population abundance (per unit area) or density – To be assessed via long-term comprehensive surveys of key target species using repeatable protocols.
- Local and regional distribution – To be assessed via banding and radio-marking studies – integrate this with the current FWS mid-winter surveys
- Survival - To be assessed via long-term (winter and annual) monitoring programs to evaluate effects of contaminants, prey availability, and improve understanding of how SFB area birds survive in comparison to birds from other regions within the Pacific Flyway and across flyways
- Demographics – Assessment of changes in age ratios to determine the ratio of juveniles to adults over time and space.
- Body condition (morphometrics, mass, fat content, etc.) – To be assessed via long-term monitoring program to evaluate bird condition in the context of changing habitats and prey availability/quality; may also be used to compare SFBJV area birds' condition to birds from other regions within the Pacific Flyway and across flyways.

[5] Developing contaminant thresholds for individual species is very intensive and fairly expensive. - K. Taberski, SFB Regional Water Quality Control Board.
[6] This objective links directly with prioritized objectives outlined in the climate change section module.
[7] This objective links directly with general objectives outlined in the climate change section module.

HABITAT FUNCTION

- Food resources – Sediment coring is used to determine benthic invertebrate density and biomass, in association with foraging behavior assessments. In addition, project level estimates of submerged aquatic vegetation structure and composition may serve as an appropriate surrogate for invertebrate abundance utilized mainly by dabbling ducks.
- Foraging behavior - To be assessed via time-activity surveys, foraging and foraging intensity (dive : pause ratios) among different regions. This metric is much more powerful if it is used in combination with benthic invertebrate coring to determine prey composition and densities.
- Stable isotope analyses – Utilized to determine diet changes in foraging regions across a salinity gradient and to help link the SFB to the effects from outside the region, looking at isotope ratios in tissues that were laid down while the target bird was outside the region (primary feathers, muscle collected in fall, etc). However, there are some caveats of the isotope methodology (see Smith et al. 2009) to be considered.

ENVIRONMENTAL CHALLENGES

- Biomarkers– Use current non-lethal techniques (via gene expression, metabolites, etc) to determine exposure and effects of contaminants of concern and emerging contaminants.
- Phenology – To be assessed via seasonal ground (or aerial count surveys). This provides a means to assess potential climatic and cross-seasonal effects if 'before' baseline data are available

Recommended Protocols

Below is a listing of the recommended monitoring and evaluation protocols relevant to the various objectives outlined above.

POPULATION STATUS & TRENDS

- Area scans/searches – Used to obtain abundance and density estimates.
- Behavioral scans/focal behavior monitoring – Coupled with data on benthic prey density and biomass, these data are useful for assessing habitat function and value.
- Mid-winter aerial surveys (FWS) – Currently, during midwinter flights, ducks observed are assigned to transects, and those transects may cut across habitat types. But to focus on habitat selection and be able to model the effects of habitat conversion, the midwinter surveys should be flown with GPS software that marks the actual locations of birds observed; otherwise radio-marked individuals are needed. To further improve data quality, the level of effort and influence of weather on counts needs to be reported and accounted for in subsequent analyses.
- Mark recapture/resight – This is used to determine survival.
- Capture mass and morphometrics – This provides body condition measurements.
- Stable isotope analyses – This method can help determine source of diet and changes over time requires non-lethal (blood, feather, biopsy) sampling

HABITAT FUNCTION

- Radio-marking Birds – Used for survival, connectivity and habitat association studies.
- Benthic Invertebrate Coring – See SFB Benthic Macroinvertebrate Atlas (Rowan et al 2011). Could also use project level estimates of submerged aquatic vegetation structure and composition, which may serve as an appropriate surrogate for invertebrate abundance.

Research & Information Needs

Priority Research & Information Needs

Summarized below are the highest priority research needs the Waterfowl focus group identified at the May 26, 2011 workshop based on these criteria: 1) Ease of implementation
2) Long-term importance;
3) A natural "early" step;
4) Usefulness for managing or modeling;
5) Ability to help manage JV "effectiveness";
6) Cost-effectiveness.

