WILLIAM & MARY
VIMS

Virginia Institute of Marine Science
School of Marine Science

June 25, 2004

Mr. William A. Pruitt
Commissioner, Virginia Marine Resources Commission
2600 Washington Avenue
Newport News, VA 23607

Dear Commissioner Pruitt:

We have completed our comprehensive assessment of the *King William Reservoir-Mattaponi River Fisheries Impact Assessment and Mitigation Report (*the Versar report, dated April 1, 2004), and summarize our findings below. This letter is the fourth in a series of advisory communiqués addressing the continuing King William reservoir issue. Our letter dated March 12, 2003 provided general comments on the overall potential adverse environmental impacts associated with the construction and operation of the intake, including policy recommendations. At the Commission's request, we also provided guidance in a May 8, 2003 letter on compensatory mitigation strategies that were raised during the initial public hearing. Our latest review is a continuance of the assessment of the potential success of one compensatory mitigation alternative– the application of a seasonal water withdrawal hiatus during critical periods of anadromous fish spawning and development. In a letter of May 20, 2004 to Mr. Randy Hildebrandt of the City of Newport News and Mr. Jack Travelstead of the VMRC Fisheries Management Division we provided data for the benefit of the applicant and VMRC demonstrating the seasonality of vulnerable life stages of American shad specific to the York River watershed. We will reiterate our comments of May 20th in this letter and also provide critiques of other information provided in the Versar report. It is important to note that the information included in the communiqués of March 12, 2003 and May 8, 2003 remains relevant and should be a continued source of reference during the decision-making process.

The concept of a withdrawal hiatus to mitigate the mortality of fish eggs and larvae has merit and has been applied to situations with similar social needs and natural resource concerns. The success of this mitigation strategy depends on the application of a model that must account for inter-annual and intra-annual variations in weather and life histories of the species of concern. The Versar report proposes to address these variations through a detailed long-term study of the Mattaponi River. The proposed study would be designed to quantify the numbers and distribution of American shad eggs and larvae, which then would be used to develop temperature-based signals that define a pumping moratorium protective of approximately 97% of vulnerable life stages. The utility of the model is evaluated in the Versar report using data from

PO Box 1346 • Route 1208 Greate Road • Gloucester Point, Virginia 23062-1346 USA
804/684-7000 • FAX 804/684-7097

the Hudson River. The Versar report suggests that protection of American shad eggs and larvae will also protect other important species' eggs and larvae.

The Versar report also addresses concerns that we previously raised on intake screen protection efficiency and pump-generated noise. Each part of the report is separately addressed below.

Proposed Study Design

The concept of ceasing pumping when susceptible fish eggs and larvae are present near the reservoir intake has intuitive appeal. The Versar report suggests exactly this type of strategy to mitigate potential impacts, and suggests that the period during which pumping should be stopped might be adequately defined by river water temperatures. The reasoning behind this approach is based on information from the Hudson River in New York. It was necessary for the Versar panel to rely on Hudson River data because currently there is an inadequate understanding of the seasonality and distribution of anadromous fish eggs and larvae in the Mattaponi River. The Versar report proposes a detailed monitoring program to address this problem. The proposed Mattaponi River monitoring program is separated into an initial two-year pilot study and at least a six-year extended study. The pilot study is designed to cover approximately 60 river kilometers over a 10-week period beginning when water temperature reaches 8^{o} C. A bi-weekly to weekly sampling schedule using gear amenable to the physical limitations of river geomorphology is planned. The extended study would incorporate modifications developed during the pilot study and rely on weekly samples with start and end dates based on temperature cues derived from the pilot study. Continuous temperature monitoring would be undertaken throughout the study.

The basic study design is sound. However, should the Commission grant permission to construct the intake and decide to incorporate this study into the permit conditions, we recommend that the applicant and the Commission consider the following modifications:

- The area covered by the proposed monitoring program appears to include the majority of known spawning and nursery grounds in the Mattaponi River for American shad. The stratified random sampling design and in-river spatial coverage may allow for quantifiable comparisons among strata; however, in light of the unknown variability due to patchiness, replicate sampling within a subset of the strata is recommended during the pilot study years.

- The study proposes to include analysis of American shad life history stages from eggs through yolk-sac-larvae. American shad post-yolk-sac larvae are still early in development, although larger in size. In these stages, the caudal, dorsal, and anal fins are incompletely developed and maximum swimming performance has not been attained. Therefore, the post-yolk-sac stage prior to the development of the full adult compliment of fins is vulnerable to mortality from the influence of the intake array. We recommend expanding the study analysis to include post-yolk-sac larvae in the proposed protection strategy.

- Based on hatch dates reported for 1998 and 1999 in the Pamunkey River, the proposed sampling times are not sufficient to capture eggs and larvae in all years. For example, in 1998, sampling would be necessary beyond the period when water temperatures reach 24°C, possibly to 30°C. Only 60% of this year class was hatched in the 10-22°C temperature range. If the ultimate goal is to establish water temperature as a surrogate for the presence of American shad early life history stages, then the survey period should be extended to at least the end of June and optimally to mid-July to capture larvae through the post-yolk-sac stage.

