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FISH AND WILDLIFE SERVICE

Dworshak Fisheries Assistance Office

Ahsahka, Idaho

Project Leader

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A "DELPHI" SURVEY INTO THE METHODS AND PRACTICES OF SPRING CHINOOK SALMON CULTURE

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CONTENTS

ACKNOWLEDGEMENTS

John Varley, former office project leader, originally saw the potential of applying the "Delphi" technique to the issue of spring chinook salmon culture. He must be given credit for the creative spark that launched Delphi and for convincing me that the mountain of paper we were about to generate would be worth the effort. Several individuals assisted in the collation, tabulation and presentation of the questionnaires and their results over the rounds. I want to thank Sandra Rubrecht, Mark Gamblin, Susan Espinosa, Cindy McMurray, Sharon Russell and Mary Lou Galloway for their efforts. Thanks are also due for the Idaho Department of Fish and Game Regional Office in Lewiston, Idaho for use of their micro-computer graphics program without which I would still be drawing histograms for this report. Finally I wish to sincerely thank all of the expert participants who stuck with us and dedicatedly responded to the avalanche of questionnaires, results and justifications over three rounds. It is their insight, knowledge and experience that made this whole effort possible.

DWORSHAK FISHERIES ASSISTANCE OFFICE
SPRING CHINOOK SALMON
DELPHI EXPERIMENT

The decline in the numbers of spring chinook salmon (SCS) returning to the Columbia River drainage is well-known. Many, if not most, of the major causes incident to the decline have been identified and relate to the direct result of land, water, and energy development in the basin. Attempts to compensate for losses have primarily centered around construction and operation of public hatcheries. However, as a solution to the problem, they have had mixed results. On one hand, hatcheries are widely accepted as being responsible for the maintenance of spawning runs surviving at the present time. Yet, on the other hand, hatcheries have failed to restore runs to historic sizes despite the millions of smolts they release.

While substantial efforts have been directed toward the more obvious negative factors affecting smolts (such as the chronic downstream mortalities at main stem dams), lesser attention has been paid to those factors directly controllable by hatchery management. It appears that the juvenile mortality enigma has been compounded to degrees by wide variations in those factors affecting the smolts' performance capacity.

Examples of cultural factors affecting overall smolt quality include: diets and nutrition, feeding regimes, fish health, stage of parr-smolt transformation at release, age and size of smolts, stocking procedures, adult strain, brood and the timing of egg take, and many other variables. Thus, it could be said that a smolt's performance capacity is governed by the sum of many factors, and any comprehensive appraisal leading to a solution would require a multidisciplinary approach.

Given the very low ratio of adults returning per smolt released, any substantial progress in smolt management could result in higher adult returns. The obvious

benefit is that more adults could be realized from the same number of smolts being currently produced.

There exists two sets of data relating to the components of SCS culture influencing performance capacity. One set exists in the varied reports of normal production programs, hatchery contribution studies, production trials and experiments, etc. A definitive basinwide summary of this information has not been made and will take a dedicated, large scale effort to assimilate into a quickly referential form such as a computer data base. The second set exists in the form of professional experience and knowledge of present and past SCS fish culturalists. We sought to tap this source of information in our efforts to begin defining optimum spring chinook salmon cultural practices.

It quickly became apparent that a structured polling process was needed to organize and analyze a questionnaire dealing with several facets of SCS culture. Such a systematic method was found in the Delphi technique; a decision-making tool which, in the absence of sufficient empirically-defined data, attempts to define the best possible answer through development of a consensus of expert opinion. The Delphi concept is based on the reasonable premises that: (1) the opinions of experts are justified as inputs to decision-making in inexact areas, such as is the case in animal husbandry; and (2) a consensus of experts will provide a more accurate response to the rearing questions than a single expert.

The primary characteristics of a Delphi Questionnaire are anonymity of the experts, controlled feedback, and an estimator of group opinion. A Delphi survey is an iterative process involving answering of a questionnaire, receiving back a summary of group results and responses (feedback), and answering the questionnaire once again.

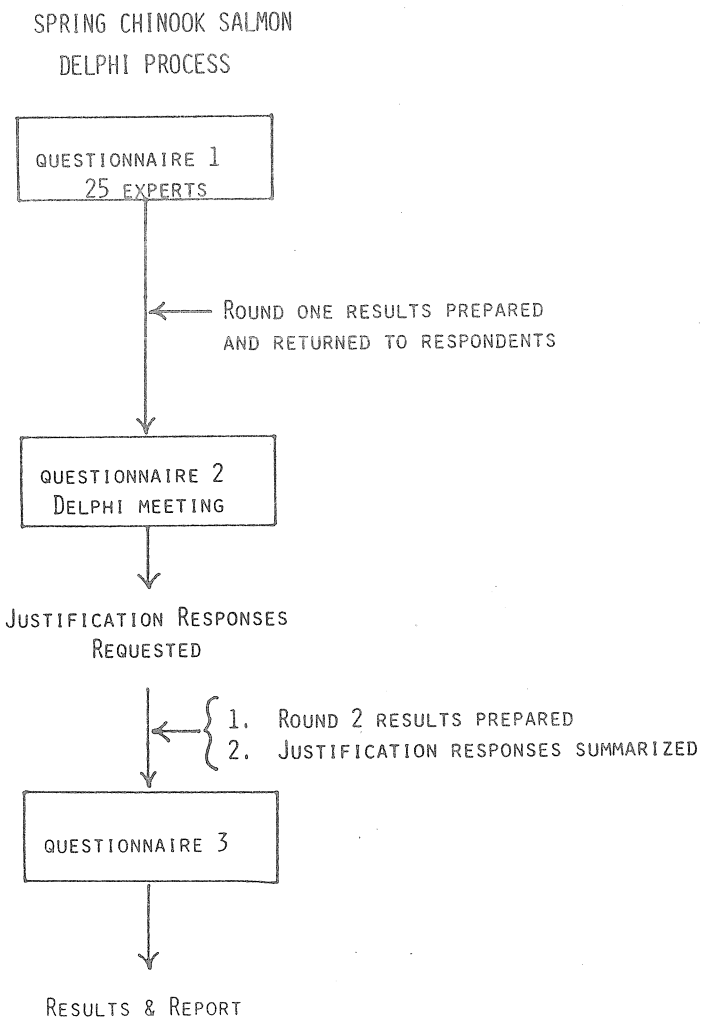
Figure 1 shows a schematic of our spring chinook salmon Delphi process. Twenty-five experts were sent a questionnaire with 71 questions pertaining to all phases of spring chinook salmon culture. Controlled feedback to the experts was provided between rounds in the form of summaries of questionnaire results and the justification responses.

The justification responses were solicited from respondents after round two if their answers still represented a low percentage of the group response. The entire group was asked to provide justifications if there was still wide variation in response to a question and no consensus was forming.

This iterative process allowed the 25 experts an opportunity to compare their answer with the other experts, review additional information, and revise their opinion (answer) on the next questionnaire. In this manner, the Delphi process attempted to develop a consensus of opinion for each question.

As indicated in Figure 1, we held a meeting for the participants after the first round. This provided a forum for discussion of the topics (additional feedback), a solicitation of other questions from the experts, and reinforcement through respondent participation.

FIGURE 1 - FLOW CHART OF SCS DELPHI QUESTIONNAIRE PROCESS.



The original questionnaire consisted of 71 questions in eight subject categories: adult holding and spawning, egg stage, nursery rearing, parr rearing, diet, disease, release, and miscellaneous. After the Delphi meeting, some questions were dropped and some added on the advice of the experts. Round two and three questionnaires then had nine questions which were new, beginning with round two. Two types of questions were presented; those requiring a fill-in response, and those requiring a rating by importance of several factors. We told respondents the questionnaire was not a test; essentially all answers were correct. But we were attempting to "force" them to make decisions between a series of very good and proven practices. In other words, we'd like them to make subtle judgments about something being a "little bit better" or "a tad worse". We also emphasized this was not an exercise to get them to repeat their station's present protocol for rearing SCS. It was, rather, an exercise to elicit their personal opinion on how they would do things if they had total freedom to choose a rearing plan at some "imaginary" station. Most had previous experience at a number of rearing stations and/or several different protocols at a single station. It is within this context that we asked them to make selections.

Presentation of Results

Those questions with the rating format required respondents to rate (in two ways) several factors potentially affecting the success in various phases of the program (see example below). First, among the choices given for each question, they ranked them (among themselves) in order of most important (lowest number) to least important (highest number). Potentially, the respondent could feel several were of equal importance, but for this response they had to prioritize them. Next, they were to consider each choice individually. On a scale from 1 (very important) to 4 (not important), they were to rate as to the importance of this factor in optimizing success at the particular life history phase in question. In the individual rating, they could use each number two or more times if they believed factors deserved equal weight.

Rating Question Example - In your opinion, which of the following species are easiest to raise:

		Inter-Ranking 1 = Most Easy 5 = Not Easy	Individual Rating 1 = Very Easy 4 = Not Easy
a.	Rainbow Trout	1	1
b.	Steelhead	4	1
c.	Brown Trout	3	2
d.	Sockeye salmon	2	2
e.	Chinook salmon	5	4

To analyze the group results for the rating questions, we calculated an overall rating for each parameter by multiplying the individual rating by the inter-ranking and then categorizing their importance. For example, if a question had 8 factors to inter-rank and each one was then given an importance rating from 1 to 4; the total possible range of overall rankings was 32 (8x4). Any factor rated 1, no matter how it ranked, was classified as very important. Therefore, the range of overall rankings between 1-8 were "most important", 9-16 were "important", 17-24 were "moderately important", and 25-32 were "not very important". If there were only four factors to rank, these same categories would be 1-4, 5-8, 9-12, and 13-16 respectively.

We then calculated a group average rating for each parameter and displayed these averages, for all of the factors in a question, in a histogram. A key is then given for each rating question defining the numerical boundaries of the importance categories. For the final results presented in this report, we used three dimensional histograms to display rating changes between rounds.

The responses to fill-in questions were put into categories. The percentage of the group responding in each category was calculated and displayed in histograms.

It was then necessary to develop a subjective interpretation of the final responses for both fill-in (percentages) and rating questions. This task was approached with great trepidation as we sought to reduce the chances of making statistical

Type I and II errors, i.e. either accepting a result as true when it is not or rejecting an answer as false when it is true. The following response category interpretations should be used as a guideline when reviewing results:

Question Type	Response Range	
Fill-In	70-100%	It is very likely that a choice selected by 70 percent or more of the expert respondents or rated "Most Important" represents a highly successful treatment or practice applicable in most situations with few qualifications. In those questions of problem identification or negative factors, this range would indicate a common problem of widespread significance.
Rating	Most Important	
Fill-In	50-69%	A majority of the time, this treatment or practice is successful. There is not enough agreement, however, to indicate this choice is a mandate to be implemented without consideration of the remaining factors which may have equal efficacy or applicability under certain conditions. If the question is related to a negative or limiting factor, a 50-69 percent rating would indicate a significant problem, but probably not a universal one; remaining factors should be considered.
Rating	Important To Moderately Important	
Fill-In	1-49%	There is no clear-cut treatment or choice which is best (or worse) under all conditions at most hatcheries. There are likely limiting factors or considerations which negate any one choice from being best for all situations. The range of responses should be subjectively analyzed for site-specific application. In the case of rating questions, a "Not Important" rating would indicate a factor of insignificant positive or negative effect.
Rating	Not Important	

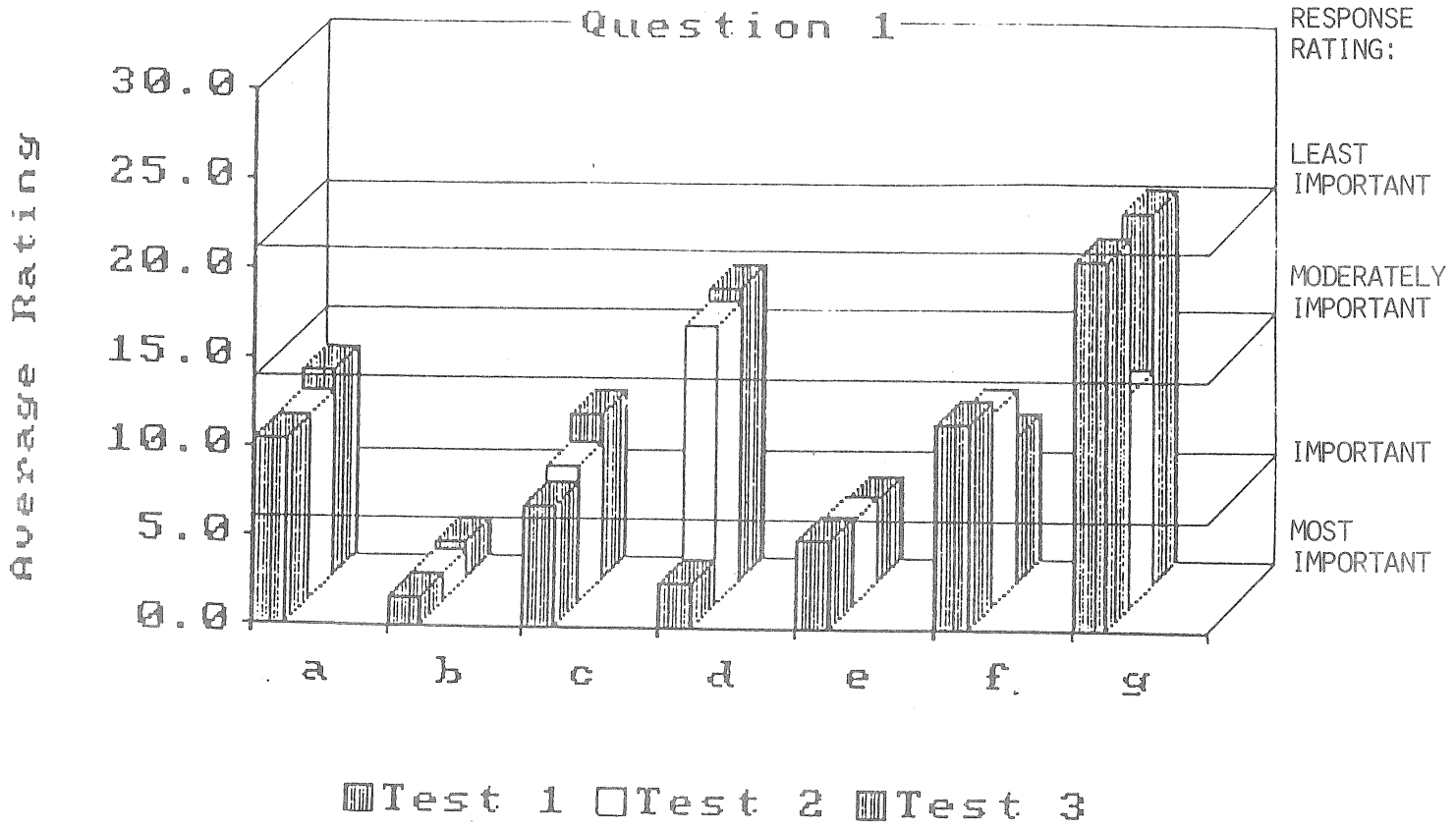
Question Type	Response Range
(cont.)	
	Considerable uncertainty may still exist in these areas indicating a need for further research or production trials.

ADULT HOLDING AND SPAWNING

The most obvious benefit of a successful adult holding and spawning operation is an increased production potential, i.e., more surviving adults and embryos. The number of eggs produced is not a singular measure of achievement in most spawning programs. It would be a short-lived success if the eggs carried a disease that later resulted in pond emptying epizootics, or represented such a narrow genetic spectrum of the run that the gene pool was reduced to a dangerously small size and the stock sat on the edge of biological disaster. Early efforts to curb disease transmission and maintain stock genetic diversity are recognized as prerequisites to maintaining successful production programs.

This series of questions seeks to define the most efficacious adult handling and spawning techniques which would hopefully optimize both quantity and quality of embryos delivered to the incubation system.