These criteria were assigned scores from 1-5 (lowest to highest value) by each participant. Final scores were averaged across participants and the top three priority objectives are listed here:

- **Priority Research Need 1:** *Habitat Use.* Radio-tag[8] individuals of target species to investigate relative use of specific habitat types over time throughout the SFBJV region.
- **Priority Research Need 2:** *Flyway Scale Dynamics – Impacts from Outside SFBJV Region*. Within the context of annual life cycle modeling, assess the impacts of breeding, survival, and migration dynamics occurring outside the SFBJV region to SFB wintering population abundance and health. This may be investigated cooperatively with the NSST.
- **Priority Research Need 3:** *Diving Duck Carrying Capacity; Regional Scale.* Continue, expand and improve current modeling work of SFB diving duck species carrying capacity to incorporate other areas and prey sources in the estuary to improve habitat carrying capacity estimates. This work should also be expanded from main target species to other diving ducks throughout the SFB area as well as for target dabbling ducks
- **Priority Research Need 4:** *Human Disturbance; Regional Scale.* Expand current investigations on the effects of human disturbance on diving and dabbling ducks in the SFBJV region, by comparing disturbed to undisturbed areas.

- ***Priority Information Need:*** Data from FWS mid-winter waterfowl surveys should be made available for annual abundance status and trend analysis.

[8] Birds do not necessarily need to be radio marked, but method yields more wide range of time and scale.

Additional Research & Information Needs

Here we provide additional non-ranked recommendations for further research and information needs, as relevant to various target waterfowl species, to support the long-term effectiveness of SFBJV habitat conservation delivery.

HABITAT QUANTITY

- Projected Change; Regional Scale - Assess and model the projected future changes in land use and habitat conversion to determine the likely impacts on diving and dabbling duck habitat availability throughout the SFBJV region. [9]

TARGET ORGANISM STATUS & TRENDS

- Trends of SFB Ducks; Regional Scale - Increase the knowledgebase of population and habitat status and trends of other SFBJV region duck species (particularly Ruddy Ducks, Northern Shoveler and Bufflehead), which currently use the South Bay salt ponds in large numbers. Information on their habitat use and foraging ecology is needed especially to help determine how landscape changes may affect them.
- Winter Survival & Condition; Regional Scale - Institute long-term marking (banding as well as radio-marking) studies that enable evaluation of winter survival and condition over time as habitat changes occur (see Kraan et al 2009), to link habitat objectives to waterfowl vital rates, a priority listed during the 2007 NAWMP Continental Progress Assessment (NAWMP 2007). More information on spring conditioning of birds and subsequent effects on migration and reproduction is urgently needed.
- Connectivity; Flyway Scale - Evaluate and model the levels of connectivity [10]of migrating waterfowl between Pacific coast, SF Bay and Central Valley populations over time. Evaluate the contribution of SFBJV projects to connectivity.
- Flyway Scale Dynamics – Body Condition - Evaluate the impact of SFB threats to the populations from spring migration to onset of the breeding period. Research should be designed to link regions using satellite telemetry, stable isotopes, triglyceride analyses and other tools.
- Flyway Scale Dynamics – Cross-Seasonal Interactions - Determine the relationships between wintering sites and breeding sites of migratory species to help convey related threats and the importance of SFB wintering populations to the Pacific Flyway overall.

[9] This may be developed in cooperation with the NSST as it is closely tied to the NSST Work Plan Task 2: "Develop approaches for generating regional waterfowl habitat conservation objectives that account for spatio-temporal variation in environmental and habitat conditions."

[10] Connectivity: The movement of organisms from place to place (e.g. among reserves) through dispersal or migration to maximize survival and reproductive potential.