- We foresee that extensive gear comparison sampling will be necessary to provide a confident level of understanding of American shad early life stage dynamics within the Mattaponi River. It may be necessary to utilize separate gear for the egg and larval stages due to ontogenetic shifts in distribution. The river morphology will restrict the use of bongo nets to the lower/mid portions of the Mattaponi, while push nets, stationary nets, plankton seines or additional methods may be more appropriate upriver. Gear efficiency comparisons will be required to retrieve quantifiable data from the surveys. If low flow years occur during the monitoring program, further restrictions will include boat access upriver of Aylett. These logistical issues will have to be addressed during the pilot survey, with the expectation that annual climate induced variability in flow may require contingency plans. Additionally, until the efficiencies of each sample technique are elucidated, the establishment of steadfast temperature triggers may be suspect. Intense quality control will be required at all stages of the monitoring program to ensure that the proposed risk threshold of 97% survival is met.

- The two-year pilot study is necessary to establish effective sampling protocols due to the variable physical attributes of the Mattaponi River. However, this may only allow an additional six years of consistent information from which to define optimum temperature triggers for an annual pumping hiatus. While six years of data will provide far more information than currently exists, extending the post-pilot survey to at least eight years will enhance the probability that variability in climate is observed.

- In the effort to define temperature cues the applicant states that the first occurrence of American shad eggs and the last occurrence of American shad yolk-sac larvae will be used to establish temperature triggers over the pre-operational survey period (p. D-8). This needs to be explicitly defined. For example, is the last occurrence of yolk sac larvae the equivalent of one larval fish throughout the sampled extent of the Mattaponi River? If post-yolk-sac larvae are included as we recommend, then the survey period should be extended accordingly.

Applicability of Hudson River Demonstration Exercise

Our letter of May 20, 2004 describes our general concerns surrounding extrapolation of Hudson River information to the Mattaponi River. Although this exercise successfully demonstrates the utility of the proposed monitoring program, it does not serve as a reliable estimate of the duration of a potential pumping hiatus for the Mattaponi River. The physical differences between the Mattaponi River and the Hudson River are significant, and we are not confident that the early life stage development rates and patterns of American shad and other anadromous species of concern are similar between these watersheds. Our May 20, 2004 letter

(Attachment 1) provides data explaining the basis of our concern and provides guidance on the probable temperature range necessary to achieve the 97% risk threshold.

An otolith (the earbone of a fish) microchemistry analysis was recently completed of young-of-the-year American shad from 2001 and 2002, and adults collected in the York River in 2002. We report these findings because they support the data presented in our March 20, 2003 letter showing the importance of the Mattaponi River to the York River watershed American shad stocks. Strontium isotopes and ratios of strontium to calcium suggest that most adult American shad in the 2002 sample likely were spawned in the Mattaponi River, with a smaller number coming from the Pamunkey River. This strongly suggests that the high juvenile production in the Mattaponi River is reflected in the relative abundance of returning adults.

Wedge Wire Screen Protection Efficiency

The Versar report includes modeling that provides estimates of the probability of an egg or larva contacting the intake screen. This modeling was limited to a one-screen unit, one pass flow scenario, which is not directly applicable under a semi-diurnal tidal environment. These data can, however, be combined with estimates of residence times under various flow regimes to develop a clearer understanding of the risk to vulnerable life stages from contact with the screen array.

The Versar report shows that the probability of interaction for a particle in the water column (e.g. an egg or larva) with one screen during one flow pass ranges from 0.2% for a particle 1.2 statute miles from the screen under a 14.1 mgd withdrawal rate and at peak tidal flow to 10.3% for a particle 0.23 statute miles from the screen under a 75 mgd withdrawal rate and at low tidal flow. The Versar report also includes other estimates within this distance/withdrawal/flow range. We have concerns regarding the general applicability of the assumptions underlying the cumulative probability estimates in the Versar report, especially the presumed linear decrease of the hydrologic zone of influence between the complete mixing length and the intake (Appendix E, page 34). Hence, we used the Versar report data to develop an independent estimate of cumulative probability that captures the effects of a water column particle under tidal hydrology. Our analysis built upon the model results from the Versar report, but did not rely on their specific assumptions.

Our March 12, 2003 letter presented the results of a tidal excursion model that defined the extent of the intake array's zone of tidal influence. This model showed that the water within an area 2.9 statute river miles (2.5 nautical miles) upstream and downstream of Scotland Landing would cross the intake array during each tide cycle. For the semi-diurnal tidal hydrology that is characteristic of the Chesapeake Bay, eggs and larvae within the zone of tidal influence generally would be in the vicinity of the screen array 4 times within a 24-hour period.

VIMS faculty recently modeled water residence times in the York River watershed (Shen and Haas, in press). This modeling exercise aged a water particle as it progressed from the fall line in the Pamunkey and Mattaponi rivers to the mouth of the York River under three flow simulations – low (3.5 cms), mean (14.4 cms), and high (38.5 cms). Using these data, the residence times within the zone of tidal influence and number of times a particle will pass the screen array under semi-diurnal tidal hydrology (screen passes) is estimated at:

- 31.3 days under a low flow condition– 125 screen passes
- 6.84 days under a mean flow condition– 27 screen passes
- 2.47 days under a high flow condition– 10 screen passes

These estimates were used with data from the Versar report to further estimate the cumulative probability of a screen encounter by an egg or larva. The documentation of our modeling is included as Attachment 2.

