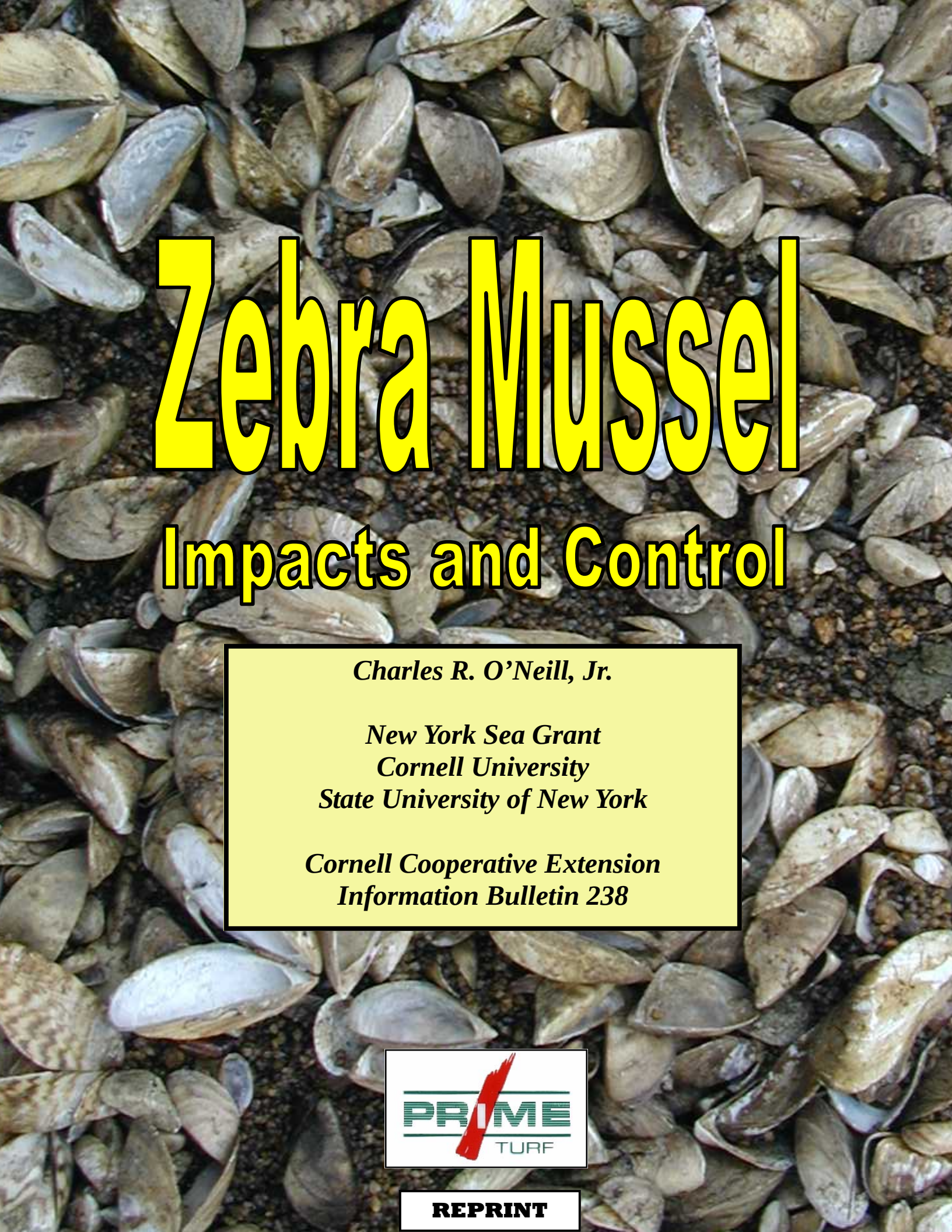

Zebra Mussel

Impacts and Control

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Information Bulletin 238

PRIME TURF

REPRINT

Environmental Tolerances as Indicators of Mussel Infestation Potential

The degree to which a body of water- and thus a facility using it as a source of raw water- is at risk of becoming infested with Zebra Mussels can be approximated by comparing the organisms' known environmental tolerances to the limnological parameters of that body of water. Because zebra mussels can tolerate a wide range of environmental conditions, mussel colonization is usually constrained rather than precluded except at the extremes of most environmental variables.. A matrix of important variables and their relation to colonization is presented in Table 1.