HABITAT FUNCTION/QUALITY

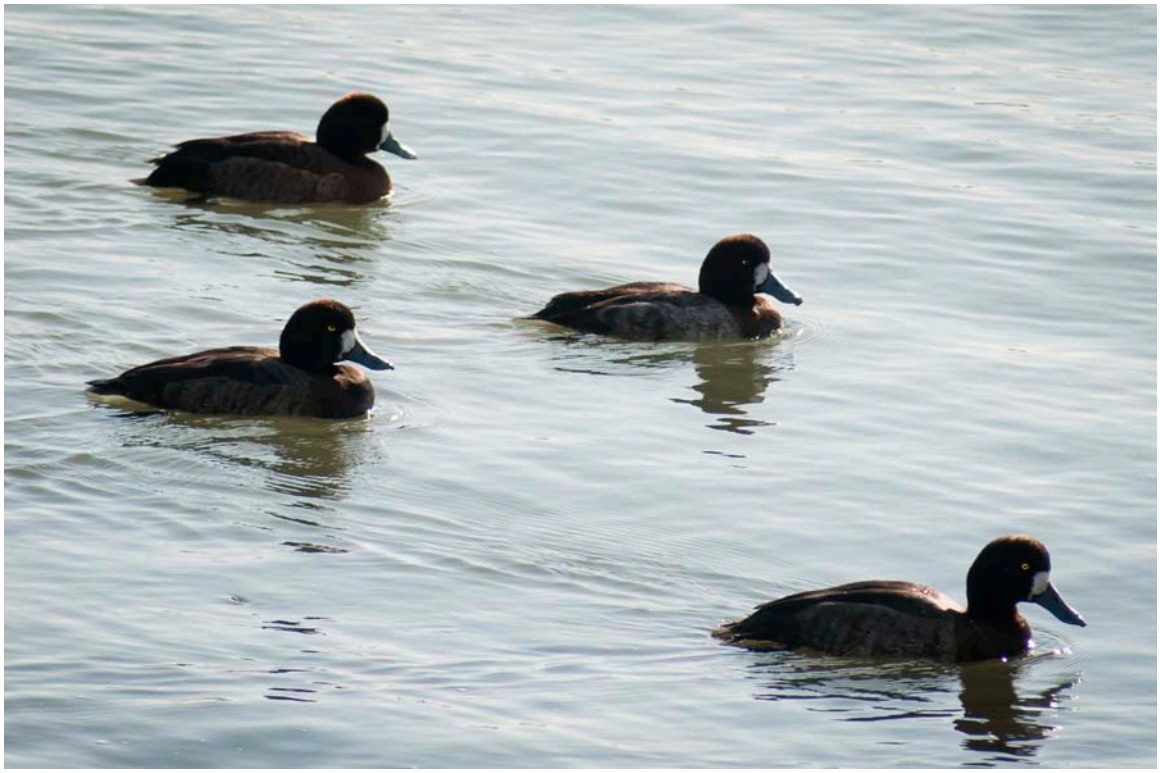
- Relating Habitat Features to Target Organism Performance; Regional and Flyway Scale - Investigate the relationship between specific winter habitat features and winter survival and/or cross-seasonal effects on breeding performance.[11] This should entail developing a conceptual model (or empirical model, where data exist) to explicitly describe the influence of habitat management actions on vital rates, and should ultimately evolve to incorporate the influence of both management actions and population sizes (density dependence) on vital rates.
- SFBJV Impact; Regional Scale - Model the impacts of added/restored/enhanced habitats to habitat function and evaluate benefits to target waterfowl species.

ENVIRONMENTAL CHALLENGES

- Climate Change; Regional Scale[12] - Evaluate and model the impacts to respective diving and dabbling duck abundance and health from climate change as it relates to projected impacts of sea level rise, salinity and phenology (migration timing) changes, invertebrate prey abundance and quality, on survival and foraging energy expenditure.

[11] This objective is directly relevant to NSST Work Plan Task 1: "Develop methods for setting demographic population objectives (i.e., vital rates) at BCR/JV-scales for focal species based on recommendations of the NSST Alternative Performance Metrics Committee. These objectives must relate to measurable population metrics or facilitate rolling-up to continental objectives from BCR/JV scales."

[12] This objective links directly with research objectives outlined in the climate change section module.



Female Scaup - *Photo by Beth Huning*

Data Management

Data sets from previous annual surveys should be compiled, analyzed, and made available through data sharing. Collective standardized data sharing protocols should be developed for the SFBJV region and linked to existing relevant national databases. A useful way of collective data storing is to create a common metadata website that provides relevant information on the data, shows the spatial extent of the data on a map, data format and ease of transfer, and includes disclaimers about data availability and allowed uses. This approach lets data owners decide whether to post entire datasets, or to just provide their metadata information and allow others to request a full dataset directly from the source, specifying intended use. An existing portal for this proposed online forum is in development via the San Francisco Bay Conservation Commons. This metadata approach still allows datasets to reside in different databases, and after standard data conventions are developed and followed, will enable easy transfer. Development of clear protocols on the rights and responsibilities of data sharing will only help this process of collaboration.

Diving and dabbling duck population and habitat status monitoring data should be contributed or linked via metadata portals to online repositories, such as: Migratory Bird Data Center, BIOS, etc. These are already linked, or may be linked further, with other programs (i.e. Audubon Christmas bird counts, eBird) via the Avian Knowledge Network to enable larger-scale assessment of local changes across a broader climatic gradient. This could also be linked to the SFBJV project database to determine waterfowl use and changes within habitat project areas.