Our model estimates that the probability of interaction with the screen array for eggs and larvae within the tidal excursion zone ranges from 3% for a high flow condition pumping at a minimal rate of 14.1 mgd to 88% for a low flow condition pumping at the maximum rate of 75 mgd. Eggs and larvae under mean flow conditions are subject to interaction probabilities of 8% for a 14.1 mgd pumping rate, 18.7% for a 33.2 mgd pumping rate, and 36.7% for a 75 mgd pumping rate. Although there is not a clearly defined correlation between intake interaction and egg/larval mortality, it is reasonable to assume a cause and effect relationship. Interpretation of the probabilities as an indicator of potential relative mortality gives us reason for concern with respect to potential effects on anadromous fish stocks under a range of residence time/pumping conditions.

It is important to place the cumulative probability estimates solidly in the context of the pumping hiatus mitigation proposal and the Department of Environmental Quality's permit water withdrawal conditions. The cumulative estimates for high flow conditions are the most applicable to springtime spawners, which captures the primary species of concern. Species other than American shad, river herrings, striped bass, white perch, and yellow perch generally will have vulnerable life stages subjected to the cumulative probabilities for water withdrawal during the mean flow and low flow conditions.

Potential Effects of Pump-Generated Noise

Based on our initial concerns surrounding the potential effects that noise from the operation of the intake may have on fish migration behavior, the Versar report provides a comparison case study of a similar pumping station in Lake Gaston, North Carolina. Although we are not convinced that the Mattaponi River in the vicinity of Scotland Landing is similar in recreational use patterns, and natural and anthropogenic background noise to Lake Gaston, the report provides sufficient information to conclude that the frequency and duration of the noise expected from intake operation may have a minimal influence on the fish in the littoral environment.

Policy Guidance

The general knowledge base for large-scale water issues in Virginia has changed little since our initial review of this project. Thus, the basis for our primary recommendations forwarded in our March 12, 2003 letter remains- we continue to consider it vital that the Commonwealth develop a comprehensive water allocation strategy that incorporates environmental, social, and economic needs prior to consideration of any more projects like the King William reservoir.

Specific to the Newport News proposal for a King William reservoir, and in response to the Versar report, we offer the following findings and recommendations.

1. The fact that the chosen intake location poses some of the highest potential risk to juvenile anadromous fish populations in the area remains unchanged.

2. The proposed use of a water withdrawal hiatus to reduce risk to larval shad populations in the Mattaponi River has the potential to minimize impacts on that species, but effectively implemented may prevent the City from realizing a satisfactory safe yield of water.

3. The fact that the intake is in tidal water means the probabilities of early life stages of fishes being impacted by the intake are significantly higher than estimated by the Versar report. Flood and ebb tides will transport eggs and larvae past the intake multiple times under any river flow condition. The resulting multiple exposures will exist any time the intake operates, affecting whatever happens to be in the river at those times.

4. We believe there is insufficient information to support an appropriate risk assessment of the pumping hiatus proposal. It is our considered opinion that the uncertainties cannot be properly evaluated before more is known about conditions in the Mattaponi River. In order to reduce the risk of undesirable impact to either the fish resources or the City's safe water yield objective, we strongly recommend completion of a monitoring program prior to any final permit decision.

Sincerely,

Dr. Roger L. Mann
Director for Research and Advisory Services

References

Shen, J. and L. Haas. In press. Calculating age and residence time in the tidal York River using three-dimensional model experiments. Estuarine Coastal and Shelf Science.

May 20, 2004

Mr. Randy Hildebrandt, City Manager
CITY OF NEWPORT NEWS
2400 Washington Avenue
Newport News, VA 23607

Mr. Jack Travelstead
MARINE RESOURCES COMMISSION
2600 Washington Avenue
Newport News, VA 23607

Gentlemen:

This letter and the accompanying figures serve as a follow up to our recent telephone conversation concerning the revised Fish Impact Assessment and Mitigation Report as prepared by Versar (the Versar report) and dated April 1, 2004. The VIMS review team has met several times to discuss this report and wish to share with you the following observations.

Our analysis of the Versar report along with our own information evokes concern for this proposed mitigation strategy. The uncertainty associated with the use of a pumping hiatus to eliminate significant risk to important fish stocks should be considered by the City of Newport News and the VMRC with respect to the potential success of this approach in resolving competing goals of water harvest and resource protection. The available information for the Hudson River appears to support a temperature-based model from which to assess the presence of vulnerable American shad life stages, but limited data do not support extension of this model to the York River watershed. The uncertainty in the extension of the Hudson River model is of concern given that:

1. In comparison to the Mattaponi River, the Hudson River is deeper and the variation in its flow is influenced by dams. As a result, temperature fluctuations are smaller. This can be observed in the plot of water temperature against time for the Hudson River (Versar report Figure 5-1). By contrast, the Mattaponi River is a relatively shallow system that is not obstructed and its discharge rate responds dramatically to rainfall events. Spring freshets are frequent and initiate marked temperature changes over short periods of time. These patterns are reflected in the high interannual variability of water temperature on the Mattaponi River in relation to the Hudson River (Versar report Figure 5-1). Temporal patterns of survival of young stages of anadromous fishes such as striped bass and American shad are influenced by these temperature fluctuations.