Suggested references: (46, 50)



Question 1. In your opinion, what is the most important factor in reducing spring chinook adult holding mortality?

a. Pond configuration; e.g., oval versus deep, steep-sided ponds
b. Water temperature
c. Chemotherapy for fungus control
d. Erythromycin inoculation
e. Minimizing stress of handling, moving, etc.
f. Overhead cover; e.g., surface turbulence or actual cover
g. Advancing spawning time (reducing holding time) via photoperiod control

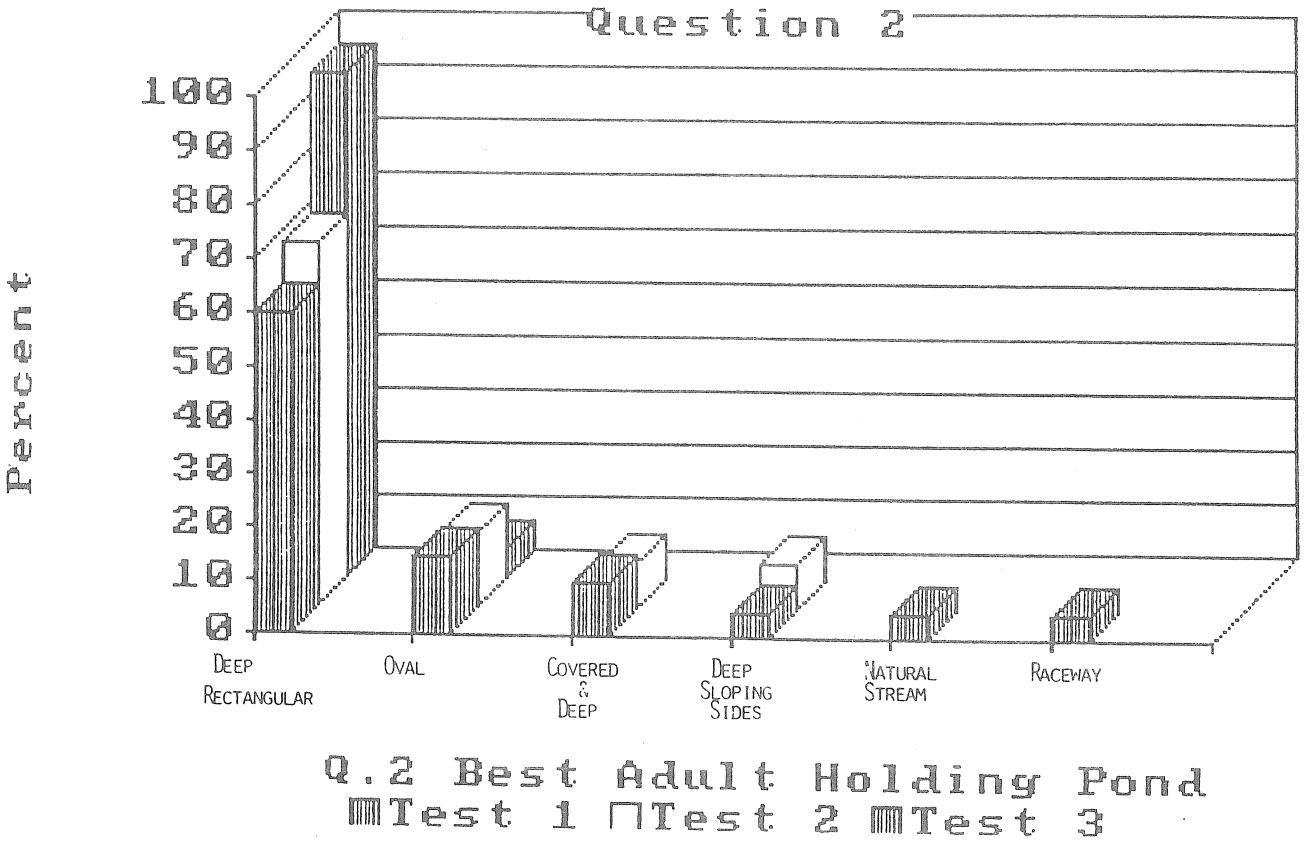
Response Rating Guide

1- 7	Most important
8-14	Important
15-21	Moderately important
22-28	Least important

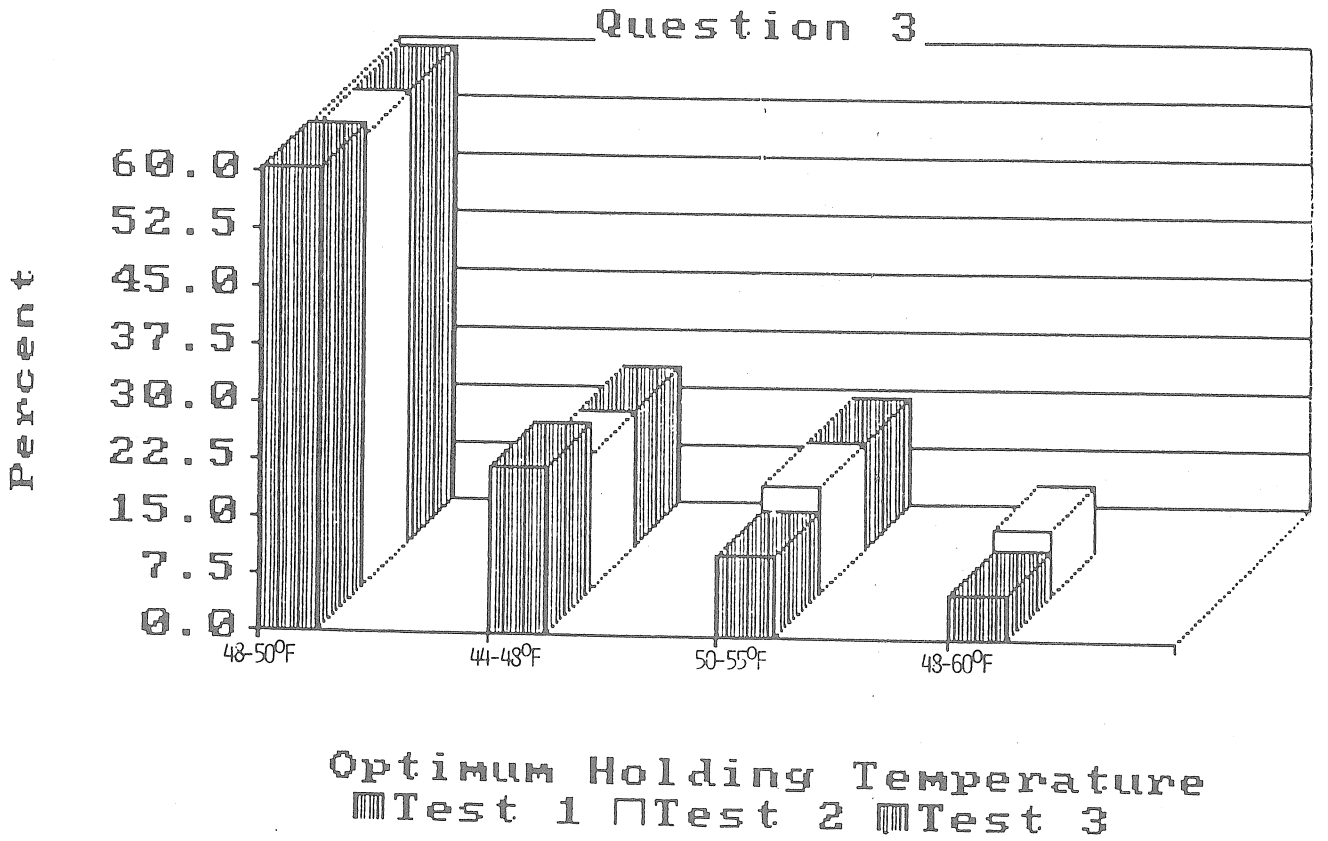
Question 1

Water temperature was rated the most important factor through all three questionnaires followed closely by minimized handling. Chemotherapy for fungus control and overhead cover ranked very important. The interesting shift came in Erythromycin inoculation which fell from very important to moderately important.

Inocuation is a BKD prophylactic treatment that has shown positive results in reducing adult mortality at some hatcheries. The trade-offs are handling stress and inoculation mortality. The group response indicated a preference to reduce BKD exacerbating stresses through control of pond environment (water temperature and cover), minimized handling, and fungus control. The Region 1 Fish Health Group of the Fish and Wildlife Service (FWS) has recommended that spring chinook adults be injected with Erythromycin $^{-}PO_4$ in their hatcheries with BKD problems. A controlled experiment comparing mortality of inoculated adults and their progeny to adults left uninoculated in an optimum holding environment would greatly assist in defining the net benefits to both types of adult treatments.

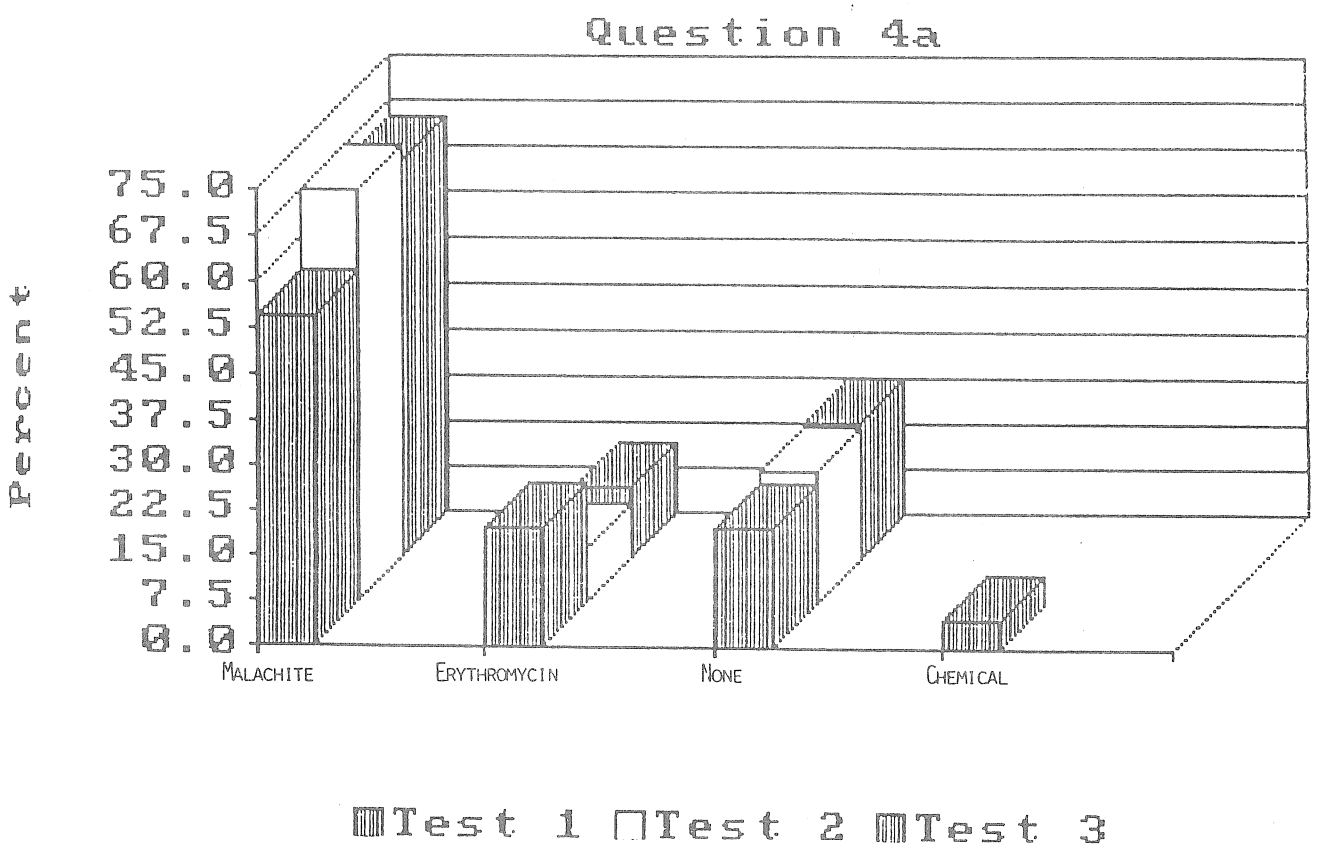


A deep rectangular pond was the strong consensus for best holding pond. There was a significant shift in opinion on this as the percentage favoring the pond changed from 60 percent to 94 percent. One respondent favoring oval ponds suggested jumping is greater in straight sided ponds but that cover would alleviate the problem. On Question 1, pond configuration ranked very important, but fifth out of seven factors, to reduce adult mortality. It appears there is a number of other treatments to control adult holding mortality before pond reconstruction should be considered.

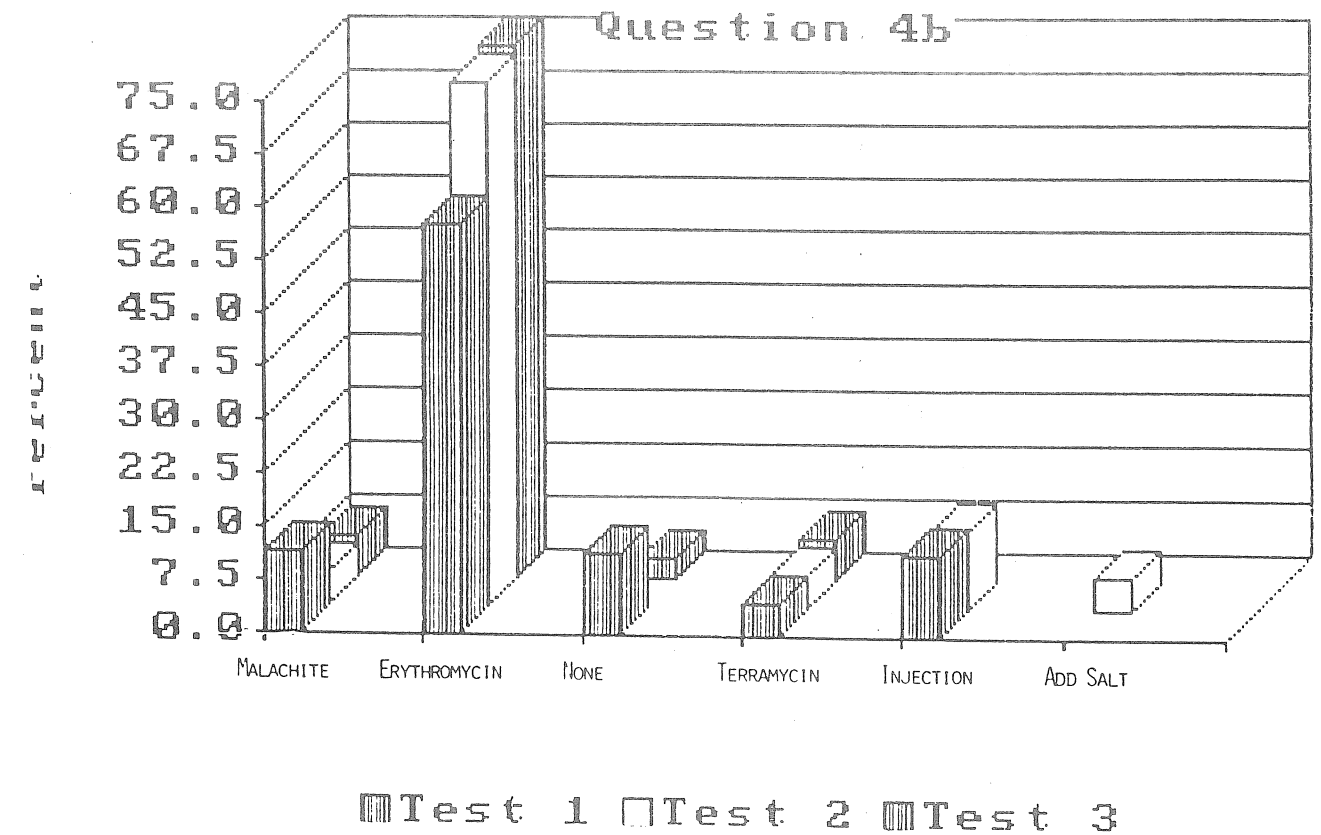


Nearly two-thirds of the respondents favored 48-50°F as optimum holding temperature; 22 percent favored cooler water at 44-48°F. The primary consideration of most respondents in defining optimum holding water temperature was disease and fungus control. However, egg fertility, embryonic development, and maturation rate can all be affected by adverse temperatures, too cold or warm, and should not be forgotten. As one respondent justified his warmer holding water response (55°F), he questions why we would seek colder temperatures than the fish may hold in out in the stream. The answer may be to reduce disease risks in unnaturally crowded conditions; a benefit which may outweigh shifts in maturation rates due to cooler or warmer water temperature.

