Major Comments (requested modifications)

1) **"The Methodology is unclear and must be clarified before publication. The habitat model is not well described and the reader must "guess" essential information about the environmental factors under study (i.e. salinity and depth). The first occurrence of the word salinity is found page 8. At line 24, the reader guesses that "acceptable salinity and depth" are the environmental factors under study. I advice to clarify that point from the beginning (i.e. in the Abstract, and in the Introduction p.4 line 15, and in the Methodology), and make clear that the only environmental factors influencing the habitat area in the present study are salinity and depth (just as the authors did in their paper in Estuar. Coast., 2012)."**

In the submitted manuscript, an relationship was established between ecological responses and freshwater inflow fluctuations by simulating potential positions and area of the critical habitats considering different requirements for different species, and diversity of environmental factor for typical species. Potential habitat area and potential habitat position were analyzed based on distribution of environmental factors influenced by combined action of freshwater inflows and tidal currents. Based on analyze of habitat area and its variations, a boundary of environmental flows was defined to maintain a high level of habitat area and low variability of habitat area for typical species in estuaries.

In the section methodology, the proposed integrated multi-objective method indicate two steps, environmental flows for typical specie integrating diversity environmental factors (equation 1) and environmental flows for ecosystems integrating freshwater inflow requirements for different species (equation 6 and 7).

In section methodology, not only environmental factors, such as salinity and water depth, were used in the case study in the Yellow River Estuary, but also additional environmental factors such as water temperature, velocity, total suspended, dissolved solids, and others factors can be included in the assessment to determine a suitable habitat area and position influenced by hydrological alteration. As a result, habitat area was considered as an integrated index that represents the intertwined requirements of a variety of different environmental factors included in the study, the habitat area can be determined as:

$$A = \{A_1 = f_1(S_1) \cap \cdots \cap A_i = f_i(S_i) \cap \cdots \cap A_n = f_n(S_n)\} \quad (1)$$

where A_i is the habitat area under requirements of ecological factors S_i; S_i is the ecological factor number i. Suitable habitat area considering environmental factor S_i is determined by $A_i=f_i(S_i)$. While, $f_i(S)$ is the relationship between the distribution of environmental factors and habitat area.

Following sentences were added in the modified manuscript. “Suitable habitat area can be determined at different scale. In our research, habitat area is defined as the average result of suitable area in a tidal cycle. And amplitude of habitat variability was calculated by the differences between the maximum and the minimum habitat area in one tidal cycle”.

Based on the distribution of environmental factors under action of river discharges and tidal flows, we can determine the position and area of the habitat for typical species considering their requirements of typical environmental factors with the minimum and maximum levels of thresholds.

The interwined requirements of habitat area can also be presented as Figure r1. The area of the shaded part is the habitat area under requirements of various ecological factors.

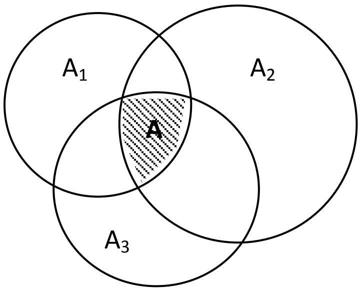

Figure r1 The habitat area under requirements of various ecological factors.

It should be pointed out that the recommended ranges of environmental flows may also be varied when additional ecological objectives for ecosystem protection are involved in the assessments. For example, recommended environmental flows are likely to require adjustment when additional species are included in the assessments. And additional environmental factors such as water temperature, velocity, total suspended and dissolved solids and others can also influence available habitat area and quality, consequently, the recommended environmental flows will also be different according to the variations of the relationship between habitat area and hydrological alteration. In the case study in the Yellow River Estuary, salinity and water depth was selected as two critical factors in the habitat of four species. Following sentence was added in the abstract. “Responses of habitat area, and the magnitude of those responses influenced by salinity and water depth were established influenced by fluctuations in river discharge and tidal current.”

"**Equation (2) does not make much sense in this study, according to me. When you know that Si is the salinity or the depth, what is the function g(Q) “the relationship between ecological processes and flow regime”? Where is the relationship defined or referenced? Beside, I would suggest that g(Q) is changed into another symbol (e.g. j(Q)) because g is further allocated to the gravitational**

acceleration in Eq (4)."

