Fish habitat assessment using 2D hydrodynamic model and long-term hydrologic monitoring data: a case study of an upstream reach of the Kumagawa river

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BACKGROUND:

- Extreme climate events increasingly affect water resource availability.
- Significant impacts on agricultural productivity and aquatic ecosystems.
- Healthy aquatic habitats are essential for biodiversity and resilience of freshwater species.
- Understanding hydraulic conditions and aquatic habitats is crucial for effective ecosystem management.

SIGNIFICANCE:

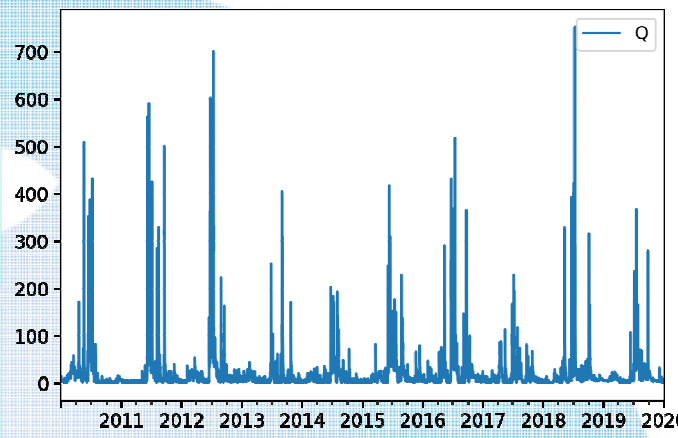
- Rivers serve as vital corridors for freshwater biodiversity.
- Agricultural channels are essential for productive agriculture.
- Quantitative assessments are needed to evaluate habitat suitability for aquatic organisms.
- Advanced modeling techniques and comprehensive hydrologic data are key to effective management.

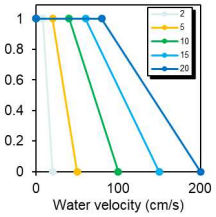
STUDY OBJECTIVES:

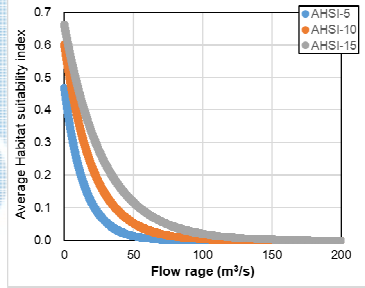
- **Assess Flow-Habitat Relationships:** Evaluate the relationship between flow rate and average habitat suitability index (AHSI) using a 2D hydrodynamic model for an upstream reach of the Kumagawa River.
- **Evaluate Temporal Dynamics:** Analyze the temporal dynamics of fish habitats using long-term hydrological monitoring data from 1993 to 2023.

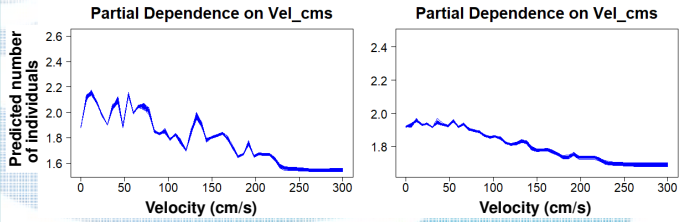
RESULTS:

- **Flow-Habitat Relationships:** High flows (>200 m³/s) were identified as unsuitable for the target fish species. HSI was computed for various flow rates, demonstrating a clear relationship between flow discharge and habitat suitability of a species. Separate habitat suitability models were developed for different life stages (larvae, juvenile, adult), using the national river environmental database.
- **Temporal Dynamics of Fish Habitats:** Using hydrological monitoring data from 1993 to 2023, we observed temporal variations in habitat suitability. Certain periods showed significant habitat degradation due to extreme flow events.









Habitat suitability looks different even though the same dataset was used for data-driven habitat assessment using Random Forests (a machine learning algorithm)

CONCLUSIONS:

2D Hydrodynamic Model: Built an unsteady 2D hydrodynamic model in the Kumagawa River for ecohydraulic simulations to assess fish habitats.
Flow-Habitat Relationships: Due to the high computational cost of long-term 2D hydrodynamic simulations, we employed flow-habitat relationships for a range of observed flow discharges.
Habitat Suitability Models: are critical in simulations as they represent species' responses to different flow rates. We utilized the national census data from the river environmental database to build habitat suitability models for various life stages (larvae, juvenile, and adult fish).
Data Quality Challenges: Despite the large dataset, data quality issues posed challenges in building accurate habitat suitability models.
Future Research Directions: Should focus on filtering data effectively to responsibly assess species-habitat relationships from large datasets.

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