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Ecosystem-Based Wetland Conservation and Restoration in the Lower Columbia River and Estuary, USA: A Description of the Columbia Estuary Ecosystem Restoration Program*

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Abstract: The Columbia Estuary Ecosystem Restoration Program (CEERP) in the U. S. Pacific Northwest provides programmatic processes, experiences, and lessons applicable to the eco-friendly utilization of the littoral zone in the Three Gorges Reservoir (TGR) in China. The CEERP applies an ecosystem-based approach to help mitigate the environmental effects of the Federal Columbia River Power System by working to understand, conserve, and restore ecosystems in the lower Columbia River and estuary (LCRE). Wetland ecosystems in the LCRE, which is 235 km long and about 80% tidal freshwater, have been altered significantly by agricultural, industrial, hydrosystem operations, and other practices that disrupt food webs, reduce macrodetritus flux, and restrict rearing and refuge areas for juvenile salmon, among other consequences. The restoration program has five main objectives: 1) understand the primary stressors affecting ecosystem controlling factors, e. g. , diking restricting access to and contributions from wetland ecosystems; 2) conserve and restore factors controlling ecosystem structures and processes, e. g. , reconnecting wetland areas to the main stem; 3) increase the quantity and quality of ecosystem structures, e. g. , removing invasive plants and restoring emergent marshes; 4) maintain and enhance ecosystem processes, e. g. , revitalizing food webs; 5) improve the ecosystem function of salmon performance, e. g. , increasing life-history diversity, foraging success, growth, and survival. To accomplish these objectives, the CEERP implements an adaptive management process led by the funding agencies and performed in collaboration with regional stakeholders. This paper uses the five phases of the annual CEERP adaptive management cycle—Strategize, Decide, Act, Monitor/Research, and Evaluate—as the context for presenting key results from the program. The paper closes with lessons to consider for ecosystem-based conservation and restoration in the Three Gorges Reservoir.

Key words: ecosystem-basis; wetland restoration; hydrologic reconnection; adaptive management; lower Columbia River and estuary

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1 Introduction

The Columbia Estuary Ecosystem Restoration Program (CEERP) in the U. S. Pacific Northwest provides programmatic processes, experiences, and lessons applicable to the eco-friendly utilization of the littoral zone in the Three Gorges Reservoir (TGR) in China. For both efforts, scientists are working to enhance and use altered ecosystems for the betterment of the region's people. The objectives of this paper are to describe the adaptive management methods used in the CEERP, present pertinent results from CEERP implementation of restoration and research, monitoring, and evaluation (RME) projects, summarize progress toward meeting

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the CEERP objectives, and offer recommendations for applications from CEERP to eco-utilization of the TGR littoral zone.

1.1 Background

The CEERP restoration effort was mandated under the Endangered Species Act for operation of the Federal Columbia River Power System and its effects on listed Columbia Basin salmonids[1]. The overall goal of the CEERP is to understand, conserve, and restore ecosystems in the LCRE. The CEERP is managed and funded by two federal agencies—the Bonneville Power Administration (BPA) and the U. S. Army Corps of Engineers (Corps) (collectively known as the Action Agencies)—and is conducted by other federal, state, and local agencies and non-governmental organizations. The program's underlying principles are that projects are founded on the best available ecological restoration science, implemented in an ecosystem context, and developed with the intent to restore relevant ecological processes. It is also important that projects incorporate adaptive management practices with testable hypotheses to track ecological responses to a given restoration effort [2]. Another CEERP principle is to implement projects using a coordinated, open process with scientific results from monitoring and evaluation communicated widely.

The CEERP objectives reflect an ecosystem-based strategy [3-4]: 1) understand what effect primary stressors① have on ecosystem controlling factors②, e. g., flow regulation, passage barriers; 2) conserve and restore factors that control ecosystem structures③/processes④, e. g., hydrodynamics, water quality; 3) increase the quantity and quality of ecosystem structures, e. g., estuarine habitat for juvenile salmonids; 4) maintain and enhance LCRE food webs to benefit salmonid performance; 5) improve ecosystem functions⑤, including salmonid performance in terms of life-history diversity, foraging success, growth, and survival (definitions are from[5].) The CEERP focuses on restoration of ecosystems for juvenile salmonids, whereas the TGR effort concerns a broad array of plant and animal species.