2. For American shad, the Hudson River data considered in the proposal are limited to eggs and yolk-sac larval stages. Occurrence of post-yolk-sac larvae is reported for all species except American shad (Versar report Tables 2-2, 2-3, and 2-4). Although there are no published data on swimming speeds of larval American shad, the Versar report concludes that larval American shad have “strong swimming abilities.” We

note that the average size at which the full complement of fin rays is attained in this species is somewhere between 15-20 mm, suggesting that swimming speeds of larval American shad increase the most during this size range. Prior to this size (that is, at a size from hatching to ~ 15mm), swimming speeds are reduced. We advise that post-yolk-sac larvae be included in the analysis of Hudson River data given that swimming speed to escape impact of the intake structures is critical in minimizing adverse effects, and the post-yolk-sac larvae probably have limited escape swimming ability.

1. We anticipate that American shad larvae at a size range that could be impacted by the proposed withdrawal are present in the Mattaponi River in the vicinity of the proposed intake for more than 100 days from March through mid-June. Accompanying this letter are graphs of recent data on the presence of American shad larvae in the Mattaponi River by river mile and temperature (Figure 1). Also included are frequency distributions of juvenile American shad hatch dates, determined from estimates of daily age, for populations in the Pamunkey River for 1998 and 1999 (Figures 2 and 3). In 2003, larvae <15 mm were present in the zone of influence of the proposed intake through mid-June judging from the temporal distributions of larvae 15-20 mm (Figure 1). In 1998, approximately 40% of surviving juveniles were hatched at temperatures that fall outside of the proposed temperature window of 10-22^{o}C (all were hatched at temperatures above 22^{o}C). In 1999, all surviving juveniles were hatched within the 10-22^{o}C temperature window. These data suggest that a pumping hiatus that encompasses a temperature window of 10-30^{o} C would be required to protect more than 97% of the larvae – a window that represents nearly the entire annual temperature variation observed in the river.

Our analysis of this and other parts of the Versar report are ongoing. We are amenable to convene should the Fisheries Panel have questions.