QUESTION 4A: WHAT TYPE OF TREATMENT (CHEMICAL, INJECTIONS, ETC.), IF ANY, WOULD YOU USE ON ADULT SCS? (FIRST CHOICE)



QUESTION 4B: WHAT TYPE OF TREATMENT (CHEMICAL, INJECTIONS, ETC.), IF ANY, WOULD YOU USE ON ADULT SCS? (SECOND CHOICE)

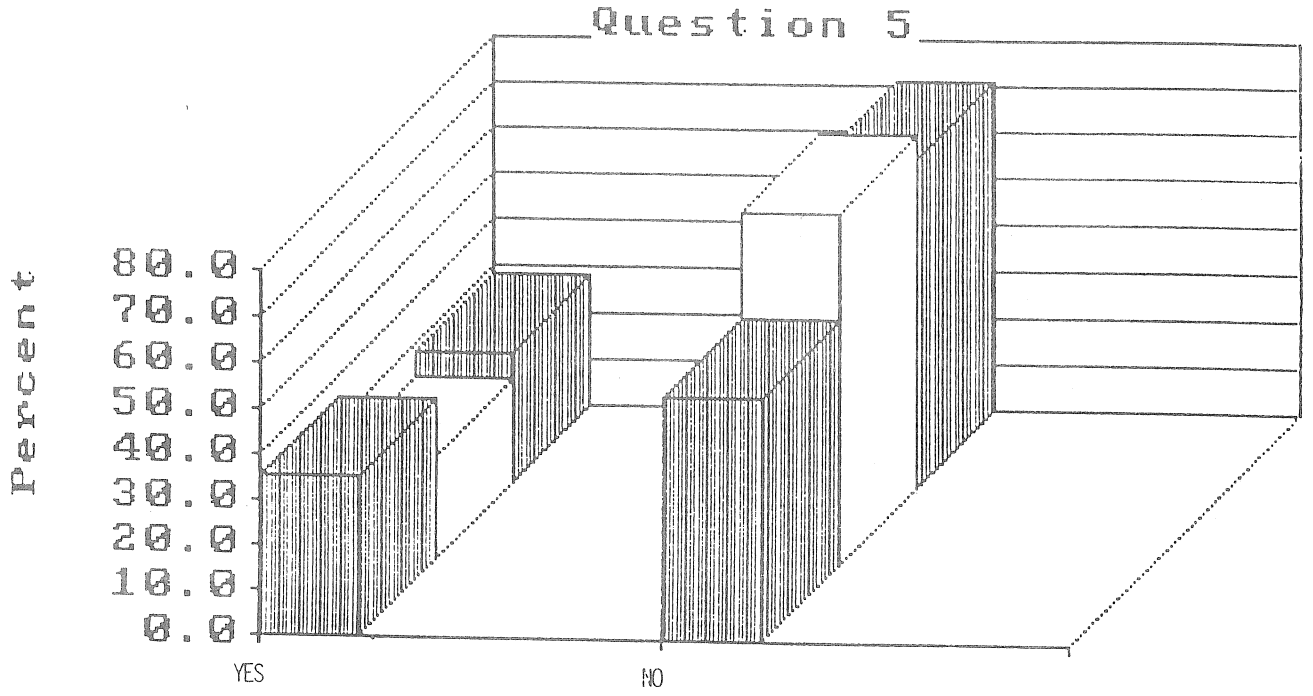


Questions 4A and 4B

We should have stated these questions differently as many respondents indicated they would answer differently depending on which disease was to be treated. We do see that Malachite was a favorite first choice and Erythromycin the favorite second choice which probably rates fungus treat.

Malachite present two dilemmas: one is the administrative restrictions on its use,and the second is its suspicion as a real health hazard to humans. But to paraphrase some hatchery managers, "...to take away malachite is to take away my spring chinook program...". Malachite remains a potentially very messy issue on which all managers would like more clarification.

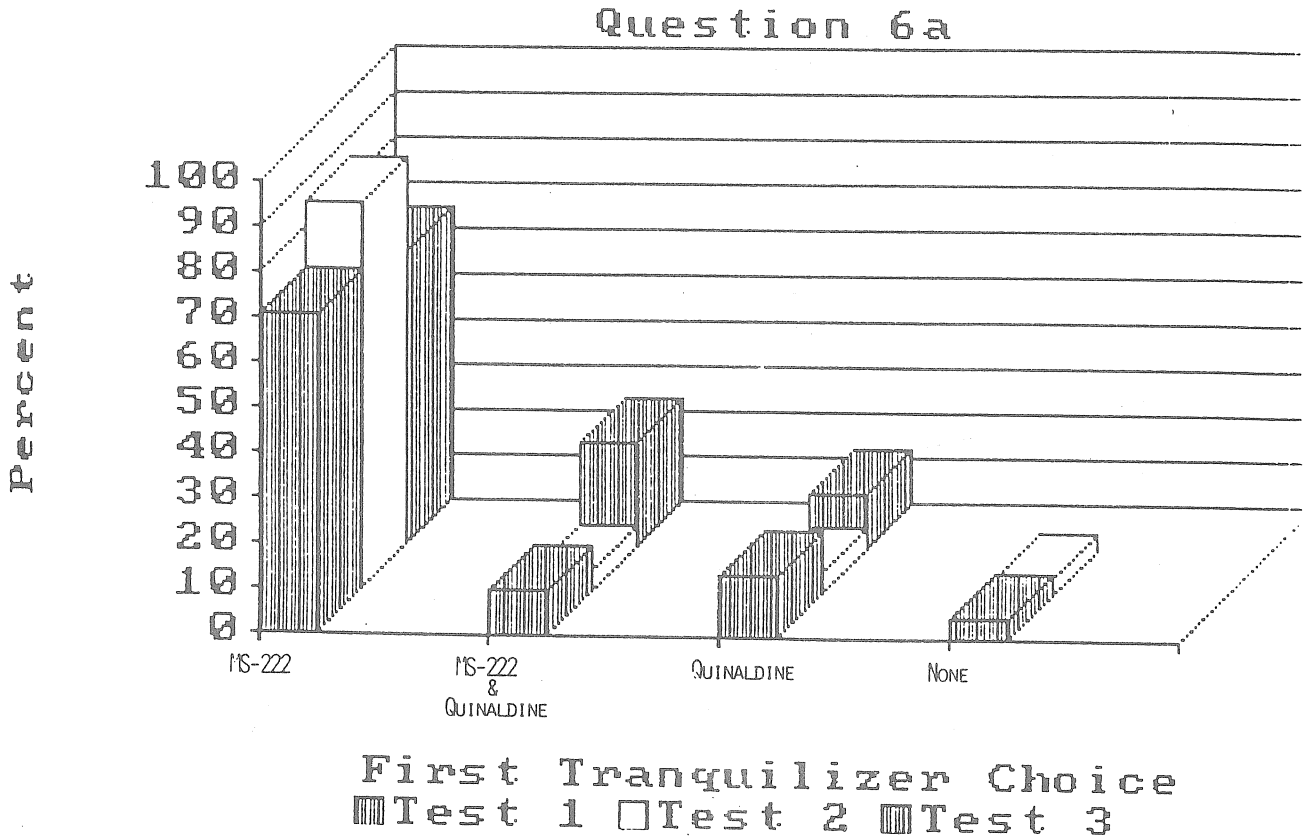
We discussed some of the benefits and trade-offs in Erythromycin inoculation programs under Question 1, but another question needs to be raised. That is how long and how intensely can Erythromycin be used (on adults, eggs, and in feed) before BKD bacteria become desensitized and the drug loses its efficacy. It seems prudent that further research continue on alternate BKD bactericides such as sulfamerzaine. Hopefully, an array of antibiotics could be used in alternate years or life history stages in hatcheries in order to slow down the possible development of resistant strains.



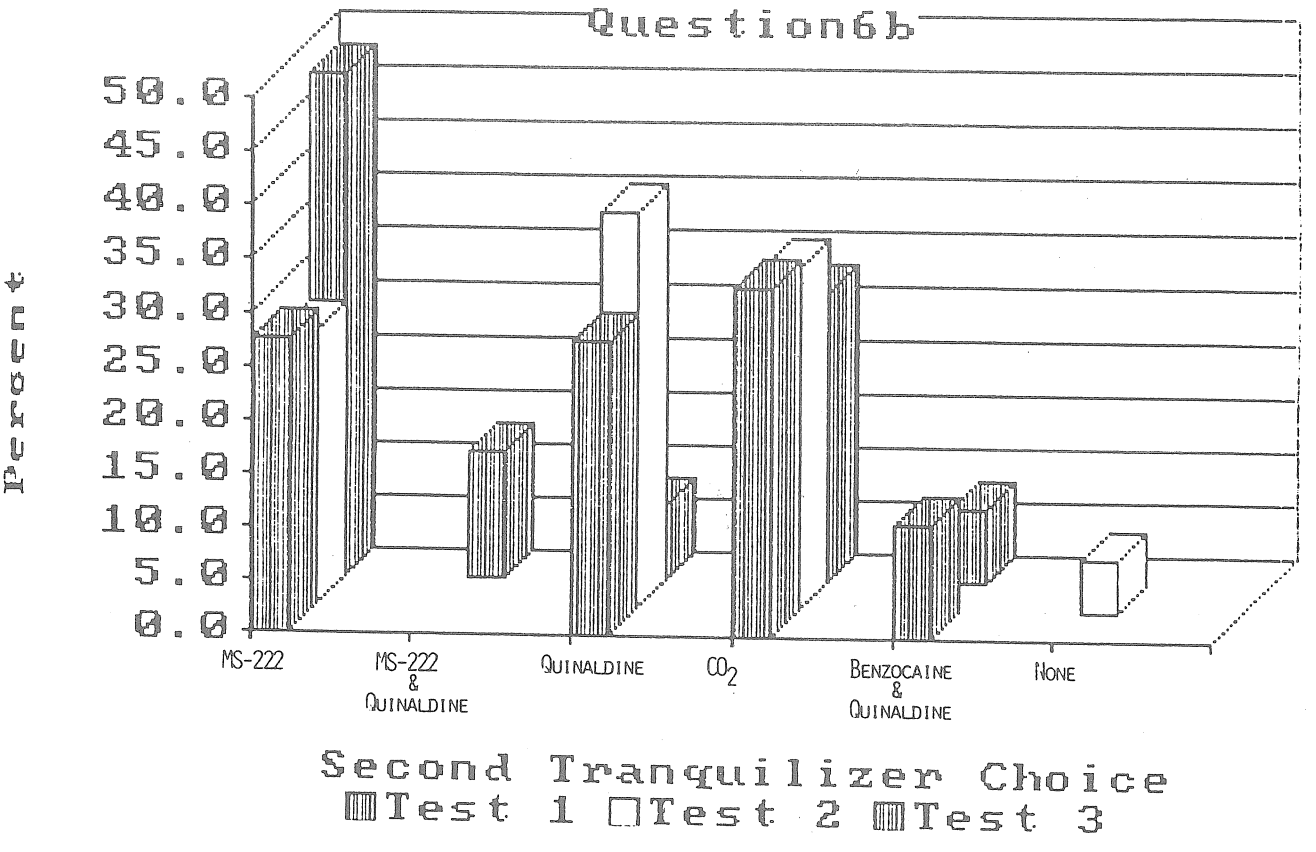
Adult Handling Prior To Spawn
Test 1 Test 2 Test 3

There was not much shifting of opinion on the danger of handling adults; 71 percent said there was increased mortality risk, 29 percent said there was not. The justification responses for those who said adults could be handled cite several examples of significant handling and transporting with no apparent ill effects or examples of non-handled fish with higher mortality than handled fish. Certainly handling is a conditional decision based upon the health of the fish, quality of pond environment, and the benefits to be gained by the action that necessitates the handling.

QUESTION 6A: WHAT WOULD BE YOUR "TRANQUILIZER" OF CHOICE FOR USE ON ADULT SCS?
(FIRST CHOICE)



QUESTION 6B: WHAT WOULD BE YOUR "TRANQUILIZER" OF CHOICE FOR USE ON ADULT SCS?
(SECOND CHOICE)



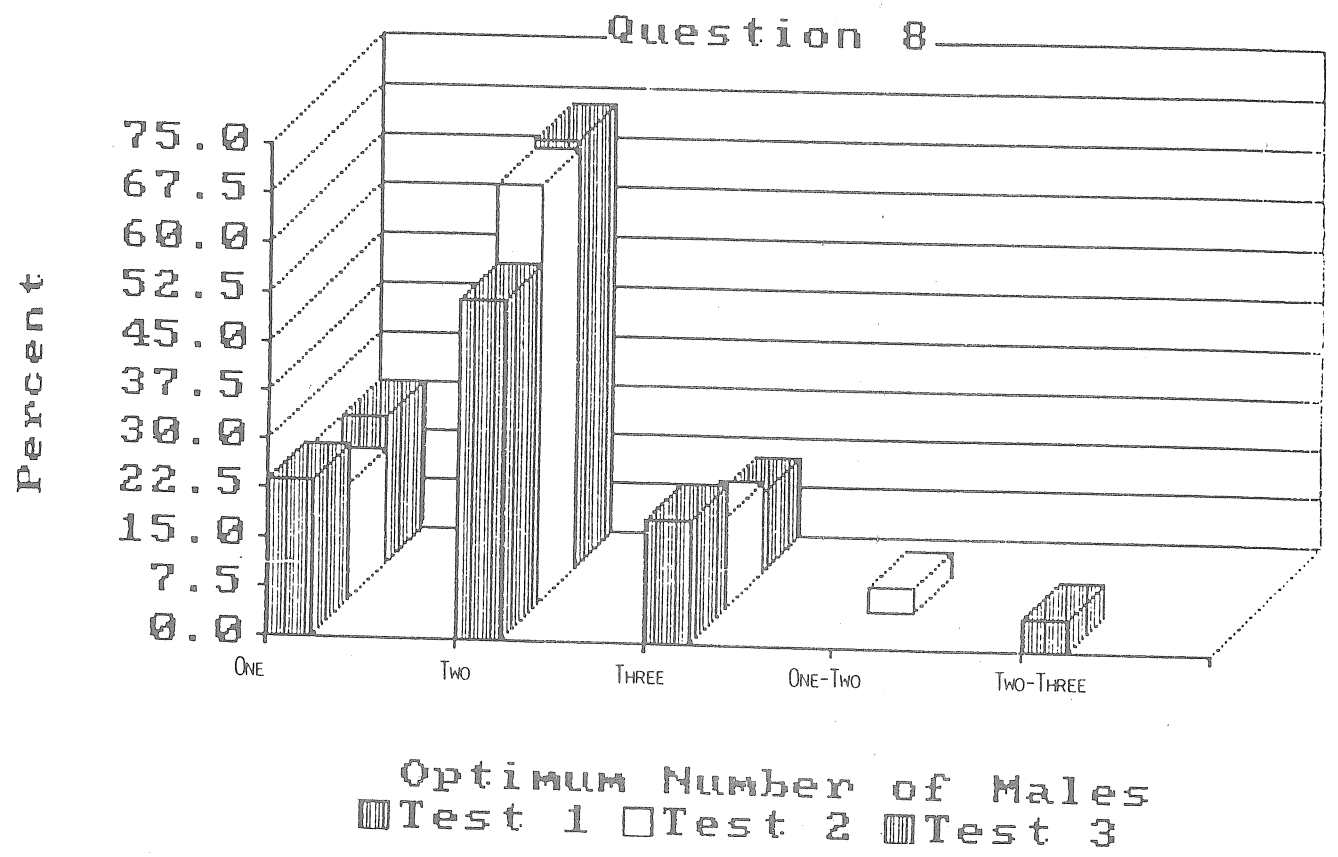
Questions 6A and 6B

MS-222 was the first and second choice of the majority for tranquilizer of choice. There was a 13 percent gain however, in those who would use a mixture of MS-222 and quinaldine. The justification given for this mixture is quite persuasive in my view, citing a cheaper, faster-acting, more effective drug. Perhaps a few more people should try it out.