1.2 Study area

For CEERP's purposes, the study area includes the floodplain of the Columbia River from the mouth 235 km upstream to Bonneville Dam, encompassing the estuary proper and the tidally influenced part of the river (See plate 1, color page Ⅴ). The semidiurnal tidal range in the estuary is relatively large at 3.6 m and oceanic tides affect water levels throughout the entire 235-km reach to Bonneville Dam[6-7]. Maximum seawater intrusion during low river flow is variable but less than 37 km upstream [7]. The width of the Columbia River is less than 2 km at river kilometer (rkm) 84, nearly 15 km at rkm 32, and approximately 3 km at the jetties at the river mouth[7]. The Columbia River, with a drainage basin area of 660,480 km^2[8], has the fourth highest average discharge at mouth and the sixth largest watershed in the United States.

Historically, unregulated flows were estimated to range from a minimum of 2,237 m^3/s (79,000 cfs) in the fall to maximum flood flows of over 28,317 m^3/s (1 million cfs) during spring freshets [9]. Since the 1930s, however, the timing of the Columbia River's discharge has been progressively regulated due to construction and operation of 28 major dams and approximately 100 minor dams that reduce spring freshet flows and increase fall/winter flows on the river's main stem and tributaries. Modeling studies have estimated that a

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① Stressors are entities or processes that are external to the estuary or anthropogenic and that affect controlling factors on estuarine ecosystem structures or processes.

② Controlling factors are the basic physical and chemical conditions that construct and influence the structure of the ecosystem.

③ Ecosystem structures are the types, distribution, abundances, and physical attributes of the plant and animal species composing the ecosystem.

④ Ecosystem processes are any interactions among physicochemical and biological elements of an ecosystem that involve changes in character or state.

⑤ Ecosystem functions are the roles plant and animal species play in the ecosystem. They include primary production, prey production, refuge, water storage, nutrient cycling, etc.

45% flow reduction in the spring freshet (May–July) is attributable to flow regulation, irrigation withdrawal, and climate change[10]. Another modeling study showed that diking has reduced shallow-water habitat area during the spring freshet by 52%, while flow cycle alteration reduced it by 29% [10]. Alterations in the physical processes of the estuary that are attributable to human intervention include decreased freshwater discharge rates, tidal prism, and mixing, and increased flushing time and fine sediment deposition, resulting in a net accumulation of sediment[9]. Thus, the LCRE has seen significant changes in the past 150 years; in particular, the significant conversion of vegetated habitats to agriculture and urbanization, together with loss of access to habitats through passage barriers and changes to the hydrograph. These losses and alterations have had unmeasured but presumably important impacts on the once abundant salmon populations that migrated through on their way up and downstream[11].

2 Methods: Adaptive Management

The CEERP is based on an adaptive management process consisting of five phases (See plate 2, color page Ⅴ)—strategies, decisions, actions, monitoring/research, and synthesis and evaluation[12]. An adaptive management approach proceeds through each of these phases based on the results of monitoring and/or research, evaluation, or an overarching strategy in the preceding phase. The CEERP adaptive management process is described in detail by Thom et al[13]. Teams of key staff perform specific functions and assume certain responsibilities to produce desired outcomes. For example, under the CEERP, the Expert Regional Technical Group (ERTG) for estuary habitat restoration is responsible for evaluating the survival benefit units (SBUs) of proposed habitat restoration actions. As management questions are answered by RME results, program objectives and strategies are revised as necessary and inform future restoration and RME actions. Activities to support all phases of the CEERP adaptive management process are underway in the LCRE, thereby institutionalizing the process regionally across stakeholders/partners.

The CEERP adaptive management process has three main annual work products: Strategy Report, Action Plan, and Synthesis Memorandum. The Strategy Report applies the scientific knowledge base to develop strategic, programmatic guidance for restoration implementation and RME; the Action Plan applies strategies to prioritize and select specific implementation and RME projects composing the CEERP; and the Synthesis Memorandum uses RME data to refresh the knowledge base for restoration ecology and engineering at site, landscape, and estuary-wide scales. The CEERP work products serve to guide or inform, as appropriate, the Actions Agencies, various agencies, restoration project sponsors, researchers, and interested parties.

The RME effort includes compliance/implementation monitoring⑥, status and trends monitoring⑦, action effectiveness monitoring and research⑧, and critical uncertainties research⑨ to support and inform adaptive management of estuarine habitat restoration actions and critical uncertainties. In turn, RME is adaptively managed based on lessons learned and CEERP needs. Adaptive management is only successful if the parties to the program commit to sustained roles and responsibilities. Adaptive management can be efficient if existing, required reporting functions are adapted to ensure the

⑥ Compliance/implementation monitoring covers the execution and outcomes of projects. This type of monitoring does not require environmental response data directly linking restoration actions to physical, chemical, or biological responses.