In the submitted manuscript, equation (2) is used to indicate the relationship between river discharges and distribution of critical environmental factors (such as salinity). Equation (2) has a similar means of equations (3), (4), and (5). In order to make the manuscript more clear, equation (2) has been deleted in the modified manuscript.

"**It should be explained somewhere how to derive habitat areas from salinity and depth. The reader can only guess the following (without being sure): the 2D-hydrodynamical model produces results of salinity and depth distributions in 2D-space at every time step. Then, the authors delimit the habitat area by projecting on these salinity and depth results the tolerance thresholds of the species. The habitat area of one species is derived from these projections by taking the smallest intersection of both salinity and depth-derived areas. This is only a supposition from me, and I request from the authors that they clarify this point in their manuscript.**"

Methodology has been modified and the response to the comments is similar with the last one. Habitat area and habitat position varies at different scale. In our research, habitat area is defined as the average result of suitable area in a tidal cycle. And amplitude of habitat variability was calculated by the differences between the maximum and the minimum habitat area in one tidal cycle. In the case study in the Yellow River Estuary, salinity and water depth was selected as two critical factors in the habitat of four migratory species during pivotal life-stage seasons.

"**The two primary objectives (i.e. habitat area and habitat area variability) that are found in the Abstract (p.2 line 9) should be well described in the Methodology, including the way they are estimated. For instance, Figure 4 (p.24) shows the "Amplitude of habitat variability". How do you calculate the variability? It is difficult to understand how most graphs are produced. How do the authors derive the maximum habitat area (p. 9 lines 22-24 and Fig.4)? Figure 2 (p.22) shows the "Temporal variation objectives for environmental flows". What is it? How is it calculated? Why is it an "objective" or "objectives"? Where is it explained in the Methodology? Table 2 (p.20): how do the authors derive the "Annual environmental flows (109 m3)"?**"

The method to determine habitat area and habitat area variability has been added in the section methodology. Following sentences were added in the modified manuscript.

"*Suitable habitat area can be determined at different scale. In our research, habitat area is defined as the average result of suitable area in a tidal cycle. And amplitude of habitat variability was calculated by the differences between the maximum and the* *minimum habitat area in one tidal cycle.*"

Section "2.3 Temporal vatiations of environmental flows" was added in the methodology, and following sentences were added in the modified manuscript,

With temporal variations in hydrological and biological processes, environmental flows usually exhibit temporal variability at various scales. However, the identification of every specific objective for environmental flows is still difficult, particularly given the different spatial and temporal scales at which those processes are manifested. Considering the close relationships between hydrological and biological processes in ecosystems, the temporal variations of environmental flows is expressed as the ratio of the monthly or daily river discharge to the annual discharge (equation 1).

$$R_i = \sum_{j=1}^{n} W_{ji} \Big/ \sum_{j=1}^{n} W_j \ , \qquad (9)$$

where R_i is the ratio (%) of the monthly (or daily) river discharge in month *i* (or day *i*) to the annual discharge; W_j, the annual river discharge (m^3) in year *j*; and W_{ji}, the river discharge (m^3) in month *i* (or day *i*) of year *j*.

Figure 2 shows the temporal variation, based on equation (1), in the monthly natural river discharge of the Yellow River Estuary. The figure indicates the ratio of the monthly river discharge to the annual total in the 1960s, 1970s, 1980s, and 1990s at Lijin Station, which is the last hydrologic station before the estuary in the Yellow River Basin.The average ratio of the temporal distribution of natural river discharge was considered to be representative of the temporal variation in water availability.

After integrating objectives for ecosystem protections in a special season and temporal variation objectives of natural flow regime, the environmental flows can be defined to satisfy the desired ecological objectives in a critical season in addition to objectives in other seasons that may not be included in initial environmental flows assessments. And the annual environmental flows can also be determined by the water requirements in special seasons and monthly or daily variations of environmental flows defined in equation (1).

