The influence of geomorphological complexity on hydromorphological condition within recently deglaciated streams

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Introduction

Our knowledge of how geomorphological complexity develops, and its effects on the hydromorphological condition of rivers is not well understood[1].

Rapid glacial recession in Glacier Bay National Park, Alaska, combined with accurate historical and geological information, provides a unique opportunity to study the geomorphological development of streams and associated physical and ecological responses over time. Stream age is related to the distance from the retreating glacier termini [2], and thus temporal changes in stream complexity can be studied on the basis of spatial differences. Five streams were chosen for study ranging in age from 57- 200 years (Figure 1).

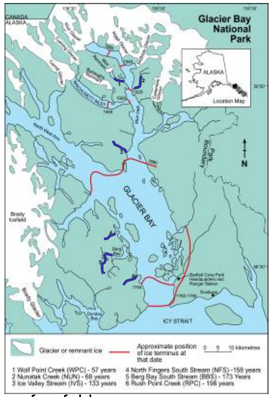


Figure 1: Map of Glacier Bay National Park, highlighting the position and age of the study streams

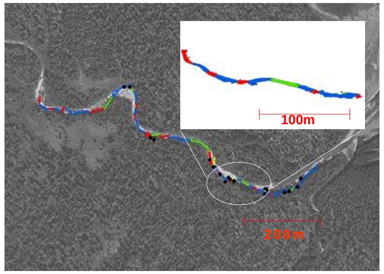


Figure 2: An example of habitat mapping at the meso and representative reach levels at Rush Point Creek

The goals of this project were fourfold;

1. Determine if geomorphological complexity develops over time by mapping differences in the geomorphic composition of streams of different ages
2. Assess differences in the hydraulic and habitat diversity within geomorphic units over the stream chronosequence to determine how channel geomorphology may change over time
3. Identify the influence of coarse woody debris (CWD) in creating geomorphic and hydraulic diversity
4. Assess the response of fish to changes in geomorphic complexity

1 Mapping of geomorphological features

Channel geomorphic units (CGUs, e.g.- riffle, run pool etc) were identified and quantified at the 'meso' scale within the five study streams (Figure 2). Smaller, representative reaches were then assessed in greater detail in order to quantify hydraulic and habitat diversity across the stream chronosequence.

Results

- Geomorphic diversity increased as stream age increased (number of CGU types increased)
- Older streams contained a greater number of slower flowing CGUs (e.g.- glides and pools; Figure 3)
- The number of CGUs per 100m of mapped area were also found to increase with increasing stream age.

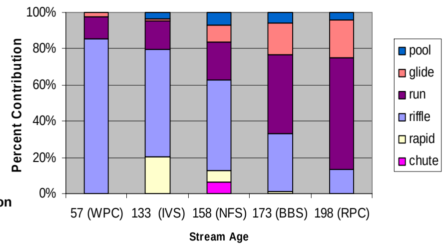


Figure 3: CGU composition within the study streams

References

1. Yarnell, S.M., Mount, J.F. and Larsen, E.W., 2006. The influence of relative sediment supply on riverine habitat heterogeneity. *Geomorphology*, **80**: 310- 324.
2. Milner, A.M., 1988. Community development in a glacial stream. In: A.M. Milner and J.D. Wood (Editors), *Second Glacier Bay Science Symposium*, Glacier Bay, Alaska, pp. 116-119.
3. Le Coarer, Y., 2005. "HydroSignature" software for hydraulic quantification, Cost 626- European Aquatic Modelling Network, Silkeborg, Denmark.

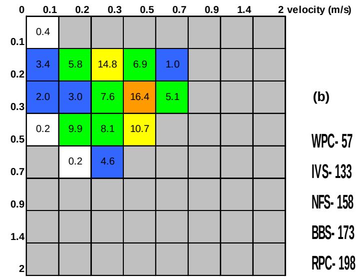
2 Assessment of hydraulic diversity within CGUs

Thirty random depth and flow measurements were obtained from each CGU within the representative reaches of each stream. These data were then assessed using HydroSignature [3] software to provide a hydraulic signature of each unit (e.g.- Figure 4a). Intra and inter CGU and stream hydraulic diversity were assessed across the stream chronosequence, using HydroSignature's inbuilt 'Hydrosignature Comparison Index'; (HSC).

Results

- Comparison of CGU and hydraulic signatures between streams reveals an increased dissimilarity as age difference increased
- The two oldest streams were the most similar in hydraulic composition (Figure 4b)
- Hydraulic similarity within fast flowing CGUs was low, whilst slower flowing CGUs were hydraulically diverse from one another (Figure 4c)

(a)



(b)

	WPC- 57	IVS- 133	NFS- 158	BBS- 173	RPC- 198
WPC- 57	0				
IVS- 133	26	0			
NFS- 158	32	37	0		
BBS- 173	56	48	60	0	
RPC- 198	71	65	78	25	0

(c)

	Mean HSC value
Rapid	14
Riffle	34
Run	46
Glide	69
Pool	56

Figure 4: (a) An example of a Hydrosignature output (b) Hydrosignature Comparison Values (HSC) of 'run' CGUs across the stream chronosequence. Results show that runs within the youngest streams, and signatures become more heterogeneous as stream difference increases (c) Mean HSC values within CGU types

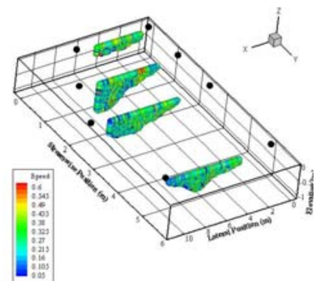
3 Influence of coarse woody debris (CWD) in creating geomorphic and hydraulic diversity

Size, position and dam properties of CWD within the study streams were mapped in order to monitor movement and formation of debris dams and associated geomorphic and ecological responses. Hydraulic diversity upstream, at and downstream of CWD was assessed using an Acoustic Doppler Current Profiler (ADCP) to produce flow profiles at each of these stations (Figure 5).

Results

- CWD characteristics alter over the stream chronosequence; becoming larger, and covering a larger percentage of the channel as stream age increases
- CWD within older streams creates hydraulic and geomorphic diversity at the microscale, which is absent from younger streams
- CWD creates slow flowing habitat which is favourable for juvenile salmonids
- The changes in CWD characteristics which occur over time may result in hydromorphological changes which were observed at the macroscale

Figure 5: An example of an ADCP transect plot within Rush Point Creek



Conclusions and Further Research

By mapping differences in geomorphic composition in streams of differing ages, we have been able to assess changes in geomorphological complexity which occur as streams develop. Our research indicates that geomorphological complexity plays an important role in determining the amount and quality of instream habitat available to biota, linking changes in hydromorphology to habitat utilisation by salmonids. These data have allowed identification of features, such as CWD, channel stability and sediment loading, which influence the extent of hydromorphological change which occurs over time. Output from this work may help to form a basis for understanding and classifying geomorphic complexity, a vital component in assessing reference hydromorphological conditions.