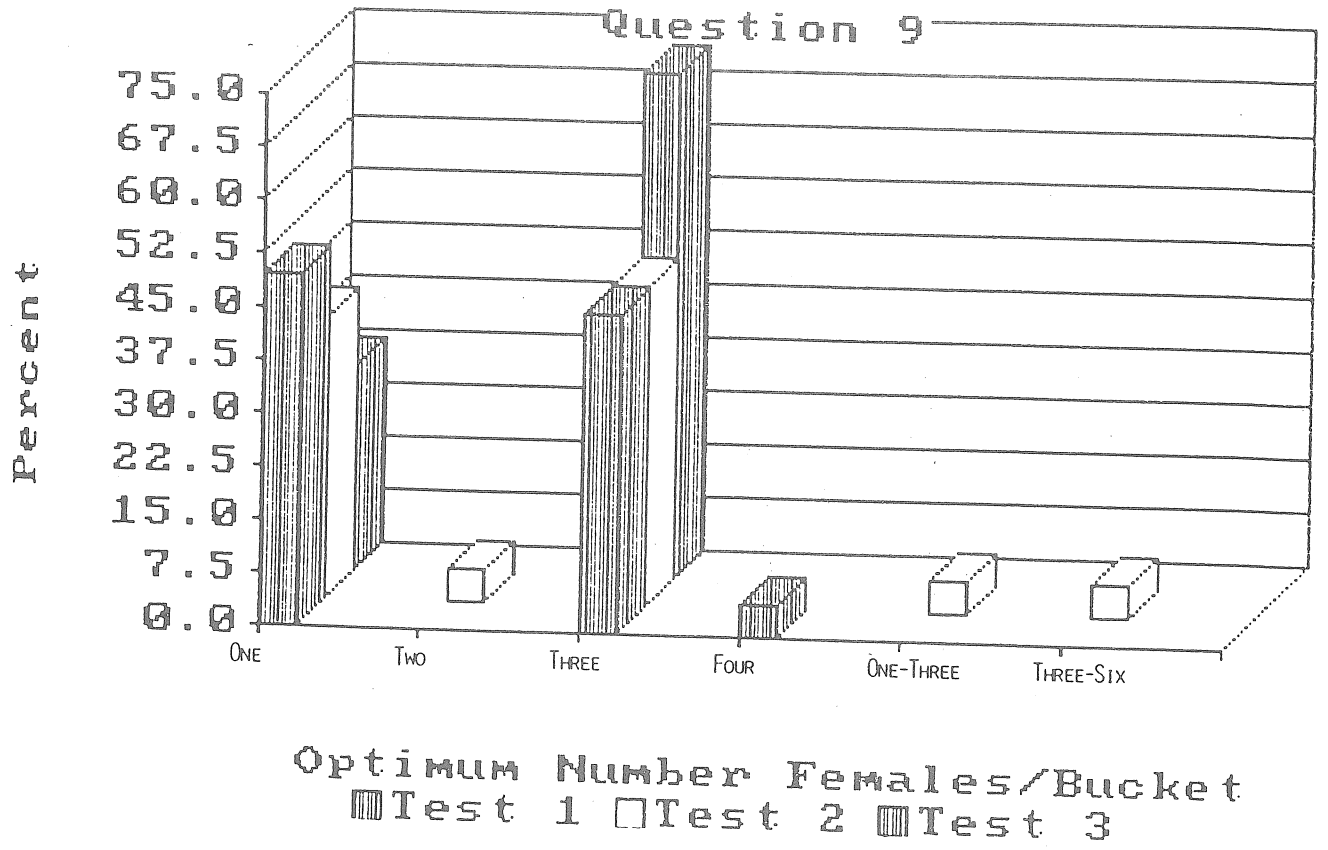
Question 7

The analysis of this question was omitted due to an error on our part which re-phrased the question between questionnaires from "which disease to first test for" to "which is most feared disease in adults." The interpretation of these two statements was different and resulted in uncomparable responses.

QUESTION 8: WHAT IS THE OPTIMUM NUMBER OF MALES YOU WOULD USE TO FERTILIZE A SINGLE FEMALE?



QUESTION 9: HOW MANY FEMALES WOULD YOU SPAWN IN ONE BUCKET?

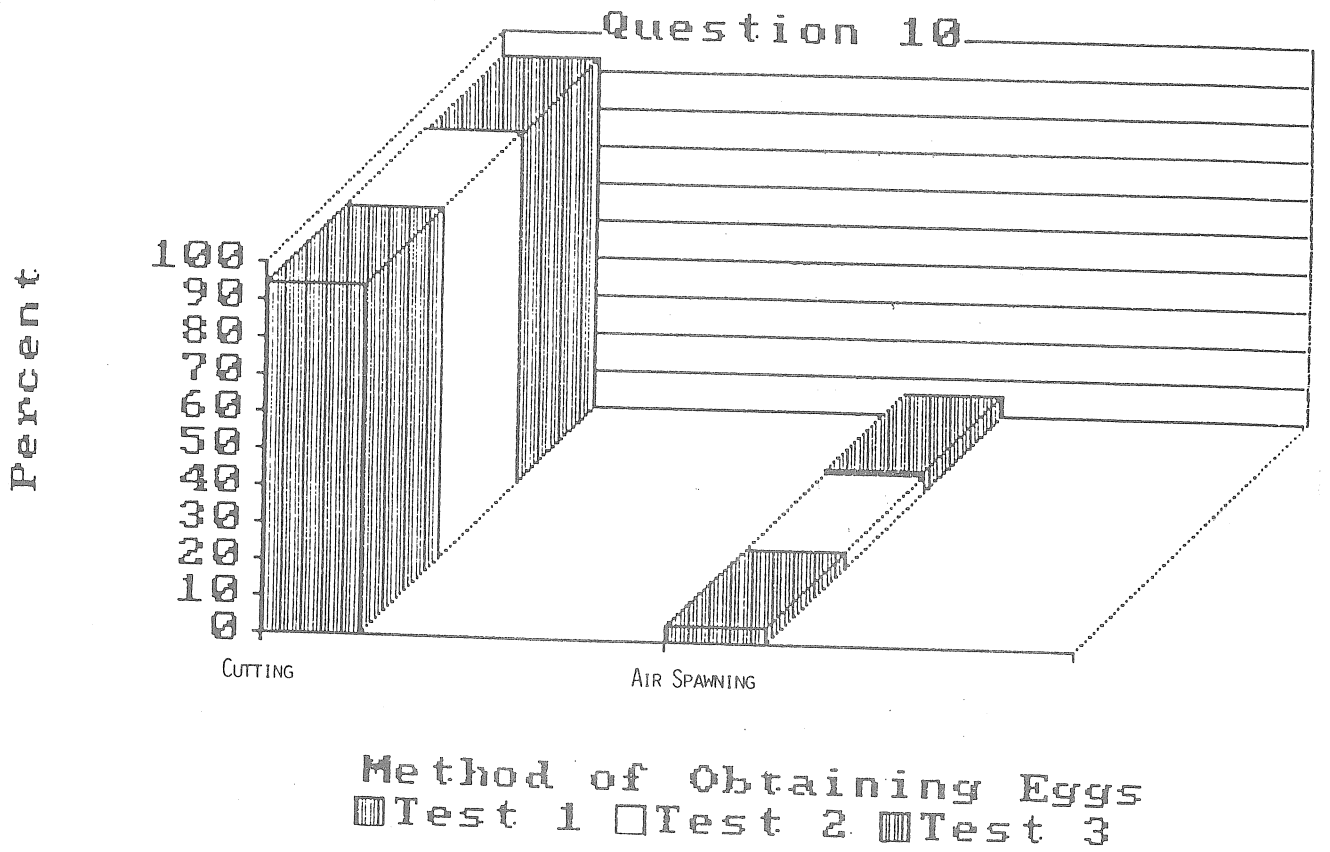


Questions 8 and 9

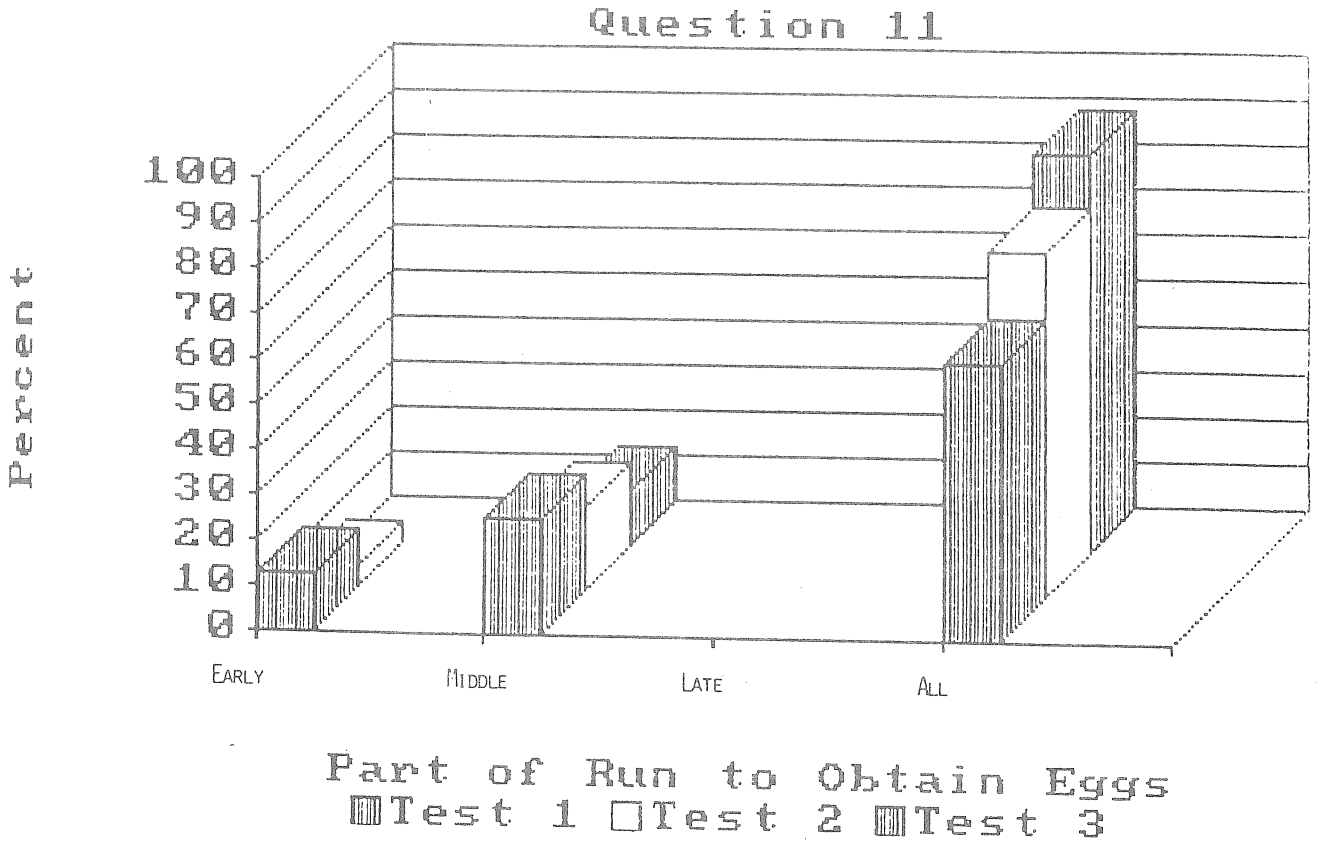
Two males per female was the choice of 65 percent of the respondents by round three. This was a 13 percent increase from round one. Twenty-three percent would use only one male and 12 percent would use three. Seventy-one percent of the respondents would use three females, a 26 percent increase from round one; 29 percent would use only one female per bucket, a significant shift down from 50 percent in round one. The reason given most often by the one male/female respondents was a desire to reduce transmission of disease in culling programs where 1:1 spawning is conducted. Use of multiple males was most often justified for maximizing fertilization and maintenance of genetic variability.

In the wild, a male may spawn with multiple females and the same for females. This is presumably an evolutionary tactic which maximizes genetic variability in the progeny.

QUESTION 10: WHAT METHOD WOULD YOU CHOOSE TO OBTAIN EGGS (CUTTING, AIR SPAWNING, HAND PRESSURE, ETC.)?



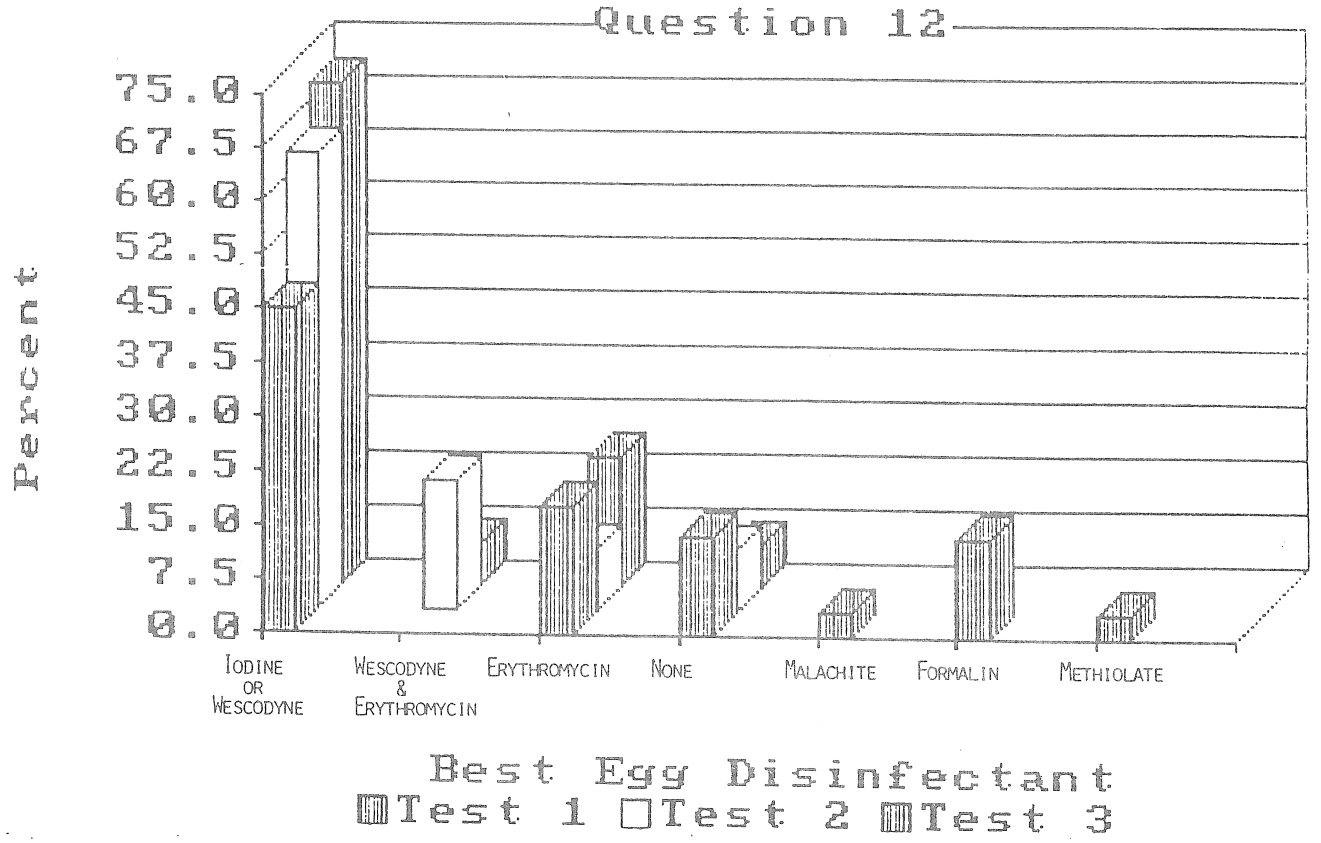
There was a 95 percent consensus on all three rounds that cutting was the best method to take eggs. The one respondent who selected air spawning felt it might be a cleaner method from a disease standpoint. If cutting is the method used in a 1:1 culling program it is now usually accompanied by disinfected knives and hands on each female to reduce transmission of any disease carried in ovarian fluids.