Table 1. The degree to which a water body is at risk of zebra mussel colonization depends on the interaction of many environmental variables. Although no predictive model yet exists that takes into account all such variables, consideration of the variables shown here can provide an infrastructure operator with a "snapshot" of zebra mussel colonization potential based upon the limnological parameters thought to be most important for zebra mussel survival.

COLONIZATION POTENTIAL

Variable	High	Moderate	Low	Very Low
Salinity (ppt)	0-1	1-4	4-10	10-35
Calcium (mg/l)	25->125	20-25	9-20	<9
Total Hardness ($mgCaCO_3/l$)	90->125	45-90	25-45	<25
pH	**7.5-8.7**	**7.2-7.5 8.7-9.0**	**6.5-7.2 9.0**	**<6.5 >9.0**
Water Temperature (°C)	18-25	16-18 25-28	9-15 28-30	<8 >30
Turbidity (cm Secchi)	40-200	20-40	10-20 200-250	<10 >250
Dissolved Oxygen (ppm)	8-10	6-8	4-6	<4
Water Velocity (m/sec.)	0.1-1.0	0.09-0.1 1.0-1.25	0.075-0.09 1.25-1.5	>0.075 >1.5
Conductivity (µ Siemens)	83->110	37-82	22-36	<22

Salinity

Although they are generally considered a freshwater species, zebra mussels can inhabit brackish areas ranging from 0.2 to as high as 12.0 parts per thousand (ppt) total salinity (MacNeill 1990). Probability of colonization is high in the 0 to 1 ppt range and moderate in waters of 1 to 4 ppt. In water with higher salinity, so much of the organisms' energy is devoted to osmoregulation of their internal salinity that, although juveniles may grow into adulthood, spawning becomes increasingly unlikely. In estuarine areas where the mussels may be seasonally inundated by washes of freshwater from upstream, some spawning might be possible.

Total salinity might not be the most important indicator of mussel survival. Rather, the balance between specific ions, particularly sodium and potassium, may be most critical. For example, zebra mussels are killed in freshwater containing greater than 0.5 mM (millimolar) potassium but survive in 0.5 mM potassium if the water contains 45 to 60 nM of sodium chloride (Dietz et al. 1994).

Calcium

Because zebra mussels need a good deal of calcium to form their shells, water containing more calcium, generally 25 parts per million (ppm) or greater, is most suitable for high colonization densities. Moderate to low potential exists as low as approximately 10 ppm and potential for growth and spawning is very low below 9ppm (O'Neill 1995).

pH

Zebra mussels thrive in water that is neither too acidic nor too alkaline, generally at pH levels between 7.5 and 8.7 for moderate to high colonization potential. Very low potential exists above 9.0 and below 7.2. The threshold for survival of adults is 6.5 (McCauley and Kott 1993) and for larvae, 6.9 (Mackie and Kigour 1993).

Water Depth

The highest densities of *D. polymorpha* generally occur with in 2 to 7 meters of the water surface, but low to moderate densities of this mussel can be found as deep ass about 50 meters. *D.bugenis*, on the other hand, appears able to to tolerate greater depths: it was found at depths exceeding 225 feet in Lake Ontario. Depth alone, then, should not be considered a limiting factor. Where sympatric populations of *D. polymorpha* and *D. bugenis* occur, the ratio of *D.polymorpha* to *D.bugenis* has been observed to decrease with increasing water depth. Colonization depths vary from lake to lake and appear to be determined by water temperature, oxygen content and availability of food.

Water Temperature

Although the European literature indicates that mussels prefer water temperatures between 17° and 25°C, dense colonization in the lower Mississippi River is occurring at water temperatures that reach and remain at 30 C for prolonged periods during the summer (Dietz and Silverman 1995). Lethal temperatures are reached at about 31° to 32° C (McMahon et al, 1994a).
Zebra mussels can live at water temperatures approaching freezing, but spawning stops below 10°C and growth slows as temperatures continue to decline, reducing density potentials. The mussels will die when the water temperature falls to levels that would cause ice to form within their bodies (McMahon et al. 1993).

Oxygen

For moderate to high colonization potentials, zebra mussels require relatively high oxygen concentrations. Little if any colonization will occur at dissolved oxygen concentrations less than 40 to 50 percent full air saturation (PO_2 = 64-80torr) (McMahon 1995).
When determining the colonization potential for deepwater bodies, both water temperature and dissolved oxygen content must be considered. Lakes that thermally stratify during portions of the year may be too cold below the thermocline for spawning to take place or for rapid growth of mussels settling below the thermocline.