Sincerely,

Dr. Roger L. Mann
Director for Research and Advisory Services

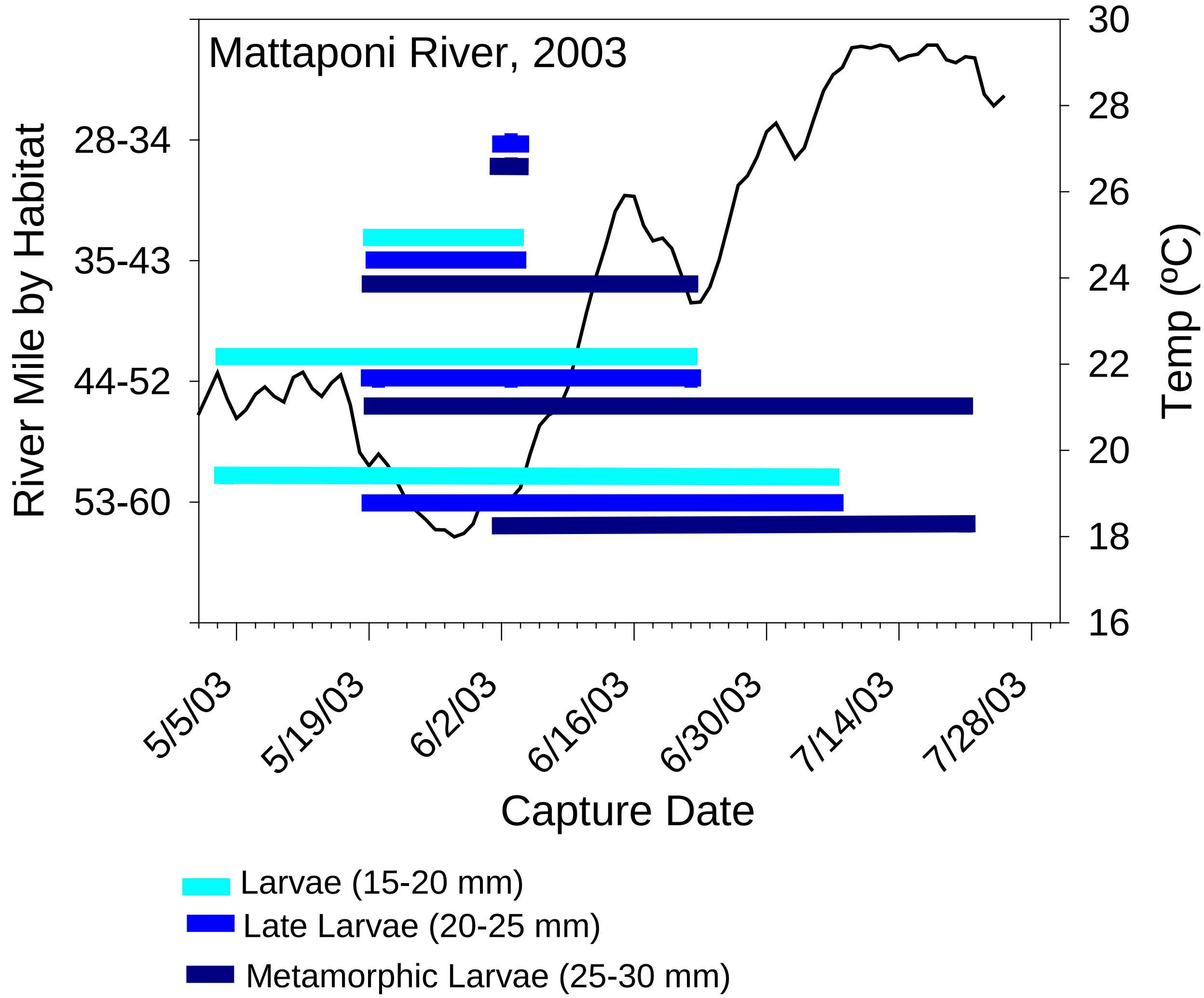


Figure 1. Presence of larval stages of American shad in the Mattaponi River during 2003. River temperature is calculated as a daily average and was measured at river mile 43. The smallest stage larvae were captured for about a month after the river reached 22º C.

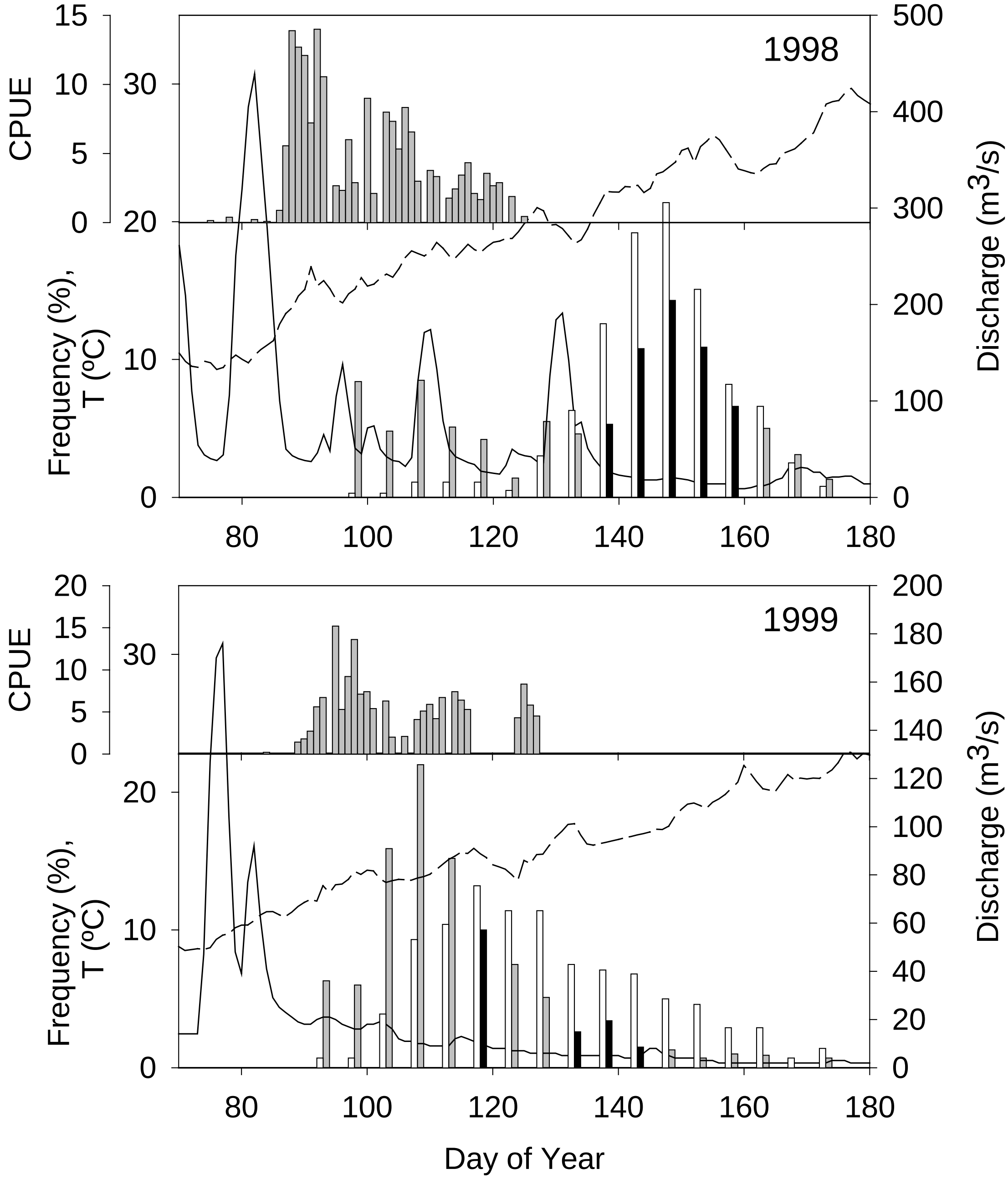


Figure 2. Hatch-date distribution of Pamunkey River juvenile American shad (30-100 mm) caught in 1998 and 1999 (white bars represent cohorts unadjusted for mortality, gray bars represent cohorts adjusted for average juvenile mortality, black bars represent cohorts adjusted for cohort-specific mortality), as well as catch-per-unit-effort of ripe female shad caught on the spawning grounds (CPUE, females per net per 4 hr set), river discharge (solid line) and estimated average daily river temperature (dashed line). Hatch dates spanned from 6 April to 24 June in 1998 and from 1 April to 24 June in 1999.