By round three, 88 percent of the respondents would use all portions of the run in their programs; an increase from the round one 61 percent response. The response makes the management biologist's heart sing! Using all portions of the run maximizes the genetic variability in the run and preserves a broad range of physical and biological characteristics. This is not only esthetically pleasing (and perhaps mandatory for replacement in kind mitigation programs) but is of real pragmatic and biological importance. A run that was developed from one part of the historical run could not provide a prolonged fishing opportunity for terminal area sportsmen. A run of all one age class invites low or non-return years if environmental or man-caused disasters such as dams, droughts, El Ninos, etc. wipe out a brood year. The homogeneous protected environment of the hatchery results in a less natural selection and a tendency towards fewer of the fitter heterogeneous geneotypes. This means we have to work harder at maintaining

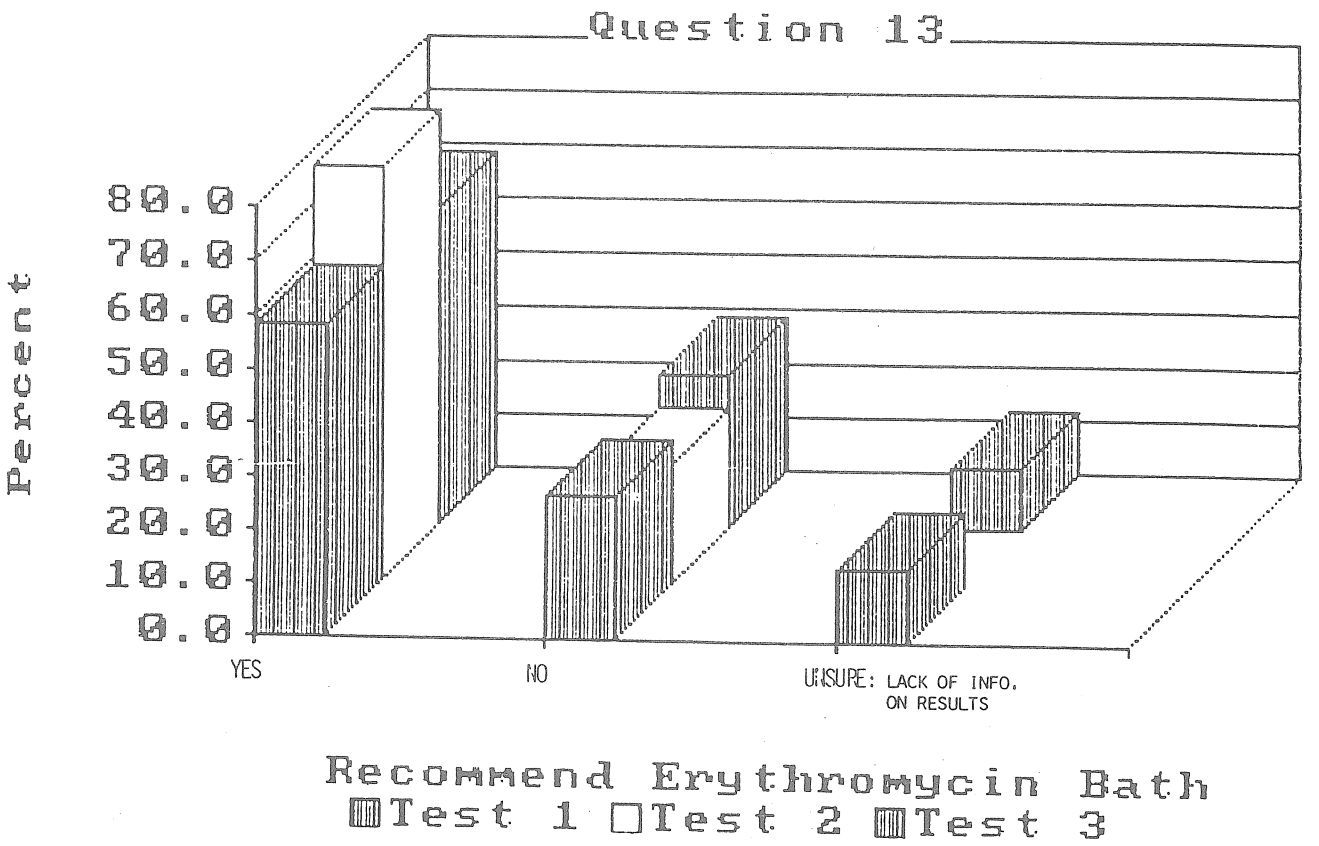
Question 11 (cont.)

genetic variability in our hatchery runs by practicing such things as random mating and use of fish from all segments of the run and perhaps periodic mixing of wild gametes into the stock, if available.



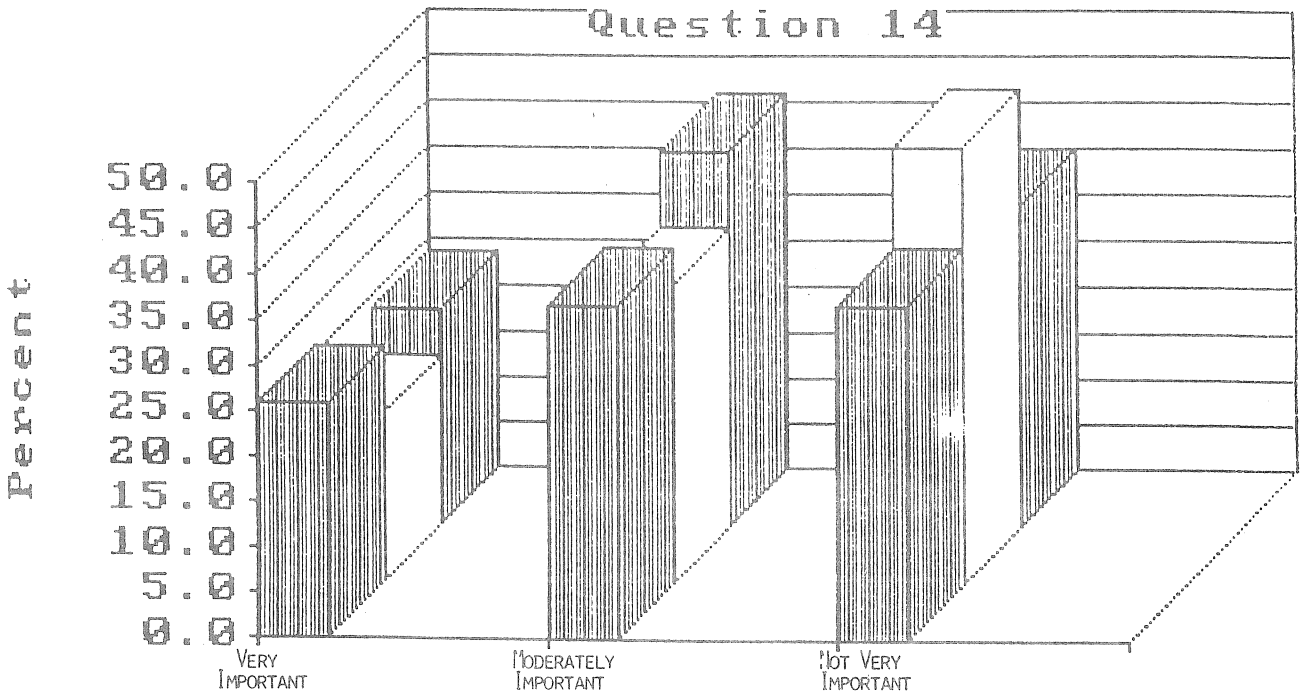
Wescodyne or Iodine were chosen by 70 percent of the respondents by round three; a 25 percent increase over round one. Eighteen percent would use Erythromycin. The bactericidal action of the Iodophores appears to be an attractive potential disease prophylactic to the majority of the respondents. Numerous Iodophores are available for egg disinfectants such as Wescodyne, Argentyne, and others. They may have different levels of active ingredients or detergents in them and may require trials to determine proper dosages and time of exposure. The FWS will be evaluating Argentyne this year to determine effects on egg viability, hatch, fry success, and first feeding.

QUESTION 13: WOULD YOU RECOMMEND WATER HARDENING OF SCS EGGS IN AN ERYTHROMYCIN BATH AS AN EFFECTIVE PROPHYLACTIC DISEASE PROCEDURE?



There was very little shift in group opinion on Erythromycin water hardening. In round one, 59 percent favored it, 27 percent were opposed, and 14 percent were unsure. These percentages were 59, 27, and 14 respectively in the first round. There is still considerable uncertainty about the benefit of this procedure as respondents indicated in the justification responses. Some trials have shown no difference in treated versus untreated eggs. The rationale I have heard mentioned by some is that it can't hurt so why not. A controlled test which clearly analyzes the efficacy of an Erythromycin bath in reducing vertical transmission of BKD is needed. This should probably be done in a comprehensive test of Erythromycin treatments, including adult inoculations and treated feedings.

QUESTION 14: TO REDUCE TRANSMISSION OF DISEASE AT SPAWNING TIME, HOW IMPORTANT DO YOU THINK IT IS TO MAINTAIN STERILE SPAWNING PROCEDURES (STERILE KNIVES, BUCKETS, HANDS, ETC.) ON EACH FISH?



Importance of Sterile Spawning
■Test 1 □Test 2 ▥Test 3

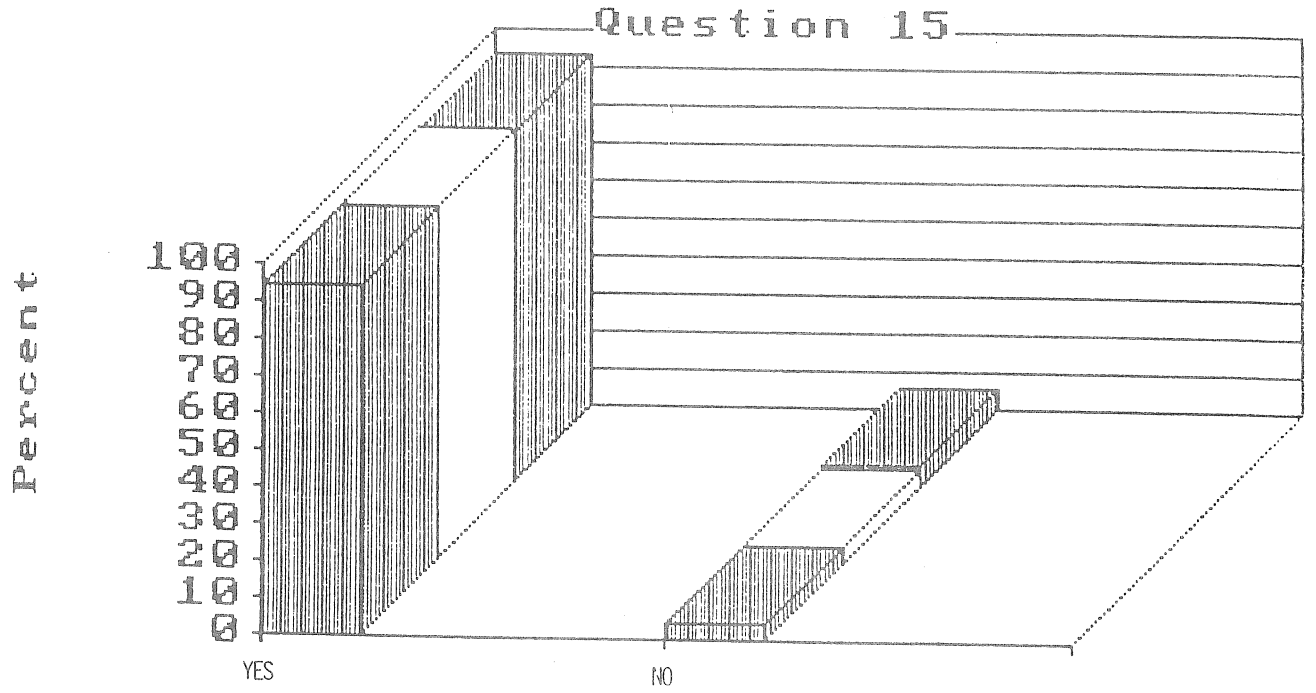
A solid non-consensus on this issue. The question itself should have been cleaned up a little and used the term "clean spawning" techniques instead of "sterile" which some people interpreted as "hospital sterile" which is impractical. Many respondents felt there is no use being sterile during spawning if the eggs are all mixed later in incubators, water systems, etc. This point is well taken, and perhaps we should have stated these conditions in the question. From the justification response, which I encourage you to review, I would infer that those stations with serious disease problems were more likely to see a need for clean spawning procedures. Some respondents could better justify sterile spawning if it were one part of a disease control program that would include individual spawning and incubating containers, adult disease diagnosis, and separation of rearing lots into groups of like infection.

We are hearing a lot from the disease biologists who are saying, in general, that we will be better off if we can reduce the titer of the disease

Question 14 (cont.)

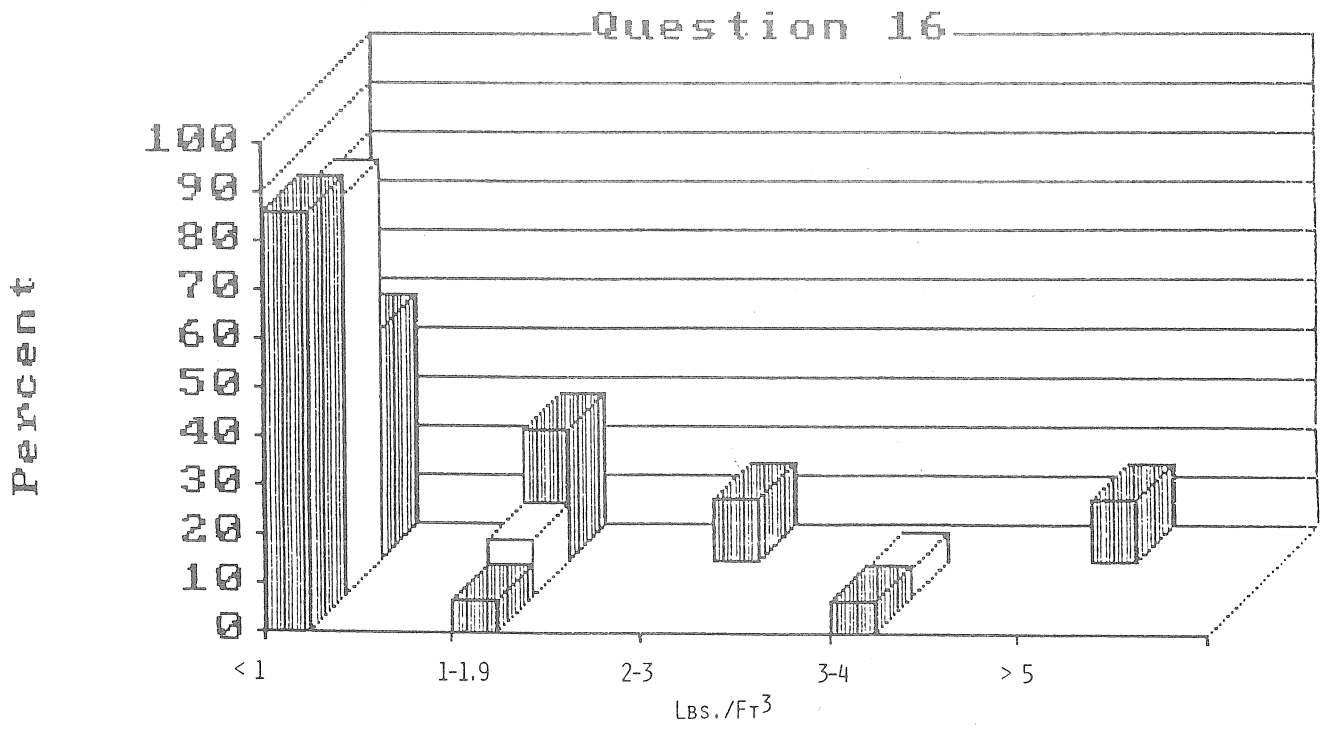
organisms in our stock wherever we can. We may be getting a double whammy from both vertical and horizontal modes of transmission. Considering the role of vertical transmission in many fish diseases, it seems any attempt to interrupt transmission of the disease at spawning may be wise.

QUESTION 15: IS THE DENSITY OF ADULTS IN A HOLDING POND AN IMPORTANT FACTOR?