⑦ Status and trends monitoring is defined as census or statistically designed monitoring of fish or wildlife populations and/or environmental conditions (i. e., watershed conditions) to assess the current status (at a particular time) or trend (over time).

⑧ Action effectiveness research is defined as research to determine the effects of an action or suite of actions on fish survival, productivity, and/or habitat conditions. This is a manipulative experiment that statistically assesses the effect of a treatment (action) condition relative to a control or reference condition.

⑨ Critical uncertainties research is defined as research to resolve scientific uncertainties regarding the relationships between fish and wildlife health, population performance, habitat conditions, life history, and/or genetic conditions.

flow of information from project monitoring staff to project planning staff, and if RME is funded appropriately.

2.1 Roles and responsibilities

It is important to establish clear roles and responsibilities for participants in the adaptive management process. To succeed, adaptive management requires active and constructive participation, communication, and support from the key parties funding agencies, estuary managers, restoration implementers, and researchers[14]. For the most effective and efficient use of funds toward ecosystem and salmon restoration in the LCRE, coordination of stakeholders and decision-makers is the primary element of this strategy. Decision-makers are those individuals or organizations that decide what restoration actions to implement, where and when. The reality in the LCRE is that there are potentially numerous decision-makers, and decisions are presently made at different times, at different scales, and for different reasons. This is one of the reasons coordination and data are so important.

2.2 Coordination and data

Coordination among stakeholders and decision-makers is critical to implementing CEERP adaptive management across multiple entities whose projects, programs, and processes address the program's objectives. Periodic meetings, annual or biennial conferences, publication of technical and nontechnical documents, and a well-maintained, professionally designed website are used to disseminate data and report information for the CEERP. Development of a publicly accessible, regional data-management system designed to allow easy input and retrieval of RME data is underway. The data function is currently performed to varying degrees at the project level, but not at the program level. Although project-level analysis is critical, the CEERP requires its own comprehensive database and synthesis of data. The estuary RME projects and CEERP restoration adaptive management process will feed data to a central, program-level location and provide web-based reports and public access as a key mechanism for data dissemination. The CEERP data center will: 1) develop RME information system architecture; 2) use existing data centers where appropriate; 3) develop a cost-sharing approach; 4) promote free exchange of information; and 5) emphasize meta-data.

The specific requirements for CEERP RME data and their management are yet to be developed. For example, to form a data-management system, one needs to decide what data will be collected, by whom, how often, where, and when; define data standards; define meta-data needs; establish access methods and policies; establish how the data will be used; and designate and fund staff to implement the data standards and maintain the database. A long-term funding commitment is necessary for this effort.

The database will include all CEERP-related data, e.g., copies of the annual adaptive management deliverable documents, project templates and site evaluation cards, and monitoring/research data. Monitoring and research data are diverse in type, volume, spatial and temporal extents, and how and where they are archived. The overarching drivers are that: 1) multi-year projects need to produce multi-year synthesis analyses and reports; 2) similar data from multiple projects need to be integrated across projects; 3) data from different sources and of different types need to be integrated and analyzed; 4) retrospective analyses need to be performed; 5) data need to be shared among collaborators across multiple agencies; 6) summary data in the form of tables, figures, and maps need to be disseminated; and 7) project data need to be submitted to funding agencies as a deliverable.

2.3 Website

The CEERP website is under construction. It will include a comprehensive library of PDF files, or at least citations, for restoration-related literature concerning all aspects of the estuary; contact information for restoration managers, practitioners, and researchers; maps showing where research, monitoring, and restoration are presently being conducted, with meta-data on these activities; full maps showing the historical and present conditions of the habitats; links to restoration and monitoring/research data; links to regional climate models and ocean circulation models; a module for the LCRE conceptual ecosystem model[15]; and an adaptive management module.

3 Results: Implementation

The results are essentially summaries of accomplishments and findings from the CEERP effort to date. The results are organized by adaptive management phase (See plate 2, color page Ⅴ).

