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Methodology to Develop A Recovery Strategy for the Sturgeon Stocks of The Caspian Sea

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Abstract

The situation of sturgeons *(Acipenseriformes)* in the Caspian Sea which many experts currently assess as "Catastrophic", is discussed. In today's complex environment of the region, traditional approaches to recovery of sturgeon stocks, based on the classical biological paradigm of stocks management already untenable. A new approach based on the extended paradigm consisting along with classical representations, ideas and methods of "Strategic planning" is proposed. Developed within the framework of this approach the methodology opens up wide possibilities to choose adequate recovery strategy in the conditions of many challenges today facing Caspian sturgeon management: Large-scale poaching, pollution of spawning rivers and sea, destruction of a unified management system (after the collapse of the USSR), transgression of the sea, invasions, etc.

Keywords: Caspian sturgeons, recovery strategy, methodology.

Introduction

The massive decline of sturgeon catches in the Caspian Sea, a consequence of anthropogenic causes, needs to be turned around by implementing a management system that has as its primary aim the recovery of the stocks to sustainable levels (Pourkazemy, 2006; IUCN, 2005). The FAO stresses that “Creation of a document giving a strategy for stock recovery should be a priority task for everyone related to the management process of the sturgeon fisheries of the Caspian Sea” (FAO, 2004a). Recent history has shown that to do this with the help of the traditional tools of fisheries management, such as Total Allowable Catches (TACs), including its modern equivalent, the “Precautionary approach” (FAO. 1996), the “Holistic approach” (Caddy, 2002), the “Ecosystem approach” (Garcia *et al.*, 2003), quotas, and technical measures (FAO, 2004b), is not effective. Moreover, to rely on such management tools under complex conditions of region is high risk for the resources.

The solution in the authors’ opinion is to invoke management tools at a higher, strategic level. These need to take into account the long-term prospects and targets for the stocks and all system issues related to the problem currently: The status and distribution of the different stocks, the extent of poaching, pollution of the sea and the rivers of the Caspian basin, national and international markets for sturgeon product, national and international legislation, the efficiency of conservation and control measures for the stocks, the developing technologies of artificial production and culture, fluctuations in the sea level of the Caspian, natural climate change, possible geo-conflicts and international terrorism, competitors for food (*Mnemiopsis leidyi*), etc.

Such tools do not exist at present in most fisheries management regimes. Numerous attempts internationally to use strategic planning for fisheries, as applied in the theory of corporate management (Andrews, 1987), have tended to fail because they do not take into account:

- Ecological and biological nature of fish stocks that distinguishes them from industrial and economic entities;
- Numerous uncertainty and risks inherent in fisheries management, which generates unjustified illusions and strategic errors;
- Multicriteria nature of fisheries which demands that any strategy be based at least on issues related to biological, economic, and social efficiency.

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Today it is clear that, despite the attractiveness of the methodology of Strategic Planning (SP) for the management of fish stocks it must be modified. The modification can be made on the basis of an integrated approach that synthesizes the ideas and methods of SP and population biology and ecology, as well as modern support tools that expand analytical capabilities of SP. Among the latter can be attributed: "Cognitive modeling", "Scenario planning", "Determinacy analysis", "Foresight-technology".

Here we offer a methodology of SP, based on such a synthetic, integrated approach. Below we provide a general formulation of a SP task, description of the substantive provisions, procedures and tools of a SP methodology, and discussion of opportunities of its practical application in the Caspian Sea.

SP Task Formulation

The preliminary remarks:

Remark 1: The strategy is a combination of all possible management measures (technical, organizational, economic, political, social, market, international), which can ensure (supply) recovery of a stock and long–term its steady exploitation under current conditions.

Remark 2: The measures are established within the framework of existing opportunities (national, regional, international) on management of a stock and external environment (habitat environment and macro environment).

*Remark 3***:** The set possible measures structured according to life cycle of a stock, as object of commercial trade (natural and artificial reproduction, growth, natural mortality, catches legal and illegal, processing, and realization in the internal and external markets).