Is Adult Holding Density Imp.
Test 1 Test 2 Test 3

QUESTION 16: IF YOU HAD OPTIMUM SPRING CHINOOK ADULT HOLDING WATER TEMPERATURES, WHAT WOULD THE BEST HOLDING DENSITY BE? (DEFINE YOUR ANSWER IN LBS./FT.^{3})



Optimum Adult Holding Density
Test 1 Test 2 Test 3

Questions 15 and 16

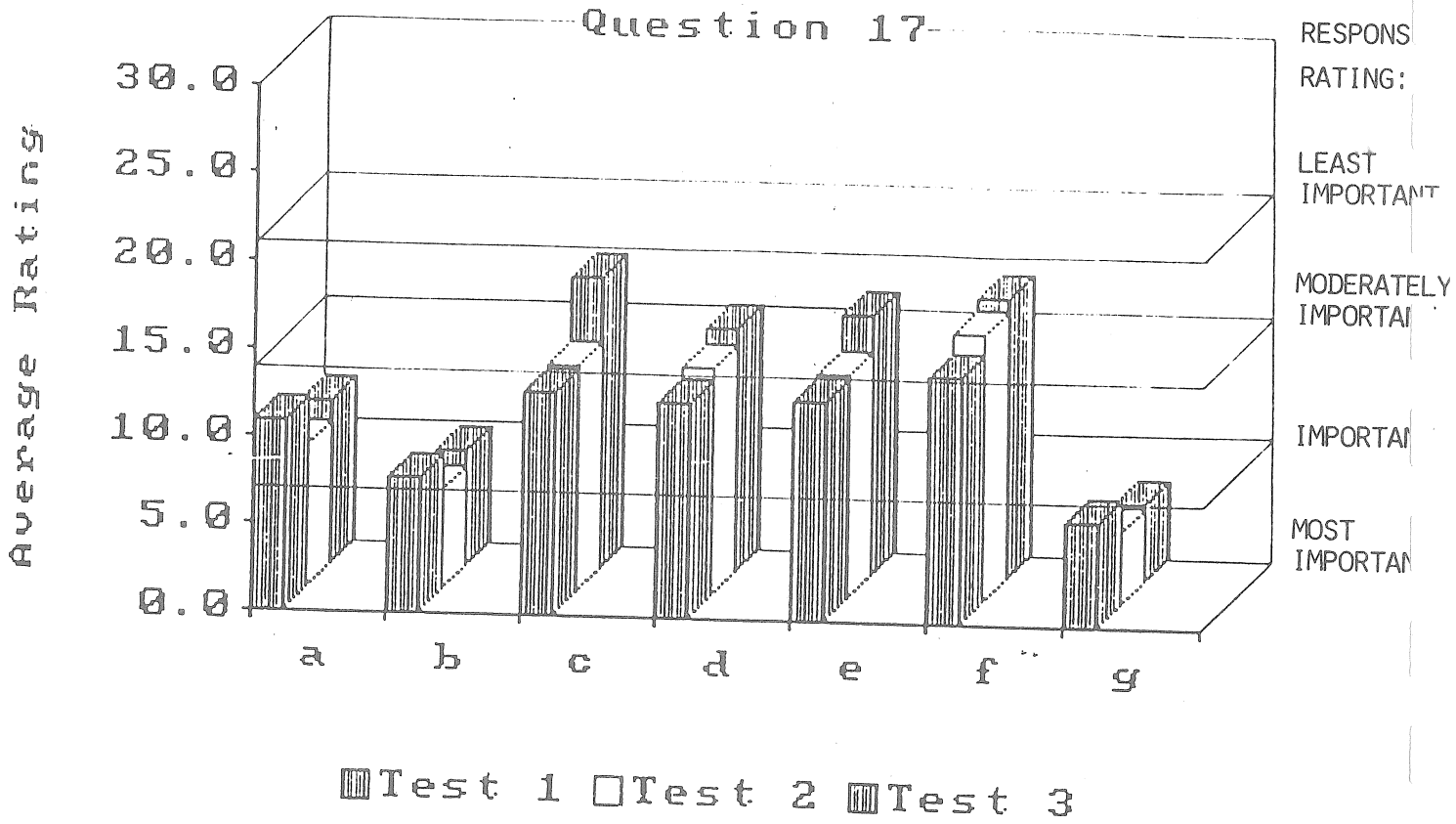
A consensus on Question 15, except for one respondent who felt safe adult pond densities are probably greater than we would dare carry them. On Question 16, there was nearly a 40 percent decrease in the respondents who would hold adults at less than one pound per cubic foot. The categories for 1-1.9 lbs./ft^3 and 2-3 lbs./ft^3 increased 20 percent and 13 percent, indicating some respondents willingness to accept higher pond densities than they originally would. I am unaware of any good references for use in calculating proper adult pond densities such as are available for juvenile fish. It appears that experience with each station's particular pond configuration, water temperature, and flow patterns will define what is appropriate for that hatchery.

EGG STAGE

This is a life history stage where hatcheries can outperform Mother Nature by increasing the percentage of embryos surviving to fry; 70-90 percent in hatcheries compared to 5-20 percent in the wild (McNeil 1975). By providing a very constant controlled environment we can circumvent mortality risks that naturally spawned fish must face: drought, ice, sedimentation, and predation. We are beset, however, with new dangers in maintaining that optimum hatching environment: maintaining appropriate water temperature and dissolved oxygen levels, de-nitrogenation and fighting fungus and other diseases in crowded incubator systems.

The majority of the questions in this section seek to define what the experts feel are the best egg incubation conditions for spring chinook.

Suggested references: (1, 3, 4, 8, 9, 10, 11, 13, 14, 18, 24, 28, 41)



Question 17. In your opinion, what is the single most important factor involved in obtaining a high quality, green SCS egg?

a. Genetic background of adults (strain)
b. Disease disposition of the adults
c. Amount of sperm
d. The portion of the run that adults are selected from, e.g., early, middle or late
e. Specialized water hardening techniques
f. Number of females used per male
g. Spawning techniques and handler experience

Response Rating Guide

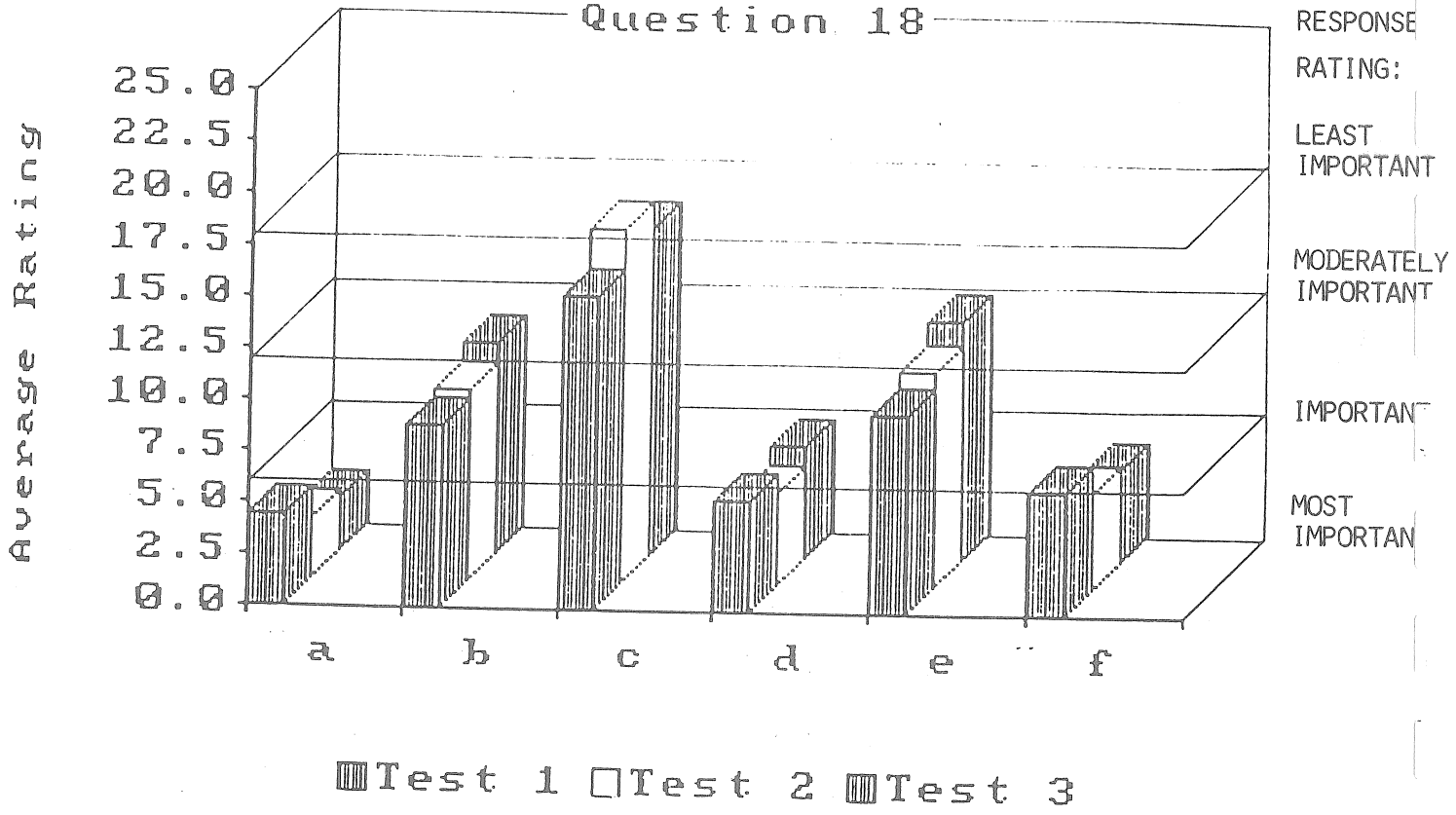
1- 7	Most important
8-14	Important
15-21	Moderately important
22-28	Least important

Question 17

There was little change in opinion on this question as not one response moved out of its original rating category. The most important factor, as indicated by the average overall rating, was spawning techniques and handler experience. To non-fish culture personnel, I believe this response will be quite surprising. The physical acts of checking ripeness, handling the fish, and removal of eggs and sperm were felt to be more important than disease, genetic or early egg treatment considerations. The key element is probably accurate analysis of female maturity by experienced personnel. McNeil (1975) says egg fertility should consistently exceed 95 percent if females are ripe.

Running a close second was the "disease disposition of adults" which ranked in the most important category. This response seems to confirm the awareness and concern of respondents regarding the need for early disease monitoring and control which we saw in answers to questions in the previous section.

One write-in for the "other" category included "condition of adult" which one respondent rated as a "1" which ties green egg success back to the importance of maintaining a high quality adult holding environment.



Question 18. In your opinion, what is the most important factor involved in obtaining a good quality egg and a high percentage of eye-up?

a. Temperature
b. Specialized picking and chemical treatments
c. Type of incubator
d. Water quality
e. Egg density in incubator
f. Minimizing movement and handling

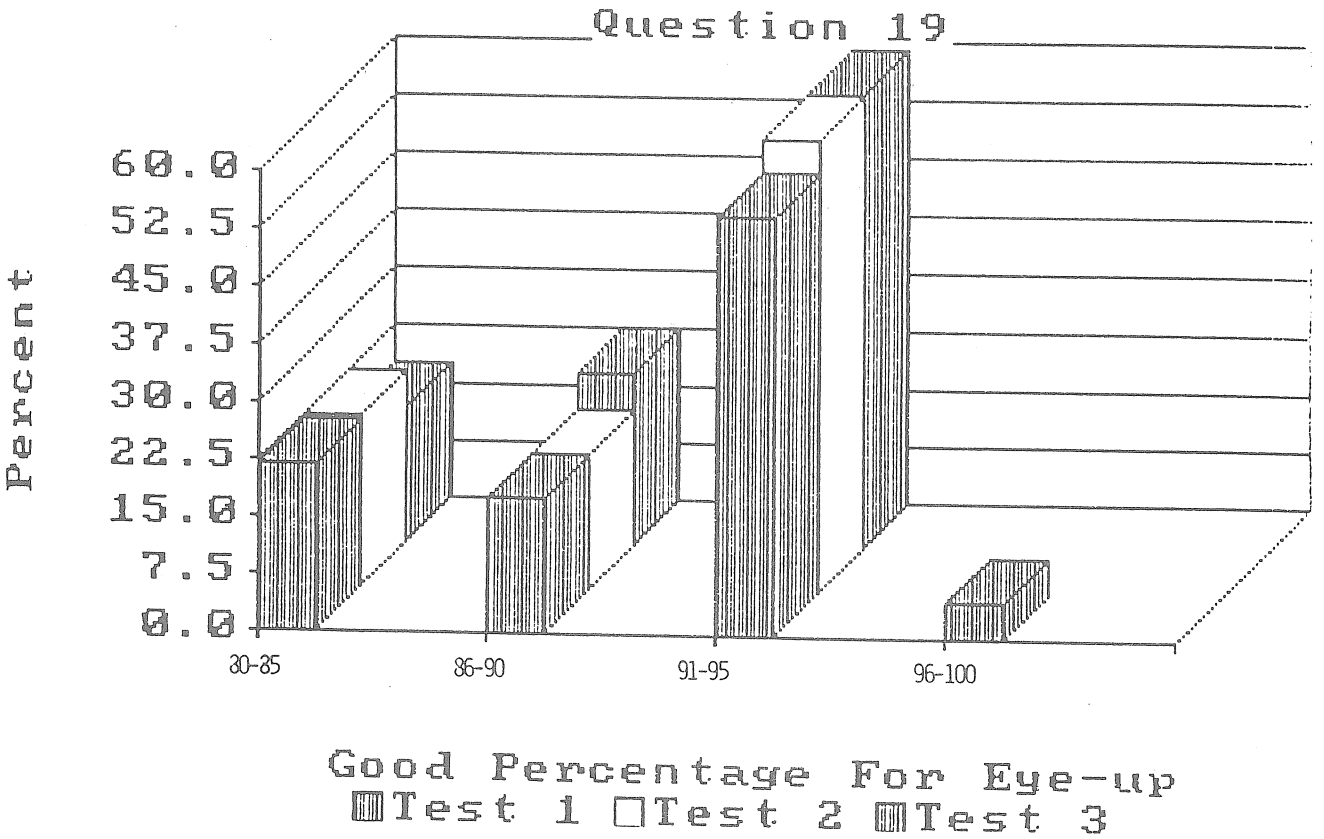
Response Rating Guide

1- 6	Most important
7-12	Important
13-18	Moderately important
19-24	Least important

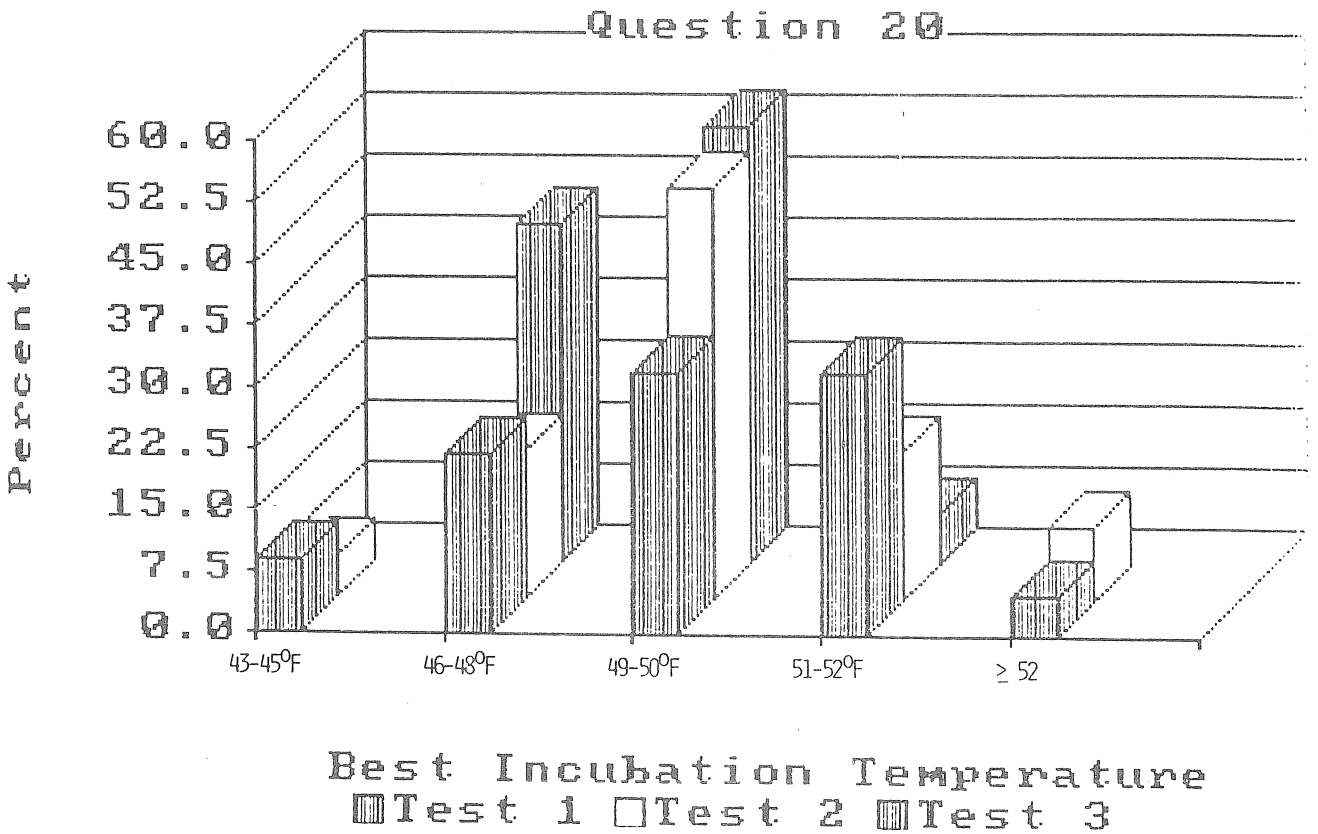
Question 18

Once the human handling is over and eggs are put in incubators, environmental factors and minimized handling become the key to high percentage of eye up. The respondents were again sure of themselves as very little shifting in ranking was seen. Temperature, water quality, and minimized movement all ranked very important. One question we probably should have asked in this section was period of egg sensitivity. Cell division in salmonid embryos begins within 12 hours (Knight, 1963). After this, eggs are sensitive to movement and handling and, as a rule of thumb, are left undisturbed until eye pigmentation can be seen. A definition of the "safe" movement period immediately following spawning should have been sought.