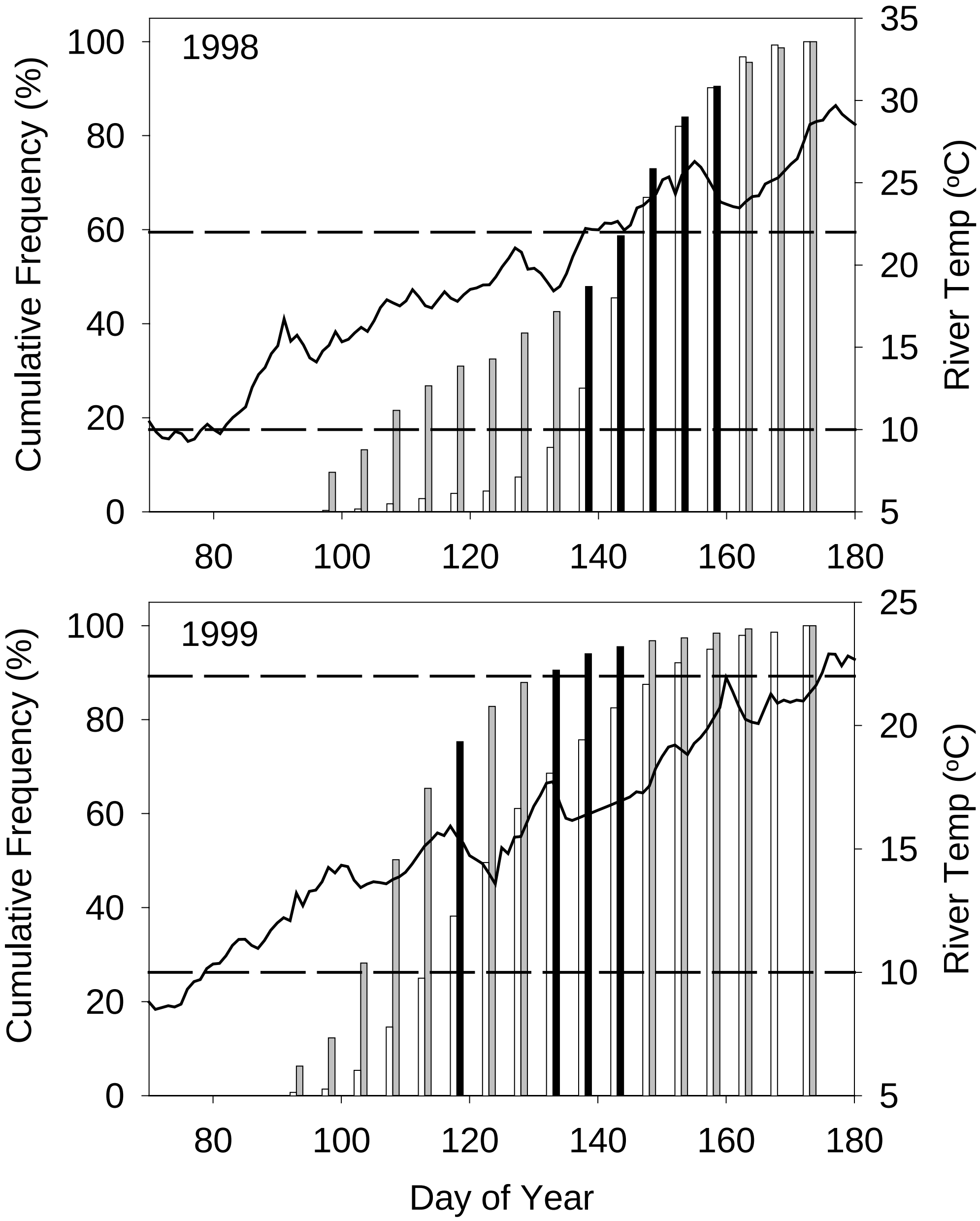
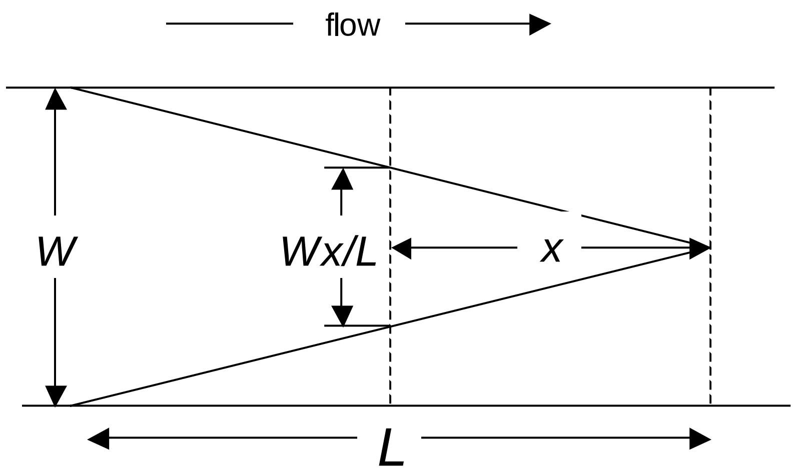


Figure 3. Cumulative hatch-date frequency of Pamunkey River juvenile American shad (30-100 mm) caught in 1998 and 1999 (white bars represent cohorts unadjusted for mortality, gray bars represent cohorts adjusted for average juvenile mortality, black bars represent cohorts adjusted for cohort-specific mortality), and estimated average daily river temperature (solid line). Dashed lines mark 22º C and 10º C. In 1998, only 60% of the year class hatched within the temperature range of 10-22 degrees; in 1999, 100% of the year class was hatched in this temperature range. Thus, in both years of this study on the Pamunkey River, a pumping hiatus of about 80 days (from late March until late June) would be required to protect the eggs/yolk sac larvae - and perhaps a week or two more (90-95 days) if older larvae are vulnerable.