Remark 4: The task of development of strategy can be formulated for separate reproductive isolated populations (for example, Volga populations of the Russian sturgeon and beluga , Ural populations of the Russian sturgeon and beluga, Iranian population of the Persian sturgeon), forming raw base of the separate areas of the sea (Volga-Caspian, Ural-Caspian, Kura-Caspian, Turkmenistan and Iranian waters) and region as a whole. In a general view the SP task statement can be presented as follows:

$$S: S^{*} \rightarrow K_{S^{*}}(E_b, E_e, E_s)\Big|_{B, \Omega, L, N},$$

where, S is a set of allowable strategies for recovering a stock; S^* is the “satisfactory” (in some sense or another) strategy; K_{S^*} (E_b, E_e, E_s) is the generalized efficiency criteria of strategy S^*, including biological (E_b), economic (E_e), and social (E_s) sub criteria;

B represents the biological characteristics of a stock that determine the parameters of reproduction, growth, and mortality;

Ω is a set of factors of uncertainty caused by incompleteness, discrepancy, and unreliability of problem knowledge;

L is a vector of resource restriction (temporal, financial, technological, legislation, etc.);

N is a network of safety, establishing borders of environmental parameter change within which the normal conditions for the stock to survive (temperature, salinity, oxygen, toxicity, food production, river flow, area and status of spawning grounds, etc.) are possible.

From the standpoint of modern management theory SP task belongs to the category of complex, multi-objective, multifactor, multiply connected, emergent, dynamic, nonlinear (no monotonic), ill-structured tasks.

This type of tasks we conventionally call "super complicated tasks. This is something more complex than the well-known ill-structured tasks investigated by Simon (1978).

Science-based solution of SP tasks within the traditional paradigm of strategic planning is impossible in principle.

A wide prospect for solving the S-task opens an integrated approach, which was mentioned above. Are newer (possibly – unique) opportunity here opens the cognitive tools, actively developed in recent years in the theory of control of complex objects of the modern real world (Eden, 1989). Cognitive tools are based on the mental models of experts that reflect the heuristic (non-mathematical) world perception of man and allow investigate the problem situations at a qualitative level, overcoming the curse of the "Bad statistics" and "Uncertain future".

Another important feature of cognitive tools is that they allow take into account "the institutional shell" of problem, reflecting the informal "rules of the game", formed in the region. Institutional factors (poaching, lack of law and order, prices on the world markets of sturgeon products, pollution of habitat, global warming, transboundary claims, etc.), playing an important role in current fisheries management practice, almost completely denies the classical methods of stockpile management (Beverton and Holt, 1957; Nikolskiy, 1974) and their current modifications (FAO, 1996; Caddy, 2002; Garcia *et al*., 2003).

Materials and Methods

The following materials were used in development of the methodology:

- World Sturgeon Conservation Society. RAMSAR Declaration on Global Sturgeon Conservation (http://www.wscs.info/media/9304/RamsarDeclarationEnglish.pdf);
- EU/TACIS. Sustainable Management of

Caspian Fisheries Project (SMCFP) (http://www.landell-mills.com/experience/experience.asp?article=274);

- Results contained in study reports and publications issued by the leading regional scientific–research organizations: VNIRO (Russian Federation, Moscow), KaspNIRKh (Russian Federation, Astrakhan), Fishery Research and Production Center (Republic of Kazakhstan, Almaty), Atyrau Branch of Fishery Research and Production Center and "Atyrau balyk" (Republic of Kazakhstan, Atyrau), and the International Scientific Research Institute for Sturgeon IFRO (Islamic Republic of Iran, Rasht);
- Documents and meeting protocols of Commission on Aquatic Bioresources of the Caspian Sea (CABCS) (2003-2013);
- Technical Reports issued by the Caspian Environment Programme (http://www.caspianenvironment.org/report_technical.htm);
- Expert knowledge of regional specialists and scientists, journalistic investigations and observations of fishermen.

Methodology of SP

The logical structure of the methodology is shown in Figure 1.