QUESTION 19: AS A PERCENTAGE, WHAT IS THE THRESHOLD NUMBER YOU WOULD USE TO DESCRIBE A "GOOD" EYE-UP? (50%, 75%, 95%, ETC.)



Fifty-nine percent of the respondents felt a 90-95 percent eye-up was satisfactory. A considerable number (41%) felt 80-90 percent was good. As mentioned earlier, if females are properly mature, more than 95 percent of eggs should be fertile. Causes of mortality in the pre-eyed stage could include poor sperm, excessive handling, or poor incubator environment. If the majority of the experts can get 95 percent eye-up, programs continually getting only 80-85 percent should probably take a close look at their procedure to determine if improvements could be made.

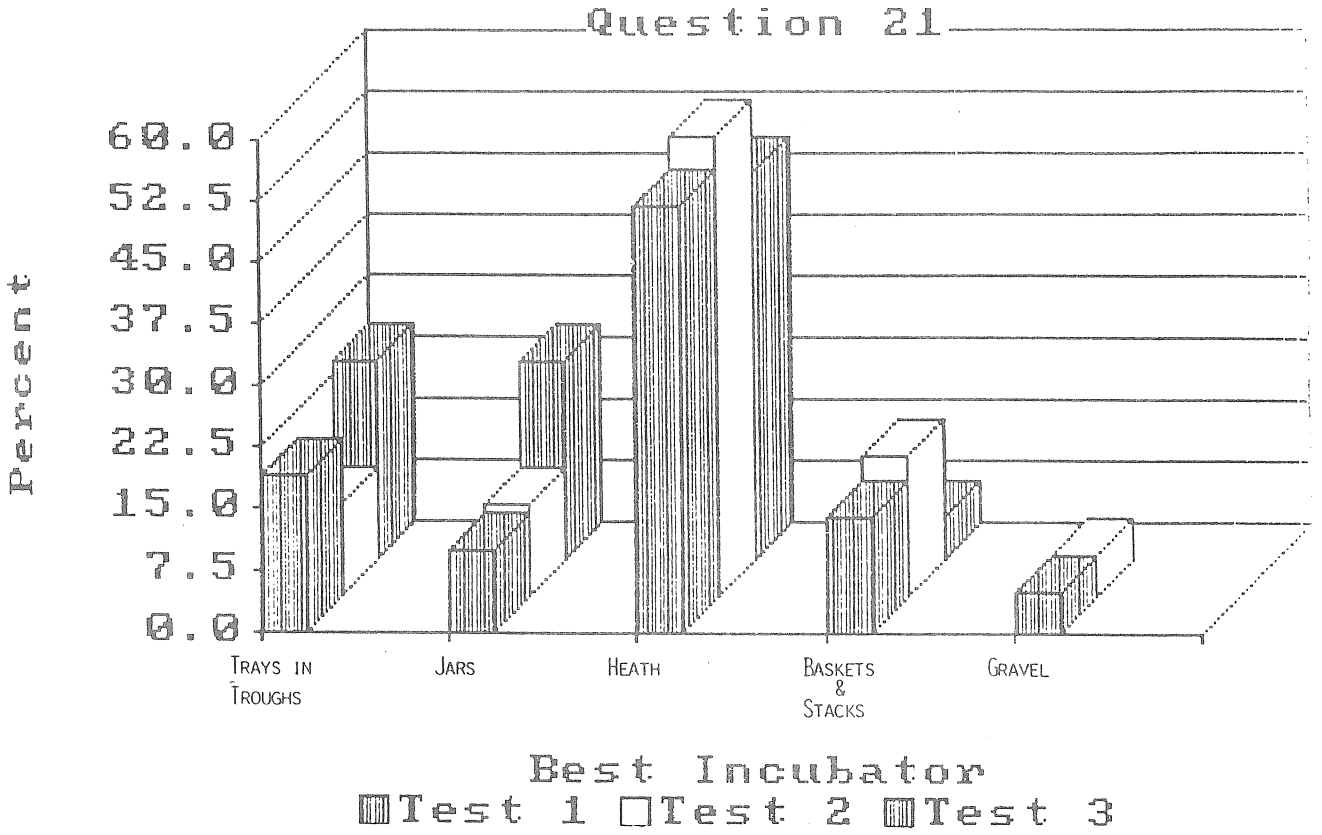


By the third round, 94 percent of the respondents had fallen in a five degree range from 46-50°F. There was a large shift away from temperatures above 50°F from round 1 (37%) to round 3 (6%). Experiments have shown that salmon eggs will incur a high mortality if incubated below 40°F during early development (10 to 30 days) (Combs, 1965). Natural spawning takes place in temperatures around 45-55°F. It appears our experts have chosen a temperature range that the literature would back up in theory.

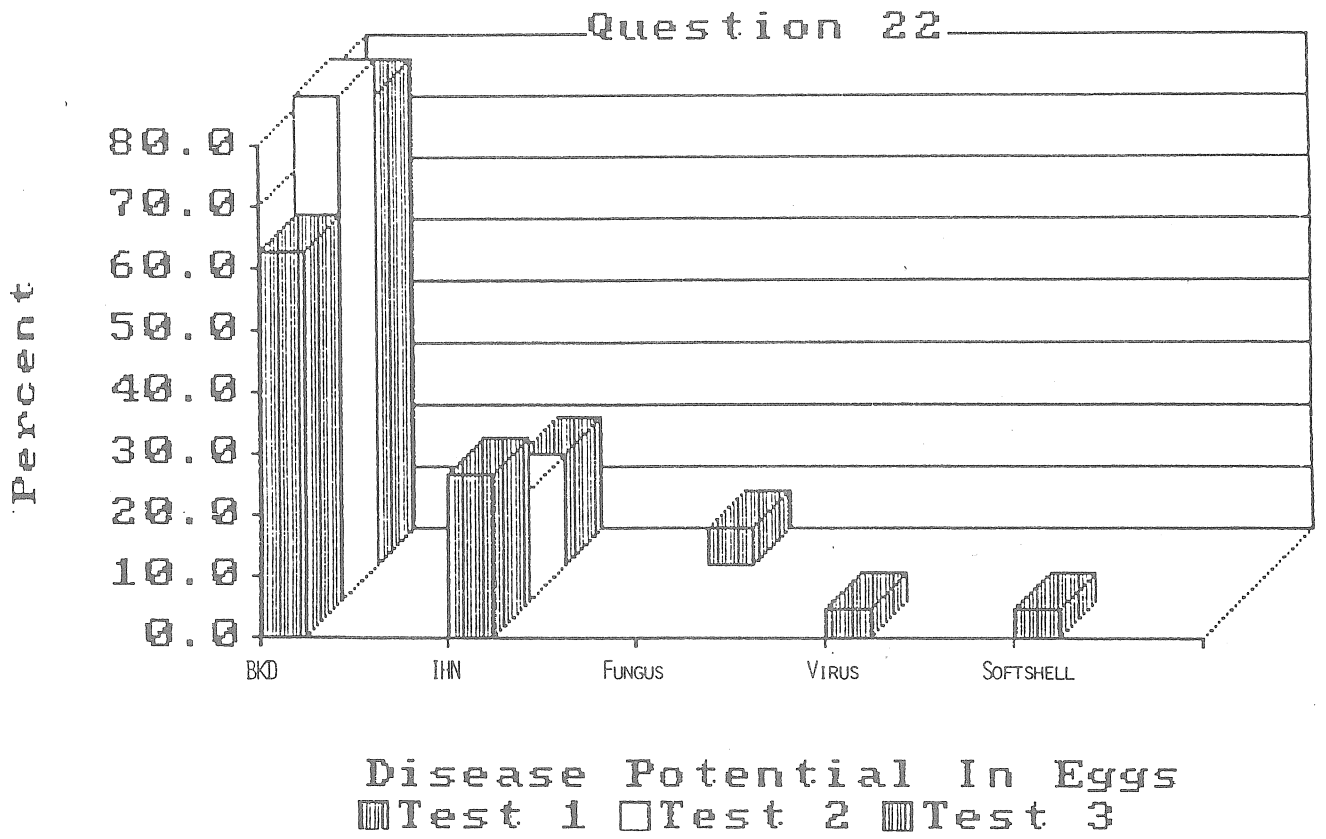
The hatchery has considerable ability to adjust the development of eggs with the use of temperature at this stage. In general, the temperature units applied to the eggs are designed so production will end up with the favored size of fish at release time. Salmon stocks are believed to be adapted to the seasonal temperature patterns of their home streams; the timing of their spawning and egg incubation appropriately adapted for the natural conditions. It is not known if artificial temperatures, beyond

Question 20 (cont.)

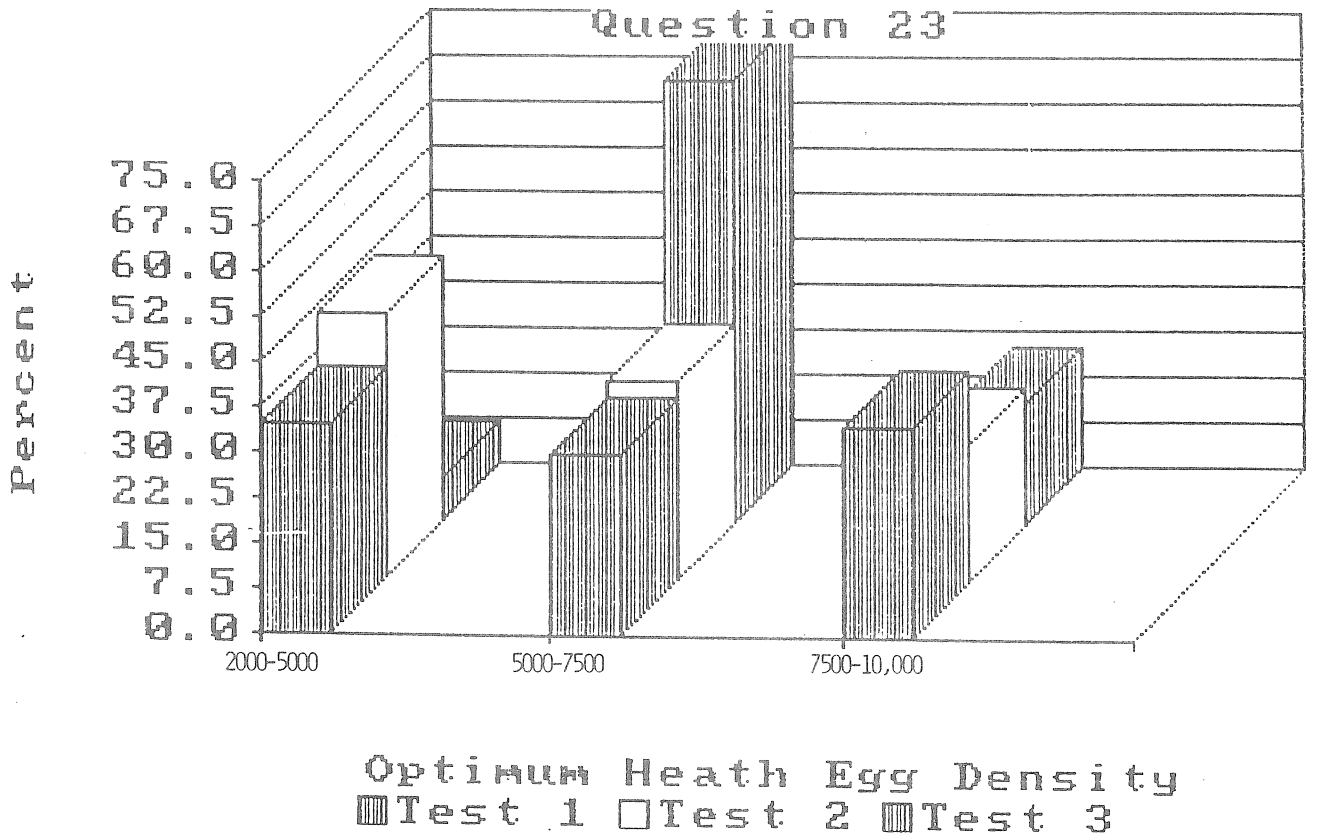
the range of what was experienced in the wild, create any eventual problems in migratory behavior or salt water adaptation. The present overriding concern is to fit the egg into a production program that results in a smolt for release at what is thought to be the optimum size and time.



As suspected, there was a varying preference for incubation systems. The favorite was the Heath incubator with a 47 percent response. Jars and troughs both had 24 percent responses by round 3. One advantage pointed out for jar incubators was that malachite treatments and fungicides were not needed. Heath's were noted for space saving and the ability to treat individual trays if necessary, but also needed more maintenance. The variety of opinions seem to indicate we have not developed a perfect incubator for all situations. The ideal incubator would provide an environment that allows the alevins to expend minimal energy and come out as fry with good yolk to body tissue conversion and energy reserve to begin the process of active feeding. Some factors that can have adverse effects on developing healthy fry include water turbulence, light, and smooth substrates.