"**(Optional) In the Methodology, it may be useful also to present the study area first, then the hydrodynamical model, the habitat model, and then how they are coupled by specifying in the Methodology how outputs of the hydrodynamical model are used in the habitat model. A figure presenting the spatial grid of the model might also be useful.**"

In the submitted manuscript, general approach to assess environmental flows considering variations of potential habitat area and position was emphasized and the research on the Yellow River Estuary was taken as a case study of the proposed model. Due to eight figures have been included in the manuscript, and spatial grid of the model may not be helpful to emphasized the proposed integrated multi-objective method, a figure presenting the spatial grid of the model is not added in the modified manuscript.

2) **As far as I can see, the manuscript does not address "ecological adaptation". The title suggests that "ecological adaptation" is the central idea of the manuscript (see e.g. also p.4 lines 11 and 13). In the Methodology, some mechanisms of adaptation are well explained in the text. It is mentioned how species may migrate into new areas under changing water flows and how they may sometimes adapt their habitat (p.5 line 2, p.7 lines 6-7). However, I do not see how this is translated into the equations, how this ecological knowledge is tested in the present study.**

According to what I understand from the methodology of the authors, the boundaries of habitat areas are estimated with the tolerance thresholds per species. These boundaries then draw the contour of a "potential" habitat area based only on salinity and depth. At most the authors can calculate the geographical shift in potential habitat boundaries related to shifts in salinity and depth. The relationships between habitat and salinity or depth is hidden in the function fi in eq.1, but I suppose that the authors have simply projected the upper and lower tolerance thresholds for each species. This is not a biological response but merely a scaling of salinity and depth results. From my point of view, this is not a study on ecological adaptation. A study on ecological adaptation would be a study that relates the presence and survival of a species to environmental factors, like salinity, with a biological response function that is validated, not just the displacement of potential boundaries. Eq. (1) and (2) suggest such a biological relationship, but these equations are not used. The function fi in Eq. (1) is neither defined nor referenced. Unless proven wrong, I would recommend that the authors use the terms "potential habitat area" (or similar terms) instead of "adaptive habitat area" or "habitat area", and do not use the term "ecological adaptation" or "adaptable relationship" in their title, objectives, methodology or conclusions."

Establishing relationship between ecosystem responses to hydrological alteration is a critical issue which should be addressed in environmental flow assessment. There are directive responses of environmental factor and biological processes in a fixed position to hydrological alteration, as well as indirect relationships between ecosystem responses and hydrological alteration because species may change the position of habitat for suitable environmental factors during hydrological processes. Due to adaptation of species to environmental alteration, the relationship between distribution of species and freshwater inflows is still difficult to be established. Consequently, ecological adaptation is seldom involved in environmental flow assessment when establishing correlative empirical or statistical relationships between typical ecological objectives and freshwater inflow alteration.

In order to deal with the complex relationships between flow alteration and ecological responses, field monitoring over decade time-scales has been suggested. In recent years, more and more upper trophic level impacts have also been included in eco-hydrodynamical modes and quantitative eutrophication models in order to capture the complex eco-hydrological processes. However, the limitations of quantitative models often make these approaches impractical. Understanding and identifying key aspects of the physical system and establishing a relatively simple model should be a preliminary step before development of detailed mechanistic linkages between flow and ecological response.

In order to link flow variables and flow regime change to biotic responses, habitat simulation models employ habitat for target species as an intermediate step in addressing environmental flow requirements in the submitted manuscript. In the submitted manuscript, a relationship was established between ecological responses and freshwater inflow fluctuations by simulating potential positions of the critical habitats following incorporation of the requirements of various environmental factors for different species.

In the submitted manuscript, ecological adaptation was not analyzed based on a biological response to environmental factors. Considering less detailed research was conducted in the submitted manuscript, the term “ecological adaptation” or “adaptable relationship” was modified to potential habitat following the reviewer’s comments. Further research on ecological adaptation in environmental flow assessments was analyzed in section discussion. The term of "Potential habitat area" and "Potential habitat position" was employed considering variations of distribution of critical environmental factors influenced by combined action of river discharges and tidal currents.