3.1 Strategize

The CEERP strategy involves using existing processes, programs, technical groups, and plans to avoid redundancy and increase efficiency. For example, the ERTG has provided guidance to restoration proponents[16-18]: bigger area is better than smaller area; close to the main stem is better than farther away; restoring remnant channels is better than excavating new ones; natural processes are preferred over engineered processes; and a holistic perspective from a landscape scale is better than a narrow, site-specific perspective. Based on this guidance, we have modified the Action Agencies' approach to focus on restoration projects concerning floodplain reconnections and wetland channel improvements that have a significant footprint in tidally influenced areas relatively close to the main stem. Using a combination of best professional judgment and best available restoration science, the ERTG determined that the aforementioned actions provide the highest juvenile salmonid densities[17,19]. Note that revegetation and invasive species removal are important complementary actions to floodplain reconnection and channel habitat restoration actions, but to ensure delivery of the most cost-effective biological benefit they should not be the primary project focus.

The CEERP's ecosystem-based strategy for restoration and implementation and RME involves five tactics. Collaboration occurs regionally to identify and prioritize strategic habitats and locations for restoration based on: 1) characterization of disturbance regimes; 2) multiple lines of evidence to target areas for strategic ecosystem restoration; 3) strategic restoration of juvenile salmon habitat in the LCRE based on ecosystem classification; 4) SBU assessment; and 5) immediate action. In general, the strategy is to expedite project development using an aggressive, systematic, collaborative approach that is informed by the best available science from the RME effort.

CEERP's RME strategy is to monitor compliance and implementation of CEERP restoration actions; monitor status and trends of LCRE ecosystems hypothesized to support juvenile salmon; research, monitor, and evaluate juvenile salmon performance in the LCRE relative to environmental, physical, or biological performance objectives; research, monitor, and evaluate LCRE migration and habitat conditions that may be limiting achievement of biological performance objectives; determine the effectiveness of restoration actions; and assess and investigate critical uncertainties related to the scientific relationships between habitat conditions, including restored sites, and the survival and condition of fish residing and/or migrating through the LCRE.

3.2 Decide

The CEERP prioritizes restoring habitat—increasing access to areas that have been cut off from the main stem system—and restoring habitat capacity and the quality of existing habitats for juvenile salmon [2,20]. CEERP decision-making involves an iterative process including technical review, cost per SBU and total SBUs, and project likelihood (social and technical complexity). All BPA-funded restoration projects go through the Lower Columbia Estuary Partnership's (EP's) review process for habitat restoration projects. A regional group called the Independent Scientific Review Panel periodically reviews the BPA-funded umbrella projects conducted by the project sponsors. Corps-funded projects are reviewed and scrutinized by the Corps' project development teams. For BPA- and Corps-funded work, project sponsors are required to develop project goal maps and fill out a project complexity questionnaire that determines the project's social and technical complexity. Projects proposed to the Action Agencies are funded based on total SBUs, cost per SBU, project likelihood, as well as other applicable factors. If a project meets the Action Agencies' goals based on these criteria at various decision-points in the process, the Action Agencies fund the next phase of the project. As the project moves through successive phases, the estimate of cost per SBU becomes more robust, thereby reducing decision uncertainty. This iterative process continues until the project is ready for construction, at which point the ERTG assign SBUs, the last decision-point for the Action Agencies.

3.3 Act

Numerous restoration actions have been undertaken by the CEERP in the last 10 years. At least 20 projects were implemented during the 2007-2011 time frame. Sixteen restoration projects are planned for implementation during 2012. Project statuses range from initial concept to design, with six projects in the feasibility phase. Three of the projects are land acquisitions. Eighteen projects are also in the queue for 2013.

3.4 Monitor/Research

For illustrative purposes, brief descriptions and key findings from eight selected RME projects conducted in the last 5 years are presented below. Such findings are used by decision-makers to advance the CEERP effort.

3.4.1 *Tidal Freshwater Research* Juvenile salmon use shallow tidal freshwater habitats to feed and grow year-round, although such habitat use varies by season, stock of origin, life-history stage, and other factors[21]. Unmarked Chinook salmon are the most common salmon species in LCRE tidal freshwater. The next most common species are chum and coho salmon. Multiple life-history strategies were evident based on fish length frequency distributions through time. Genetic stock identification for Chinook salmon varies depending on longitudinal position in the LCRE and time of year. The results of bioenergetics modeling suggest maintenance of adequate temperatures in tidally influenced shallow-water habitats is key for adequately supporting production of juvenile salmon. Restoration actions focused on maintaining adequate flow and temperature regimes in these habitats will likely benefit juvenile salmon. Feeding ecology and bioenergetics data showed the positive contribution shallow tidal freshwater habitats in the Sandy River Delta are making to juvenile salmon growth and development. The CEERP management implication is that the data support restoration of access and quality of a variety of shallow tidal freshwater habitats.