Existing Monitoring Programs and Tools

Existing waterfowl abundance monitoring programs:

- *Annual FWS/DFG cooperative midwinter surveys (midwinter waterfowl aerial counts)* - On-going every January since 1955, this is a critical program for setting habitat objectives for wintering waterfowl in the SFBJV. The DFG/FWS annual cooperative midwinter waterfowl survey estimates the number of waterfowl in the SFB during the first two weeks of January. Other areas, including Tomales Bay, are also routinely surveyed. All surveys are dependent on weather conditions, availability of personnel, planes, etc. The mid-winter survey is an aerial transect based survey, and is conducted by FWS staff in the Bay area, as DFG/FWS divide the State up for this survey. Increasing regulations (i.e. restrictions) on what planes/pilots the federal government can use for these surveys, and inclement weather has made these surveys difficult to complete in the last few years. Over time, the SFB has become more difficult for transect surveys, because of increasingly restricted air space and flight congestion (Shaun Oldenburger, DFG, pers. com.). For the past two years (and going forward) the SFB NWR Complex has been flying open-water surveys only, and used the monthly ground count data collected by USGS and SFBBO as the pond portion of this survey. Both transect and open water surveys are necessary for SFBJV to monitor waterfowl populations and determine how habitat changes may influence abundance. USGS constructed an Access Database that now resides at the Don Edwards SFB NWR (C. Strong, FWS-NWR, pers. com.).
- *Local and Regional Distribution - SBSPRP water bird/waterfowl surveys* – Since 2002 and 2006, respectively, USGS and SFBBO conduct monthly water bird/waterfowl surveys in salt production and managed ponds in the South Bay.
- *Napa-Sonoma Marshes Wildlife Area plant site and all North Bay ponds* – DFG & USGS conduct monthly bird surveys on managed ponds.
- *DFG Survey of Ocean Scoters* –DFG contractors for the Office of Spill Prevention and Response (OSPR) conduct aerial surveys for marine birds and mammals in coastal waters, both as training flights (to be prepared for oil spill response), and to document baseline distribution of birds and mammals at-sea. Before 2010, surveys were flown about once per month, and the main location was typically in the Monterey Bay area. Starting winter 2010/11, at least one survey of the entire California Coast is conducted between November and March (last surveyed in November 2010). Surveyors fly a sinuous transect between shore and about 2 km offshore, allowing them to count coastal scoters. Transect data (e.g., with habitat predictors) should be used for estimates of scoter abundance along the coast. Unlike the SFB waterfowl aerial surveys, the coastal survey is a strip transect of only 75m on each side (total of 150m). The current contract between OSPR and University of California, Santa Cruz calls for surveys for two more winters (*Laird Henkel,* DFG, pers. com.).
- *Historical monitoring records* – The DFG keeps historical monitoring records from DFG owned or managed sites.
- *Monthly aerial waterfowl surveys* - USGS conducted along FWS Midwinter transects from 2004-2007.
- *Laguna de Santa Rosa managed reclamation ponds waterfowl surveys* - Survey data are available via the California Avian Data Center (CADC).

- *Aerial surveys of salt ponds* - FWS/DFG conducted these in 1982-1986. Don Edwards SFB NWR and SFBBO staff is currently entering the resulting data.

Habitat related monitoring:

- *SBSPRP water quality monitoring* – Occurs in only a few ponds on NWR and DFG lands and only for Regional Water Quality Control Board permits, thus of limited value.
- *San Pablo Bay Corbula amurensis monitoring* - Performed by the Department of Water Resources in 1990, 1993, and 1995.
- *USGS invertebrate sampling* - Jan Thompson (USGS Menlo) leads this invertebrate program (see Benthic Atlas).
- *USGS south Bay shoals project* – John Takekawa and Bruce Jaffe are the project leaders (USGS SFB Estuary Field Station and Menlo Park).
- Benthic Atlas – provides information on benthic sampling programs throughout the Bay (USGS, Rowan et al 2011 http://www.werc.usgs.gov/Project.aspx?ProjectID=210)
- *San Francisco Estuary Institute* - Macro-invertebrate stream assessments, and invertebrate toxicity monitoring.
- *SFBJV, SBSPRP funded waterfowl and shorebird disturbance research* - Lynne Trulio and Heather White (San Jose State University) are looking at trail use and flush distances.

Habitat related monitoring cont.