Unlike the mechanism of *long-term planning* in fishery theory (the fundamental forecast), based on extrapolation of the past and present into the future, the SP ideology builds a vector of management in a reverse direction. In other words, it builds the present from what is required in the future. Thus, models of the future environment are constructed, the target position of the stocks in these models is decided, and an effective management strategy (scenario) to achieve the targets is formed.

The SP methodology includes the following components:

1. The SP concept (its mission and recovery hypotheses) (Pilling *et al*., 2008; Karayev, 2010).
2. A Reference List of recovery strategies in the format of Anonymous (2006) and Sandu *et al.* (2013). Reference List includes of "Strategic directions" and an associated list of the "Sub-strategies" structured according to the conceptual scheme of life cycle of Caspian sturgeon and "Axiomatics" of modeling anadromous herds of Caspian sturgeon (Karayev, 2006).
3. A Reference List of efficiency criteria (biological, economic, social).
4. A Library of basic procedures and methods of the SP methodology (Table 1).
5. Cognitive Map of recovery problem of the Caspian sturgeon stocks (Figure 2).

Opportunities of The Methodology

The SP methodology is executed within the format of a system shell (Waterman, 1986) which can be customize to separate sturgeon populations, or separate areas of the Sea (Volga-Caspian, Ural-Caspian, Kura-Caspian, Iranian waters, Turkmenistan waters).

It also can be used for solving of relevance tasks of region: Early diagnostics and forecasting the critical status of the different populations (Russian, Ural, Persian sturgeon); a strategic environmental impact assessment of offshore projects; identification of critical scenarios of economic activities in different areas of the Sea; strategic diagnostics of the ongoing and the planned recovery projects (e.g. moratorium on fisheries, embargo on trade in caviar and sturgeon products, construction of new hatcheries).

Correctly and in time, strategic decisions if effected will play a key role in recovering the Caspian basin sturgeon stocks. If successful there will be a future for sturgeon in the Caspian; if they fail, the die is cast.

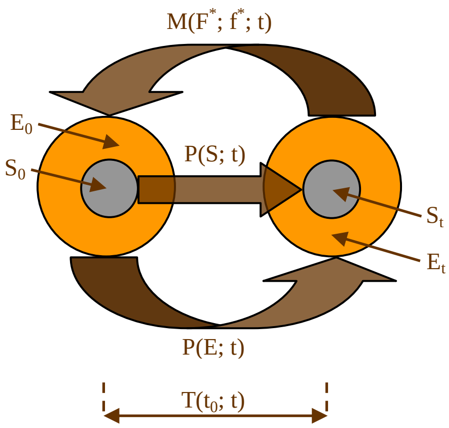

Figure 1. Logical structure of SP methodology.

Legend: S_o – current state of stock; E_o – current state of the external environment; $T = (t_o; t)$ – the horizon of strategic planning; E_t – future state of the external environment; S_t – future state of the stock; $P\ (E, t)$ – the procedure for forecasting the state of the external environment; $P\ (S, t)$ – the procedure for forecasting the state of the stock; $M\ (F^*, f^*, t)$ – a complex strategy to recover the stock; F^* – managed factors of the external environment; f^* – managed factors of the stock.

Table 1. Procedures and Methods of SP Methodology

Procedures	Methods (References)
P1. Identification of the causes (hypotheses) undermining the stock. Statements of the mission and strategic targets.	SWOT&PEST-analysis of the sturgeon stocks and their environment (RapidBi, 2011; FAO, 2012)
P2. Searching forecasting the long-term behavior of the external environment under uncertainty	Method of determinacy analysis (Chesnokov, 1987) Foresight technology (Georghiou *et al*., 2008)
P3. Building scenarios of environment development	Methods of scenario planning (Balston, and Wilson, 2006; Lindgren, and Bandhold, 2009)
P4. Design of Cognitive Map of recovery problem	Cognitive mapping (Roberts, 1976; Eden, 1989; Meyer, and Booker, 1991; RSC, 2004; IEHIAS, 2011; Karayev, 2003a, 2003b, 2014)
P5. Cognitive generation and analysis of alternative recovery strategies (“Strategic directions” and an associated of the “Sub-strategies”)	CM-based methods for 1) analyzing the structural properties of the problem, 2) generation of alternative strategies, 3) model experiments on alternative strategies. (Roberts, 1976; Karayev *et al*., 2003; Karayev, 2013, 2014)
P6. Multi-criteria analysis and choice “satisfactory” recovery strategy	Method of hierarchy analysis (Saaty, 1980)
P7. Strategic decision-making support	Method an interpretation of strategic decisions at the level of “Sub-strategies” (Saaty, 1980; Ansoff, 1984; Karayev *et al*., 2013; Karayev, 2014)