3.4.2 *Reference Site Study* Borde et al.[22] summarized fundamental data on representative reference wetlands from the LCRE. Water level has an overwhelming influence on vegetation communities. Water level is affected by tides and river flow and other factors, which have variable influences along a continuum between the mouth and Bonneville Dam. Controlling factors, such as elevation, hydrology, and sediment accretion, provide a basis for understanding conditions necessary for restoration success. The vegetation assemblage structure for undisturbed shallow-water wetland habitats provides a target for restoration project design and a means for evaluating wetland development through time. Data on the location and elevation of invasive plant species can be used to implement restoration programs to avoid colonization by non-native species. Natural channel morphology provides engineering design criteria for restoration sites. Overall, these data can be used to assess long-term changes in LCRE ecosystems.

3.4.3 *A Study of Salmonid Survival and Behavior Through the LCRE Using Acoustic Tags*-McMichael et al.[23] reported steelhead mortality from Bonneville Dam to rkm 50 was 12%, but from rkm 50 to rkm 8 it was 33%. For yearling Chinook salmon, the mortality rates were 7% and 13%, respectively. For sub-yearling Chinook salmon, the mortality rates were 11% and 8%, respectively. The CEERP management implication is that sources of mortality in the lower estuary must be removed.

3.4.4 *Migratory Pathways and Survival of Juvenile Salmonids in the LCRE* The majority of acoustic-tagged yearling and sub-yearling Chinook salmon and steelhead traveled in the main navigation channel from rkm 86 down to rkm 37, at which point most fish left the river-influenced navigation channel, crossed a broad, shallow tidal flat, and migrated through the final 37 km in a secondary channel on the Washington side of the estuary[24]. Although no significant differences in survival probability were observed between navigation channel and off-channel migrants, several areas of high mortality were identified. This study revealed life-history characteristics supporting population resiliency that can be used to focus future CEERP research and management activities aimed at protecting salmon populations listed by the Endangered Species Act in areas identified as having high mortality.

3.4.5 *Contribution of Tidal Fluvial Habitats in the Columbia River Estuary to the Recovery of Diverse Salmon Evolutionarily Significant Units* Sampling was conducted to determine the LCRE's contribution to salmon genetic and life-history diversity and the implications for habitat restoration. Preliminary genetic survey results show that stock compositions of Chinook salmon juveniles are highly variable spatially and seasonally during juvenile migration. Interior Columbia River stocks were present later in the summer and were more prevalent above St. Helens (rkm 138) than at sites closer to the estuary mouth. These data will have management implications for CEERP restoration strategies.

3.4.6 *Post-Construction Assessment of Fishes, Habitats, and Tide Gates in Sloughs on the Mainland* At Julia Butler Hansen National Wildlife Refuge, the effectiveness of newly installed self-restrained tide gates was assessed at two sloughs during spring 2010[25]. Water temperature profiles within these two sloughs approached those of reference sloughs. Numerically, more salmon were captured in treatment sloughs after installation of the new tide gates than before. However, more salmon than previously captured were also captured in a control slough that continues to be disconnected from its historical mouth. These action effectiveness data have implications to CEERP decisions on tide gate restorations in the LCRE.

3.4.7 *Evaluation of Life-History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the LCRE* Early life-history diversity indices were developed that provide a means to quantify life-history diversity to serve as a high-level indicator for use by regional managers[26]. For habitat connectivity, site-scale passage barriers, dike breaches, and wetted area can be extracted using remote-sensing and modeling techniques for passage barrier change assessment. In addition, standard nearest-neighbor distance methods can be modified for salmon using hydrologic routing and directional thresholds. Passive integrated transponder-tag detections showed salmon from the Columbia River basin above Bonneville Dam, as well as lower Columbia and Willamette river systems, were present in shallow tidal freshwater habitats. The CEERP management implications of methods to index early life-history diversity, habitat connectivity, and survival benefits pertain directly to the purposes of action effectiveness evaluations and adaptive management of the LCRE restoration program.