- *Fish monitoring* – Implemented by USGS and University of California, Davis for assessing contaminants and fish ecology in the South Bay.
- *Herring Spawn Monitoring program* - DFG is conducting this program in SFB.
- *Fisheries Monitoring program* - DFG is conducting this program in SFB and some SFB tributaries. Napa Resource Conservation District and Center for Ecosystem Management and Restoration also conduct creek Salmonid monitoring programs.
- *Regional Wetland Program* (RWP) – RMP monitors contaminants in cormorants' and terns' eggs every three years. Also, RWP monitors contaminants in fish muscle tissue every three years and spends $3.6 million/year to monitor contaminants in the SFB estuary. In the future, RWP plans to monitor for nutrients, phytoplankton, zooplankton and lenthos throughout the estuary (Karen Taberski, SFB Water Quality Control Board).

Existing Tools:

- *Carrying capacity models* for diving ducks in San Pablo Bay – Lovvorn et al (in review).
- *Habitat association models for SFB surf scoters* – De la Cruz (2010), De la Cruz et al. (in review)
- *Habitat association models* for South Bay Salt Ponds - Stralberg et al. (2006)
- *Habitat conversion models* of impact on species, particularly dabbling ducks (Athearn, USGS)

Key Partners

- Department of Fish & Game – DFG is a manager of duck habitat and a member of the project management team for the implementation of the South Bay Salt Pond Restoration Project. It is a partner agency for the annual mid-winter waterfowl count. The DFG's Office of Oil Spill Prevention conducts aerial surveys for marine birds and mammals in coastal waters on a monthly basis.

- Fish & Wildlife Service – NWR System – FWS-NWR is a land manager of duck habitat and a member of the project management team for the implementation of the South Bay Salt Pond Restoration Project. It is the lead agency for annual mid-winter waterfowl count.

- Other JVs – Other JVs are working in the breeding and migratory regions of the annual life cycles of the various waterfowl targets. Cross-regional partnerships of JVs working on portions of target species' life cycles can inform each other's modeling efforts.

- SFBBO – SFBBO has monitored waterfowl and other bird groups at project-level scale. It can provide long-term data and experience to conduct future research and monitoring.

- USGS – USGS provides over a decade of research and monitoring on waterfowl and other bird groups in SFB. Has several SFB long-term data sets on foraging, habitat use, contaminants, and flyway connectivity and continues to conduct research in collaboration with several partner agencies and entities.

Next Steps - A Phased Approach

In this first planning phase, each M&E Plan focus section features priority objectives and references supporting information determined by the SFBJV science sub-committee. This information will be utilized in planning Phase II to secure implementation funding for the outlined priority objectives, and as a basis for further Plan development to continue to refine and integrate outcome-based M&E Plan objectives as our knowledgebase evolves. Phase III will evaluate and incorporate additional conservation goals and target performance objectives into an upcoming revision of the SFBJV Implementation Plan (originally released in 2001). We therefore consider the M&E Plan a "living document" that will change over time with continually refined and focused content. For more details on the planning phases, please refer to the Introduction & Overview section of this plan under *Planning Phases – A "Living Document."*

Future Challenges For Waterfowl Related Monitoring And Research Include:

- Linking effects of conservation delivery actions to target organism status.
- Determining appropriate management strategies and desired outcomes relevant to target habitats.
- Refining monitoring objectives with focus on measuring conservation or management action impact or progress against specified outcomes.
- Developing suitable performance targets and management thresholds.
- Identifying and implementing appropriate metrics (e.g., vital rates) that are relevant to the SFBJV and larger landscape scales (e.g., flyways).
- Maximizing integration with other regional and national waterfowl conservation initiatives.

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The San Francisco Bay Joint Venture is a partnership of public agencies, environmental organizations, the business community, local governments, and landowners working cooperatively to protect, restore, increase, and enhance wetlands and riparian habitat in the San Francisco Bay Watersheds. We bring an ecosystem and collaborative approach to developing and promoting wetland and riparian habitat conservation throughout the Bay Area.

The Joint Venture Management Board

Nonprofit and Private Organizations

Bay Area Audubon Council
Bay Area Open Space Council
Bay Planning Coalition
Citizens Committee to Complete the Refuge
Ducks Unlimited
National Audubon Society
Pacific Gas & Electric Company
PRBO Conservation Science
Save the Bay
Sierra Club
The Bay Institute

Public Agencies

Bay Conservation and Development Commission
California State Coastal Conservancy
California Department of Fish and Game
California Resources Agency
Contra Costa Mosquito and Vector Control District
National Fish and Wildlife Foundation
NOAA National Marine Fisheries Service
Natural Resources Conservation Service
SF Bay Regional Water Quality Control Board
San Francisco Estuary Partnership
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Geological Survey
Wildlife Conservation Board

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