Interpretation of §4.1.2: HZI Analysis of KWR Intake

A-product of §4.1.2 is a set of probabilities, $p(x,F,D)$, for a passive particle located within the hydrodynamic zone of influence (HZI) encountering the intake, where x is the distance up-flow[1] from the intake, F is the river flow rate, and D is the rate of withdrawal. The HZI was assumed to expand uniformly upstream until it encompasses the entire width of the river, as indicated in the diagram.

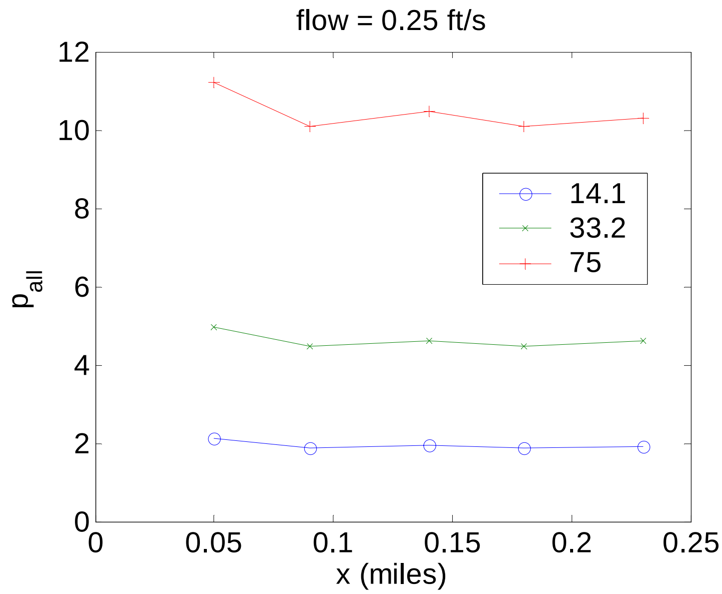


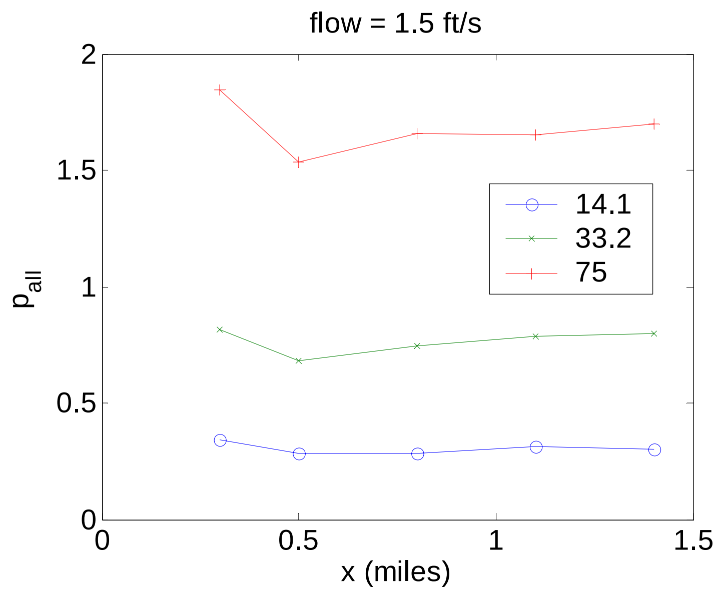
The probability, $p(x,F,D)$, is the fraction of particles *within the HZI* which are affected by the intake. It is assumed that the particles outside the zone pass the intake safely. For the present purpose, the quantity of interest is the fraction of *all* particles present in the cross-section at x, which are eventually affected by the intake. It will be assumed that the river has uniform depth, z, along its cross-section[2] and that there are n particles per unit area of the cross-section. Thus the total number of particles in a cross-section is nzW and the number within the HZI is $\frac{nzWx}{L}$. The number of particles eventually affected is thus $\frac{nzWx}{L}p$. Dividing this by the total number of particles gives $\frac{x}{L}p$, i.e., the fraction of all particles which are affected, or the probability of a particle located up-flow a distance, x, being affected, *irrespective of its lateral position in the river*. This quantity will be denoted by p_{all}.