3.4.8 *Evaluating Cumulative Ecosystem Response to Habitat Restoration Projects in the LCRE* Johnson et al.[27] provided standard monitoring protocols and methods for prioritizing monitoring activities[28]; a theoretical and empirical basis for a cumulative effects methodology using a levels-of-evidence approach [29]; evaluations of cumulative effects using ecological relationships, geo-referenced data, hydrodynamic modeling, and meta-analyses [30]; and an adaptive management process to coordinate and coalesce restoration efforts in the LCRE[13]. The CEERP management implication is that a solid foundation has been laid for future comprehensive evaluations of progress made by the restoration program to understand, conserve, and restore ecosystems in the LCRE.

3.5 Synthesize and Evaluate

The CEERP knowledge base concerning juvenile salmon ecology and ecosystem restoration in the LCRE supports actions to restore shallow-water habitats, such as hydrologic reconnections and riparian and channel improvements. The prevailing finding is that juvenile salmon tend to use restored areas[31,27]. Bioenergetics research has shown the potential benefits to juvenile salmon growth in shallow tidal freshwater water areas [32]. These types of habitats produce prey that are consumed on site and exported to the main stem[33-35]. Restored habitats help increase habitat diversity, which is hypothesized to contribute to increased early life-history diversity in salmonids and, thereby, salmonid population resiliency[36-37]. The existing knowledge base provides a science-based foundation that is strategic for CEERP restoration and RME actions. Meta-analysis and cumulative effects analysis are forthcoming. A comprehensive Synthesis Memorandum is due in June 2012.

4 Recommendations: Application to the Littoral Zone Ecosystem of the Three Gorges Reservoir

The littoral zone of the TGR where a 30-m change in water-surface elevation occurs on an annual cycle is essentially a new ecosystem. The stressor is TGR operations and the primary controlling factor is water-surface elevation, the effects of which will vary with location in the reservoir and its tributaries. Structures, processes, and functions in the new littoral zone ecosystem will necessarily respond to the water-surface elevation regime. Some of the ecosystems responses, such as bank sloughing and release of pollutants, might not be desirable. Others, such as production and harvest of commercially valuable plants, might be beneficial. The key is to adapt to this new ecosystem using ecology-based, "eco-friendly" practices to utilize the littoral zone for local communities and businesses. This strategy is supported by the Ministry of Science and Technology of China, the Chongqing Municipal Government, Kaixian County, Chongqing University, and other government and academic institutions in China.

There is an important distinction between the eco-friendly utilization of the TGR littoral zone and CEERP restoration effort in the LCRE. The TGR efforts concern adapting ecosystem structures, processes, and functions to a new, given regime for the hydrologic controlling factor, whereas the CEERP efforts involve restoration of historical hydrologic regimes, at least in terms of reconnecting lost habitats if not river discharge patterns. This fundamental difference, however, does not preclude application of CEERP experiences and lessons to the eco-friendly utilization of the TGR littoral zone because both efforts are taking an ecosystem–based approach to meeting their goals. In fact, the CEERP adaptive management process has much to offer to the TGR scientists and decision-makers.

The following recommendations for the eco-friendly use of the TGR littoral zone are at the programmatic level. Many of them are likely already being addressed in one form or another.

- Establish clear goal and objective statements. As used here, the goal is the expected ultimate outcome of the effort and the objectives are the actions necessary to achieve the goal.
- Develop and implement an adaptive management process. Adaptive management is a systematic process for addressing uncertainties: "… a structured process of 'learning by doing' that involves more than simply better ecological monitoring and response to unexpected management impacts. It should begin with a concerted effort to integrate existing interdisciplinary experience and scientific information into dynamic models that attempt to make predictions about impacts of alternative policies."[38].
- Establish a TGR littoral zone RME coordination committee that includes the pertinent government agencies, research organizations, and universities.
- Establish a TGR RME data center — a central, web-accessible repository for data and a publicly accessible homepage with links to a networked system of databases. Develop RME data specifications to support a coordinated data management system and adopt standardized methods for selected data to allow comparisons through time for given monitored attributes.
- Convene annual TGR conferences to disseminate results, exchange information, and develop new strategies. Such conferences should be documented in peer-reviewed conference proceedings and include specific action items to ensure progress and accountability.
- Engage local communities and officials to obtain their perspectives and input.

It would be informative to assess the status of the effort for eco-friendly utilization of the TGR littoral zone at the next International Symposium on Conservation and Eco-Friendly Utilization of Wetland in the Three Gorges Reservoir. Similarly, progress toward the CEERP objectives might also be reported and prove enlightening.

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