Title of the manuscript has be changed to “Environmental flow assessments in estuaries based on an integrated multi-objective method”

3) “**A comparison between the present manuscript and the paper from the same authors i.e. Sun et al. (2012) in Estuaries and Coasts (35) shows that both papers study the same phenomenum with slightly different methodologies and with different results. These differences are not discussed in the present manuscript. In Table 2 (p.20) of the present manuscript, the authors present the environmental flows in the Yellow River Estuary for four species (minimum and maximum tolerable flows in m3 s-1). They present the same flows (min and max) for the same species in the same estuary in their paper Estuar. Coast. (p.899, Table 2). The values are different (in some case by a factor 5). Idem for the conclusions: in the present manuscript the authors conclude that the river discharge must be comprised between 25% and 112% of its annual average, versus 15% and 101% in Estuar. Coast. Why is it so different? A contrario, in**

the present manuscript, Figure 7 (p.27) is a very interesting figure. However, it seems to be another version of the Figure 11 (p.901) in Estuar. Coast. Then the question: what has improved since the publication of the Estuar. Coast. paper? Shouldn't these differences be discussed by the authors as a result of the differences in methodologies?"

In general, two major issues must be addressed in environmental flow assessments, definition of ecosystem protection goals and determination of ecosystem responses to hydrological alteration. In the submitted manuscript and published manuscript, similar species were identified to be objectives of ecosystem protections in the Yellow River Estuary. However, different relationships of ecosystem responses to hydrological alteration were established between those two manuscripts.

As a first step, a fixed position of habitat for different species was identified consulted from relative literatures in the published manuscript. Fixed locations of different habitats of various species were identified. The relationship between freshwater inflows and the environmental factor (salinity) in the critical habitat was simulated based on a validated numerical model. Consequently, different levels of environmental flows were determined considering different levels of the ecological objectives in the estuary during critical seasons. Different levels of environmental flows were defined based on thresholds of salinity for the habitat of different species. And parameters of water depth were used to indicate the characteristics of habitat in the published manuscript. Various requirements the freshwater inflows for different species were emphasized in the published manuscript.

During the study in the published manuscript, we realized that distributions of salinity and water depth all changes with variations of freshwater inflows and tidal currents. Ideas of taking ecological adaptation as an important factor were derived in this submitted manuscript. It is supposed that species migrating into an area that is being affected by altered water flows may adapt their operable habitat to meet environmental changes but still encompass the ideal environmental factors for that species. The habitat can be accepted by the species only when every key factor falls within the acceptability limits. As a result, suitable habitat area or position may also be changed with temporal variations of river discharge and tidal currents. Threshold of salinity and water depth of habitat requirements was used to define a suitable or potential habitat position and area for different species. Moreover, high level of habitat area and its low variability were used to be the critical limits for potential habitat of different species.

In the submitted manuscript, a relationship was established between ecological responses and freshwater inflow fluctuations by simulating potential positions of the critical habitats following incorporation of the requirements of various environmental factors for different species. That is also a reason for the different results of environmental flows considering the same species in this manuscript and the published manuscript in Estuar. Coast. 35: 892-903.

In the submitted manuscript, environmental flows were assessed considering variations of habitat position and habitat area influenced by temporal variation of freshwater and tidal currents. It is also pointed out that the recommended ranges of environmental flows may also vary when additional ecological objectives for ecosystem protection are involved in the assessments. For example, recommended environmental flows are likely to require adjustment when additional species are included in the assessments. And additional environmental factors such as water temperature, velocity, total suspended and dissolved solids and others can also influence available habitat area and quality. Consequently, the recommended environmental flows will also be different according to the variations of the relationship between habitat area and hydrological alteration.

In the published manuscript, Figure 11 compared monthly variations in environmental flows and average river discharges every month in typical years in order to analyze temporal variations of environmental flows and river discharges influenced by human activities. In the submitted manuscript, range of variations in monthly river discharge and the associated environmental flows boundary were compared in the 1950s(Fig.7a) and the 2000s(Fig.7b). Ranges of variations in monthly river discharge were determined by the differences between the maximum and minimum monthly river discharges during those decades. It was found that in the 2000s, fluctuations in monthly river discharges were much more substantial. The most dramatic swings in discharge rates occurred in June and July, resulting in the maximum volume amplitude during this period of time. Not only maximum river discharge, but also the minimum river discharges changes out of the range of recommended environmental flows. Those results cannot be found if only average river discharges was compared with recommended environmental flows.

