作者	韩勇
中文题名	水沙变化下长江中下游典型水生动物的栖息地模型研究
英文题名	Habitat Models of Typical Aquatic Animals in the Middle and Lower Reaches of the Yangtze River
中文关键词	长江中下游,水沙变化,典型水生动物,水利工程,栖息地模型
英文关键词	Middle and lower reaches of the Yangtze River, Water and sediment changes, Typical aquatic animals, Hydraulic Engineering, Habitat model
中文文摘	水沙是河流中重要组成成分，是物质输运的动力条件。底栖动物、鱼类和长江江豚构成捕食关系链，是水生态系统中典型的指示物种、宽营养级物种和旗舰物种。长江中下游受上游水库群运行的影响，水沙情势和江湖关系发生改变，水生动物的栖息地退化。本文建立了长江中下游干流、太湖和鄱阳湖中水动力和水生生物的数据集，分析水生态变化的特征，构建了水沙变化条件下典型水生动物的栖息地模型，并对模型进行了率定和验证，进而应用于分析水沙变化和水利枢纽对水生动物栖息地的影响。水沙变化是长江中下游水生动物栖息地演变的主要物理因素。干流输沙量减少、河道冲刷，底栖动物的丰度和数量减少，且与河床稳定性呈现一定的相关性。径流量年内分配变化及干流含沙量和水位下降导致鄱阳湖出湖水沙通量增加，湖区水沙不平衡，枯水问题加剧，水生动物的栖息地适宜性下降。大坝的阻隔作用还导致栖息地破碎化，干流、湖泊中底栖动物和鱼类的数量减少，多样性降低，“四大家鱼”比例和长江江豚数量也在下降。依据典型水生动物的栖息地特征，构建了底栖动物生长动力学模型和长江江豚栖息地适宜模型。定义了底栖动物摄食、呼吸排泄和被捕食过程，量化了底栖动物对床面形态和水温等环境因素的偏好函数。采用玻尔兹曼方程、分段函数量化了长江江豚对流速和水深的偏好，定义了食物可利用度函数来表征鱼类资源对江豚丰度的限制性。通过模拟太湖中底栖动物优势种河蚬的时空分布及鄱阳湖中江豚的空间分布格局，完成了模型的率定及验证。研究分析发现：（1）太湖中风场驱动形成的床面形态和水温分别主导了河蚬空间分布的差异和生物量变化的时间周期，环境因素对底栖动物的影响具有累积作用，而底栖动物生物量对环境变化的响应有滞后性。（2）鄱阳湖中现阶段通江水道和主湖区的江豚减少的关键原因分别是水面收缩和鱼类资源的下降；预测未来时期，主湖区江豚丰度的变化将趋于平缓，但经通江水道进入的江豚减少，栖息地的破碎化还在加剧。（3）鄱阳湖拟建水利枢纽对水生动物栖息地的潜在影响具有两面性，可以改善水深和水面面积，有利于栖息地适宜性的恢复；但大坝弱化了水体交换能力，造成物理阻隔，降低水力连通度，不利于洄游动物的迁移运动。
外文文摘	Water and sediment are the dynamic conditions of material transportation in the river. Benthic invertebrates, fishes, and Yangtze finless porpoises belong to the predation chain, and are the typical indicator species, wide trophic species and flagship species in aquatic ecosystems, respectively. The water and sediment transport regime and river-lake connection in the middle and lower reaches of the Yangtze River are significantly affected by the upstream reservoirs, leading to the degradation of typical aquatic animal habitats. This study established a data-set of hydrodynamics and aquatic animals in the mainstream of Yangtze River, Taihu Lake and Poyang Lake, analyzed the characteristics of aquatic ecological evolution, and constructed habitat models of typical aquatic animals under the changing water and sediment conditions. The reliability of the models was verified through applications in Taihu Lake and Poyang Lake, and the impact of hydrodynamic changes and hydraulic project operation on aquatic animal habitats was analyzed.Water and sediment variation are the main physical factors leading to the aquatic animal habitat succession in the middle and lower reaches of the Yangtze River. The sediment discharge is reduced, and the river channel is scoured. The abundance of benthic invertebrates are reduced, which is negatively related to the riverbed stability. Changes in runoff during the year, and

	the drop in sediment content and water level, lead to an increase in water and sediment outflow from Poyang Lake. Thus, the problem of drying water bodies becomes more prevalent, and the habitat suitability of aquatic animals decreases. The barrier effect of the dam has led to the fragmentation of habitats, and the number and diversity of benthic invertebrates and fishes, the proportion of the four major Chinese carps, and the number of Yangtze finless porpoises are decreasing.A growth dynamics model of benthic invertebrates was constructed, the processes of feeding, respiration and excretion, and prey were defined, and the environmental preference functions of benthic invertebrates for bed surface morphology and water temperature were quantified. A habitat suitability model of the Yangtze finless porpoise was constructed, and the Boltzmann equation and piecewise function were used to quantify the preference of the finless porpoise for flow velocity and water depth, and the food availability function was defined to quantify the limitation of fish resources. By simulating the temporal and spatial distribution of Corbicula fluminea in Taihu Lake and the spatial distribution pattern of the finless porpoise in Poyang Lake, the parameter calibration and the reliability verification of the typical aquatic animal habitat models were completed.In the model calculation and analysis, it is found that: (1) the bed surface morphology driven by the wind field and water temperature in Taihu Lake dominate the spatial distribution difference and biomass growth cycle of Corbicula fluminea, respectively. Environmental factors have a cumulative effect on benthic invertebrates, and the benthic biomass exhibits a lag in response to environmental changes. (2) Currently, the important reasons for the decrease in finless porpoises in Poyang Lake's waterways and main lake areas are the shrinkage of the water surface and the decline in fish resources, respectively. It is predicted that, the changes of finless porpoise abundance in the main lake area will tend to be flat in the future. However, the number of finless porpoises entering the main lake area through the channel has decreased and hence, the fragmentation of habitats is increasing. (3) The impact of the proposed hydraulic project in Poyang Lake on aquatic animal habitat is two-fold, increasing the water depth and surface area, which is conducive to the restoration of habitat suitability. However, the dam leads to physical isolation, reducing hydraulic connectivity, and is thus harmful to the movement of migratory animals.
答辩日期	2020.12.09