Abstract

Throughout the world, historically large populations of native anadromous salmonids are in severe decline or extinct. In the United States alone, twenty-six Evolutionarily Significant Units of Pacific salmonid are currently threatened or endangered. These declines are most commonly attributed to degradation of spawning and rearing habitat resulting from increased loading of fine sediments. Although excessive loading of fine sediments into rivers is well known to degrade salmonid spawning habitat, its effects on the demographically critical rearing juveniles have been unclear. We experimentally manipulated fine bed sediment in a northern California river and examined responses of a juvenile salmonid. Increasing concentrations of deposited fine sediment decreased growth and survival of juvenile steelhead trout. These declines resulted from a shift in invertebrates toward burrowing taxa unavailable as prey and from increased steelhead activity and injury at higher levels of fine sediment. The relationship between deposited fine sediment and juvenile steelhead growth is linear. This suggests that there is no threshold below which exacerbation of fine sediment delivery and storage in gravel bedded rivers will be harmless, but also that any reduction will produce immediate benefits for salmonid restoration.

Figure Legends

Figure 1. Results of a direct manipulation of substratum embeddedness on the growth of juvenile steelhead trout ($R^2 = 0.63$, $P < 0.0001$). Changes in growth in mass were similar ($R^2 = 0.59$, $P < 0.0001$). Analyses of relative growth, which accounts for differences in initial size, and of instantaneous growth rate produced similar linear patterns ($R^2 = 0.52$, $P = 0.0001$ and $R^2 = 0.53$, $P < 0.001$, respectively). One experimental channel with 40 percent substratum embeddedness contained no fish that survived the minimum 25 days and is thus excluded from the analysis.

Figure 2. Biomass of invertebrates from sediment core samples taken at experiment's end (August 8, 2000). There were significant linear relationships between fine sediment and the biomass of individual functional groups of invertebrates. As fine sediment increased, biomass of vulnerable prey declined ($R^2 = 0.42$, $P < 0.001$) and biomass of unavailable burrowing organisms increased ($R^2 = 0.23$, $P = 0.02$). A similar pattern was found in the pre-stocking samples taken June 30th; there was a significant and negative relationship between fine sediment and vulnerable prey biomass ($R^2 = 0.35$, $P = 0.003$) and a significant and positive relationship between fine sediment and burrowing organism biomass ($R^2 = 0.37$, $P = 0.002$). Fine sediment had no influence on the biomass of armoured grazers. Similar taxon-specific responses to fine sediment have been observed in other studies (14, 15).

Figure 3. Behavior of steelhead parr in experimental channels. Data represent mean values for each experimental channel. (*a*) Fish activity. Presented is the best-fit line from 2nd order polynomial regression ($R^2 = 0.45$, $P = 0.004$). (*b*) Intraspecific aggression. Presented is the best-fit line from 2nd order polynomial regression ($R^2 = 0.56$, $P = 0.0002$).

Figure 1.

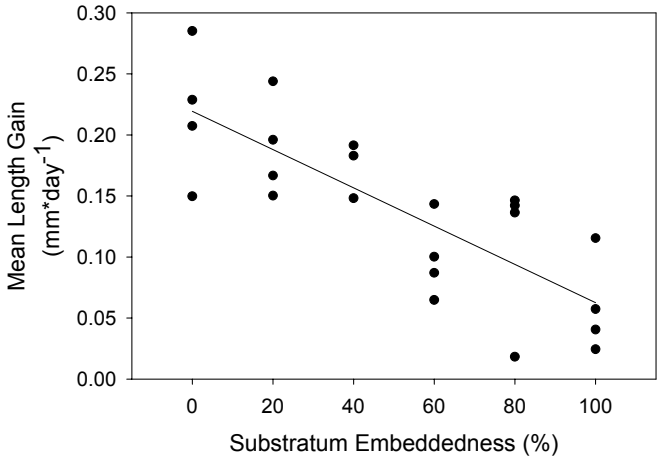

0.30
0.25
0.20
0.15
0.10
0.05
0.00
Mean Length Gain
(mm*day-1)
0
20
40
60
80
100
Substratum Embeddedness (%)

Figure 2.

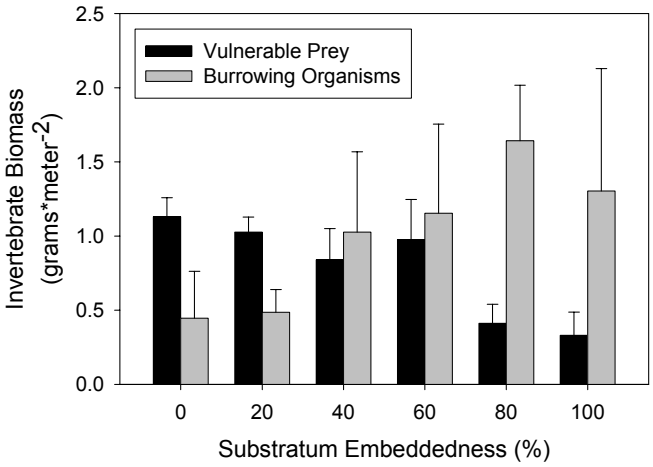
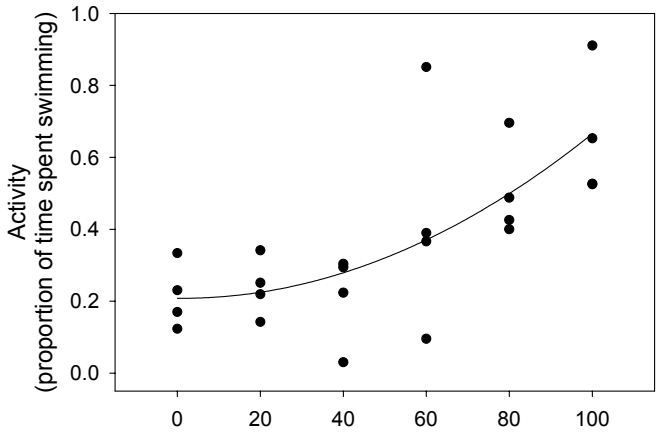
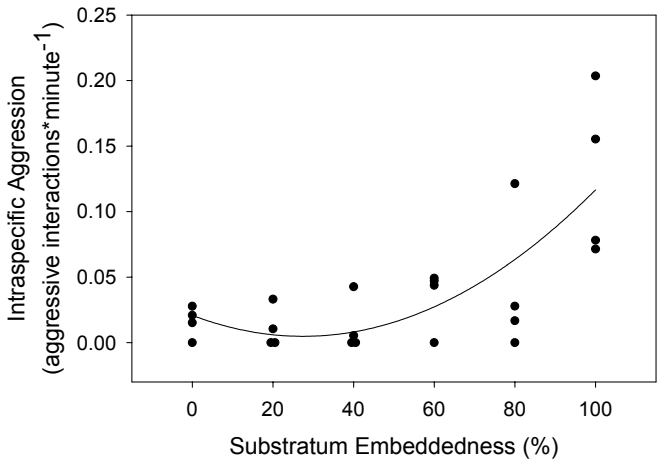

Vulnerable Prey
Burrowing Organisms
Invertebrate Biomass
(grams*meter-2)
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Substratum Embeddedness (%)

Figure 3.

a


Activity
(proportion of time spent swimming)
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100

b


Intraspecific Aggression
(aggressive interactions*minute-1)
0.25
0.20
0.15
0.10
0.05
0.00
0
20
40
60
80
100
Substratum Embeddedness (%)