Different from the published manuscript, different requirements for species, and diversity of environmental factor for typical species were analyzed in the submitted manuscript. Potential habitat area as well as potential habitat position were analyzed based on distribution of salinity and water depth influenced by combined by freshwater inflows and tidal currents. A boundary of environmental flows in estuaries based on requirements of high level of habitat area and low variability of habitat for typical species in estuaries.

Following sentences were added in the section discussion:

"*There are two major issues must be addressed in environmental flow assessments, definition of ecosystem protection goals and determination of ecosystem responses to hydrological alteration. Recommended environmental flows may be different when* *different relationships of ecosystem responses to hydrological alteration were established with same objectives of ecosystem protection (Sun et al., 2012).*"

4) "**Several crucial terms are confusing to the point that the manuscript remains long misunderstood by the reader. For example, the "multi-objective method" (omnipresent in the paper) is merely known as the "multi-objective optimization method". It is the process of simultaneously optimizing two or more conflicting objectives subject to certain constraints. There is no single solution but several tentative solutions that allow quantifying the trade-offs and make decisions. The authors must know this method as they cite Yang W (2011) who uses such a method to evaluate environmental flows in the Yellow River delta. However, the optimization method is not used in the present manuscript, as far as I can judge. Therefore, unless the authors prove me wrong, I strongly recommend the use of other terms in order to dispel the confusion. With the aim to help the authors clarify their text, I give three additional examples: 1) the term "objectives" (p.22 Fig.2) is never really defined. Is it the objective of the study, or the objective of an optimization, or something else? 2) The term "temporal variation in objectives" (p.9 line 9 and p.22 Fig.2) seems abusive to me. A temporal variation is a rate of change (ïA̧Dˇ x/iA̧Dˇ t or dx/dt), not the ratio between a monthly value and an annual value of the same variable. 3) The term "integrated" as part of the name of the method (see e.g. title, abstract) is unclear to me. Does it mean that the hydrodynamical and habitat models are coupled, as suggested in the abstract (p.2 line 7)?**"

The term of "Multi-objective method" in the submitted manuscript means that different objectives in ecosystem protection were included in the environmental flow assessment. The proposed integrated multi-objective method included two steps, integrating environmental flows considering diversity environmental factors (equation 1) and integrating environmental flows considering various of species (equation 6 and 7).

In the manuscript, the habitat is defined as an area where every key factor falls within the acceptability limits which can be accepted by the species. As a key ecological factor, habitat area is considered as an integrated index that represents the intertwined requirements of a variety of environmental factors.

Variations in the temporal and spatial distribution patterns of different species will cause incremental overlap. Consequently, environmental flow for one species is likely to be unacceptable for one or more other species. The recommended environmental flow for any given ecosystem is that which falls within the upper and lower tolerance thresholds, obtained by integrating the minimum and maximum water requirements of the keystone species:

The term "temporal variation in objectives" has been explained in equation (9).

Minor Comments

1) "p.2 line 5: suggest replace "migrated" with "migratory" 2) p.2 line 9: "low variability." ... of what? of the habitat area? 3) p.2 line 13: replace "data" with "results" 4) p.2 line 17: replace "are compensated" with "may be compensated" 5) p.3 line 28: suggest replace "population effect" with "effect on the population" 6) p.4 line 4: remove "As with many biotic and abiotic factors" 7) p.5 line 12: suggest replace "Si is the environmental" with "Si is the distribution of the environmental" 8) p.5 line 13: replace "factor of number i" with "factor number i" 9) p.5 line 23: suggest replace "presence" with "occurrence" 10) A question out of curiosity: what is the explanation, if any, of the increase in dry events in the Yellow River since the 1990's? (p.8 lines 7-9). It may be interesting to mention it. 11) Remark about the enhancement of ecosystem biodiversity with fluctuating environment (p.7 line 14): the authors might be interested to read (if not yet done) the paper of Huisman and Weissing (1999) Biodiversity of plankton by species oscillations and chaos, Nature 402."

   Done. Thanks very much for your detailed suggestions.