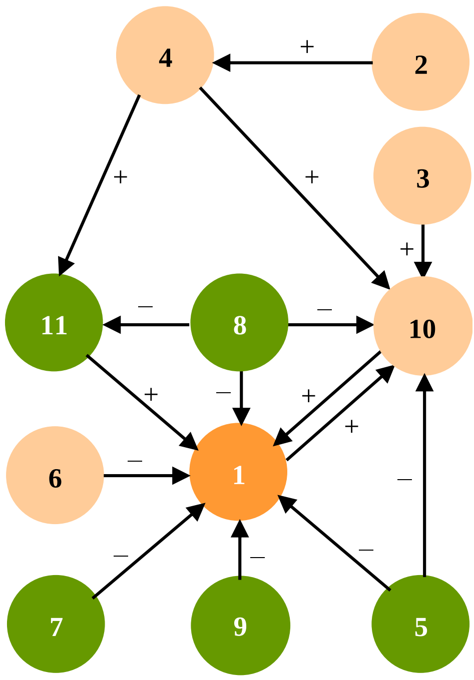

Figure 2. Signed cognitive map for qualitative modeling of the problem situation (fragment). Demonstration prototype for Volga population of the Russian sturgeon and Kura population of Persian sturgeon.

Factors of Cognitive Map:

Target factor: 1) Stock biomass; Environment factors: 2) Sea level, 3) Annual river drain, 4) Forage reserve, 6) Deregulation a drain of the spawning rivers, 10) Natural reproduction; Manageable factors: 5) Commercial Fishing, 7) Poaching, 8) Pollution of the rivers and the sea, 9) Disintegration of uniform system of protection and reproduction, 11) Artificial reproduction.

Notes:

1. Cognitive map reflects the logic of reasoning of the expert - biologist but not mathematician. In this way solves an important problem of forecasting in unforeseen circumstances - "keep mathematics simple, and let the richness of structure to carry the burden of complexity" because "no mathematics can not replace the human mind and experience in the interpretation of the real world» (Saaty, 1980)
2. Unlike well-known hypothetical curve of survival of the long-cyclical fishes proposed by W. Thompson (Thomson, 1959), in cognitive modeling counted the major species-specific characteristics of the stock and the dynamics of these characteristics caused by changes of environmental factors and manageable factors.
3. Cognitive map is being developed for a specific population and a specific period of time (horizon) of Strategic Planning.
4. Technology of creation knowledge-based support tools envisages three levels of development: “demonstration prototype”, “research prototype”, “industrial prototype” (Waterman, 1986). In the “industrial prototypes” of cognitive maps are used weighted digraphs with a time delay and functional causal relationships (Roberts, 1976) that reflect the parameters of the life cycle of populations.

Conclusion

Today, after many failed attempts to draw attention to the methodological aspect of the recovery problem of the Caspian sturgeon (Karayev, 2005; Karayev and Payne, 2006; Karayev, 2010, 2012), author going back again to this issue. This is due to:

● Continued degradation of the Caspian sturgeon stocks;

● Futility of mono-factorial linear strategy of 5 year moratorium on sturgeon "Commercial fishing", adopted at the 34th meeting of the CABCS in 2013;

● Acute necessity to develop an adequate strategy, takes into account the complex phenomenology of the problem (examples of the cognitive choice of strategies for decision of these kinds of problems are given in the study of Karayev (2013, 2014));

● In our view, the SP methodology can submit theoretical and practical interest to scholars and specialists in other fishing areas in the world, whose stocks are now under intense multi-factorial pressure-marine pollution, large-scale poaching, global warming, invasion, complex geopolitical situation, etc.

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