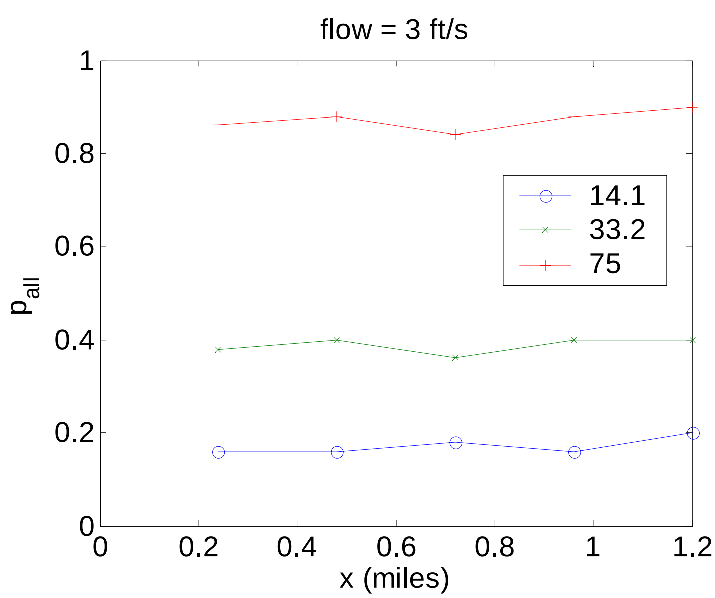
The values of p_{all} were computed for the p's in the report. The following figures show the results for all the combinations of flow and withdrawal (p_{all} is expressed in terms of percent).

[1] The flow reverses due to tidal effects, the term "up-flow" will be used as opposed to "upstream" which is considered to be in the direction of the source of the river.

[2] If the channel cross-section shelves towards the banks, the multiplying factor will be larger than x/L. Consequently p_{all} will be larger. The uniform depth assumption thus gives a conservative prediction.


flow = 0.25 ft/s
p_all
x (miles)
14.1
33.2
75
0
2
4
6
8
10
12
0.05
0.1
0.15
0.2
0.25


flow = 1.5 ft/s
p_all
x (miles)
14.1
33.2
75
0
0.5
1
1.5
2


flow = 3 ft/s
p_all
x (miles)
14.1
33.2
75
0
0.2
0.4
0.6
0.8
1
1.2

The plots demonstrate that p_{all} is essentially independent of x, the distance up-flow. The mean value of each set of points can be interpreted as $p_{all}(F,D)$, the probability of a particle being affected upon passing the cross-section of river containing the intake[3]. The values, expressed in percentages, are shown in the table I.

Table I, values of p_{all} (%)

Flow (F) kts	Widthdrawal (D) Mgal/d: 75	33.2	14.1
0.25	10.4	4.6	1.9
1.5	1.7	0.8	0.3
3.0	0.9	0.4	0.2

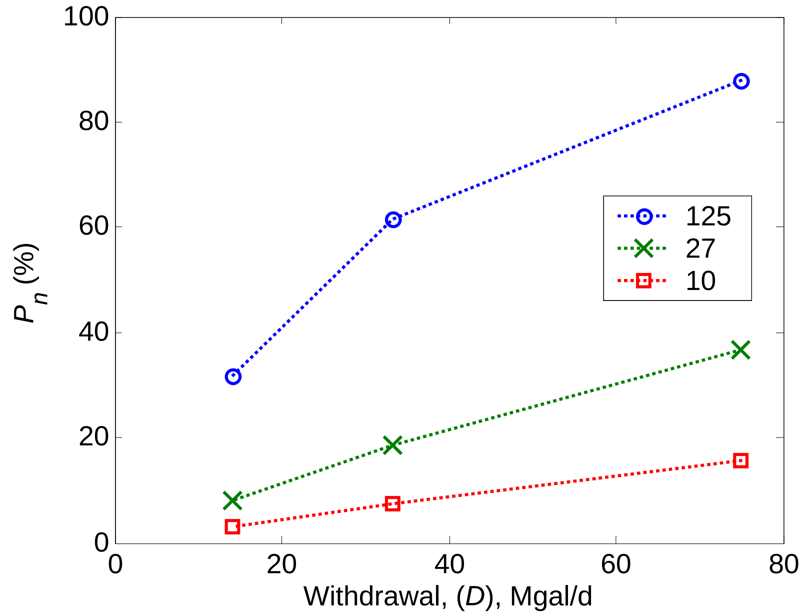
Multiple passes due to tidal cycles

Due to tidal effects, a body of water passes the intake n times before the general downstream drift takes it away towards the York River (n depends upon the freshwater input rate). During one tidal cycle, approximately 5 nautical miles of water will pass the intake. We require to calculate the probability of a particle being affected *sometime during the n passes*.

The probability of a particle *not being affected* during a pass is $(1 - p_{all})$. The probability of not being affected in all n passes is $(1 - p_{all})^n$ if it is assumed that the value of p_{all} is constant for each pass. As an approximation, the value of p_{all} for the average value of F (= 1.5 fps) will used. Thus the probability of being affected sometime during the n passes is $P_n = 1 - (1 - p_{all})^n$. It has been determined that the values of n for low, medium and high flow are 125, 27 and 10 respectively. P_n is tabulated and plotted as follows:

Table II, values of P_n (%)

n	Withdrawal (D) Mgal/d: 75	33.2	14.1
125 (low)	87.9	61.7	31.8
27 (med)	36.7	18.7	7.9
10 (high)	15.6	7.4	3.0



[3] Note that these values are almost identical to the p values for the widest extent of the HZI.