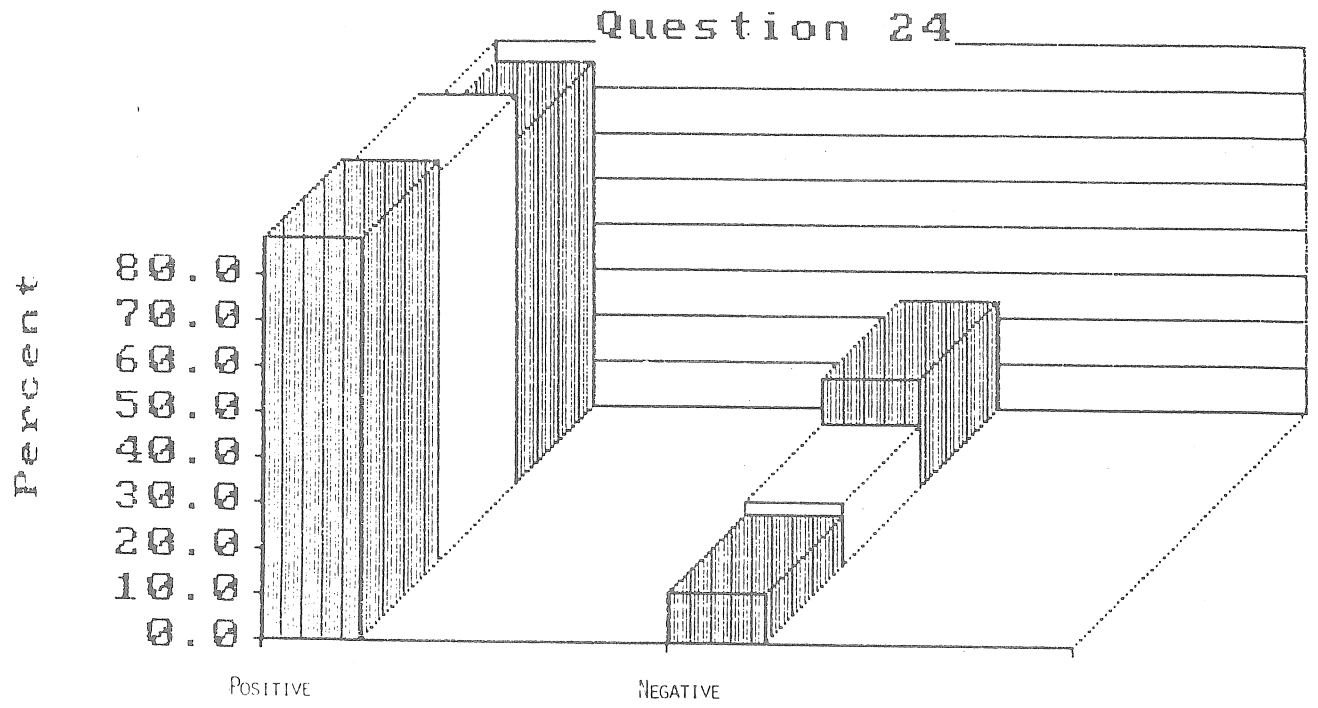


BKD was chosen by 76 percent of the round three respondents compared to 63 percent in round one. Considerable discussion of BKD will occur in the disease section and therefore will be foregone here. BKD awareness at this early stage is just another indicator that the disease is of primary concern. Eighteen percent of the respondents felt IHN should be looked for in the eggs. The Columbia River drainage has seen a dramatic rise in the incidence of this disease since 1981, but mainly in steelhead. However, IHN is known to affect chinook salmon (Amend, 1970) and presents a potential threat.



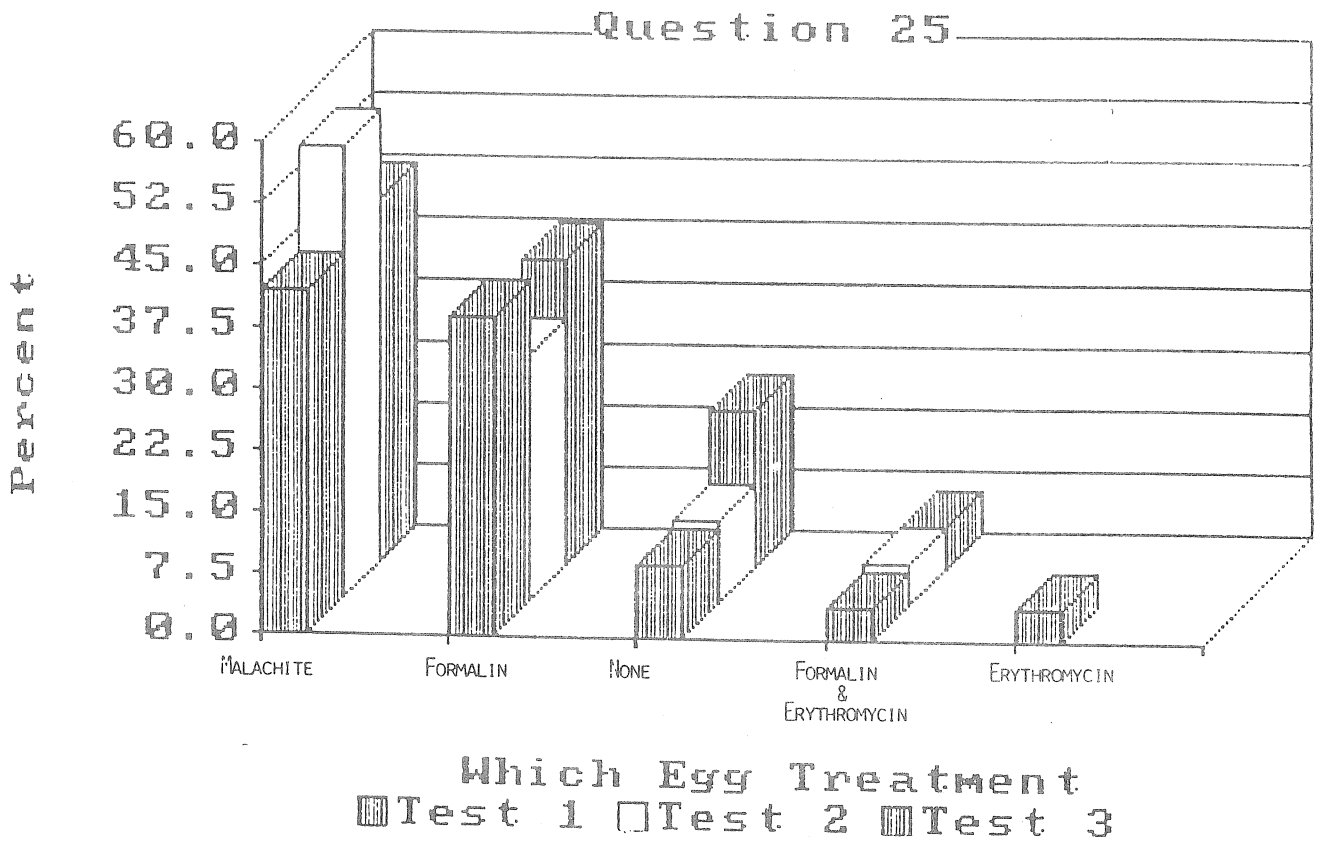
There was a major shift to the mid-range response on this question. By round three, 73 percent of the respondents felt 5,000-7,500 eggs per tray was optimum for Heath incubators; a 40 percent shift. There was a 28 percent drop in those who initially chose 2,000-5,000/tray and a 15 percent drop out of the 7,500-10,000/tray category. One respondent who recommended a low density (3,500/tray) had a valid question about the higher densities recommended by the majority "...is it because the eggs do better or is it to conserve space and water". Another cited a lack of any "definitive evaluations". Fry leaving incubators in good condition would have a head start when they begin that very important first feeding.

QUESTION 24: DO YOU THINK THE ROUTINE CHEMICAL TREATMENT OF EGGS IS A POSITIVE FACTOR OR A NEGATIVE FACTOR?



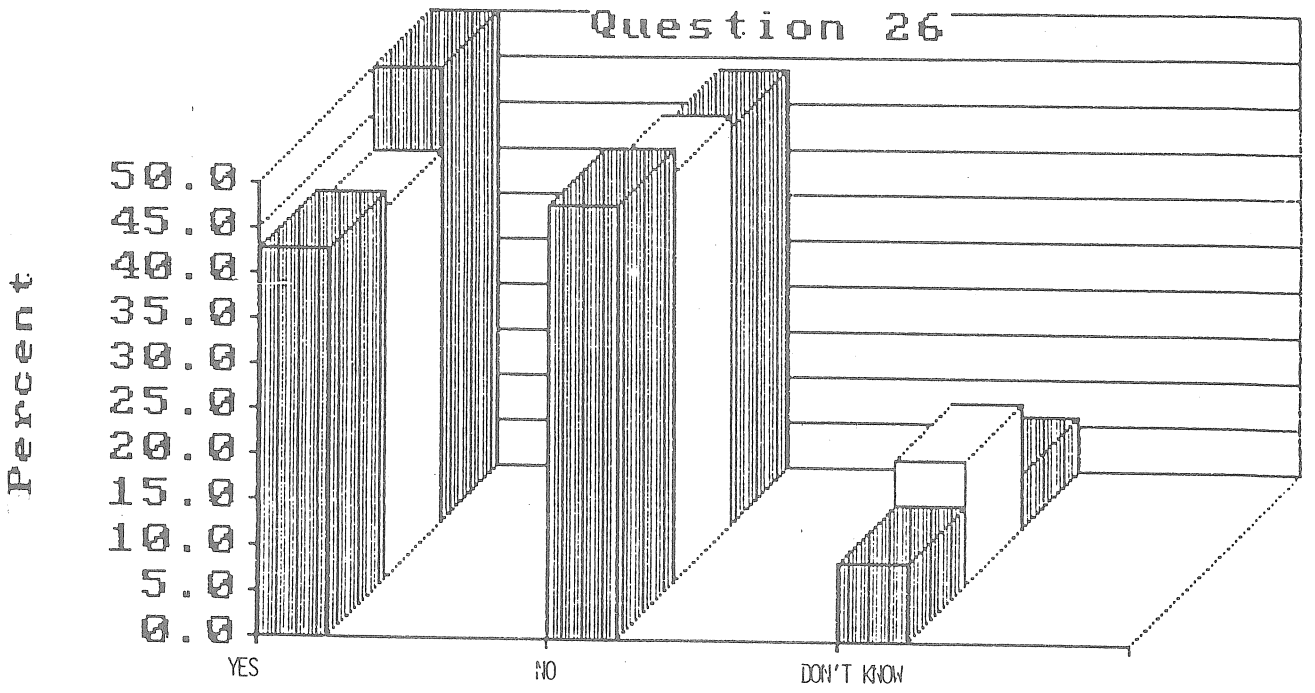
Seventy-six percent of respondents felt there were positive effects to routine chemical treatments of eggs. This was, however, a 13 percent drop from the round one 89 percent response. The disadvantages of chemical treatments are the handling stress and potential adverse reactions to improper dosages. The implication from the response, however, is that more eggs would be lost without the treatments.

QUESTION 25: WHAT CHEMICAL TREATMENT, IF ANY, WOULD YOU CHOOSE TO USE ON SCS EGGS?



There was no consensus on this question with 44, 37, and 19 percent responses by round three for malachite, formalin, and no treatment respectively. Both malachite and formalin are effective treatments for fungus, but again the administrative constraints and safety of using malachite apparently were considerations of those who chose to use formalin.

QUESTION 26: DO YOU THINK ARTIFICIAL SUBSTRATES ARE IMPORTANT IN REDUCING EGG MORTALITY AND INCREASING THE GENERAL STRENGTH/HEALTH OF SAC FRY?



A real split in opinion on this question with 50 percent feeling artificial substrates were important and 44 percent feeling they were not. There is a growing body of literature which says it can be a very important factor in producing healthy fry. The Soviets were the first to propose that incubators with smooth substrates could have deleterious effects on fry including: (1) injury to yolk sac (malformation), (2) deformation of gut, (3) translocation of liver, (4) fat distrophy, (5) small size (poor yolk to tissue conversion), and (6) poor stamina (McNeil, 1975). In many Soviet hatcheries, alevins are transfered from incubators to open gravel bed channels and Canada is making extensive use of spawning channels. Incubators with various forms of substrate from gravel to artificial grass have also been used.

If healthy, robust fry are better able to begin feeding, ward off disease, and have greater tolerance to other environmental stresses, common sense

Question 26 (cont.)

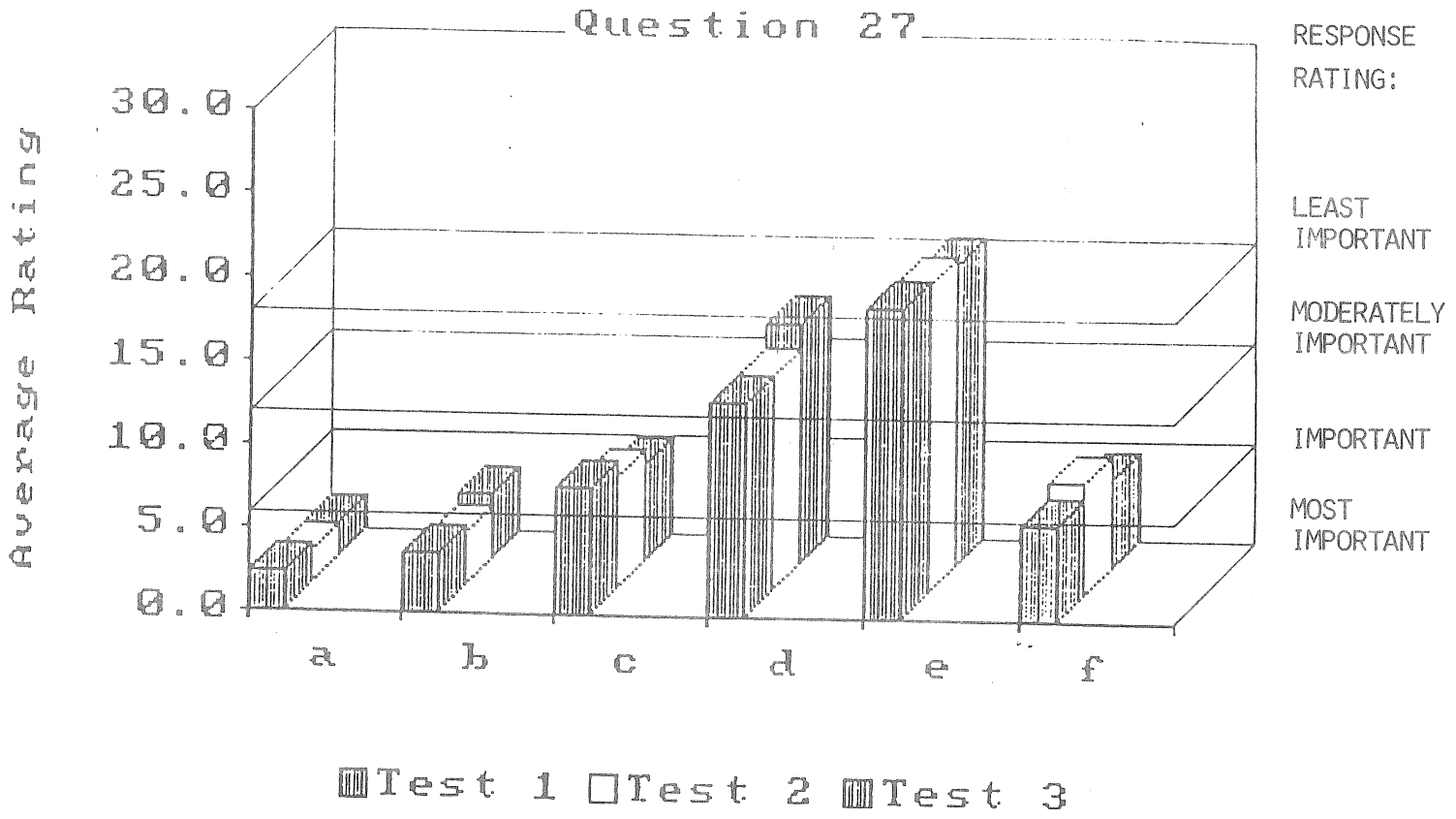
dictates we get fry to the rearing tanks in optimum condition. It appears that use of artificial substrates can have positive effects in that regard and probably should be evaluated for use at production levels.

NURSERY REARING

As alevins become feeding fry, the job of maintaining a healthy rearing environment becomes more difficult. Increased metabolic activity, waste production, and organic loads in the form of fish feed require a continuous source of high quality water to maintain a clean environment. The technology required to deliver this water may be relatively simple in spring source gravity-fed systems or extremely complex such as in a re-use system. The fish culturists will now closely monitor tank densities, disease indicators, and feed conversion data to chart the growth and health of the fish.

This series of questions seek to define the basics of a successful fry program and point out where problem areas still occur.

Suggested references: (5, 18, 33, 35, 37, 42, 45, 53)



Question 27. What are the most important factors involved in giving SCS a good start in the nursery phase?

a. Temperature
b. Starter diet
c. Loading density
d. Disease history
e. Overhead cover
f. Water quality

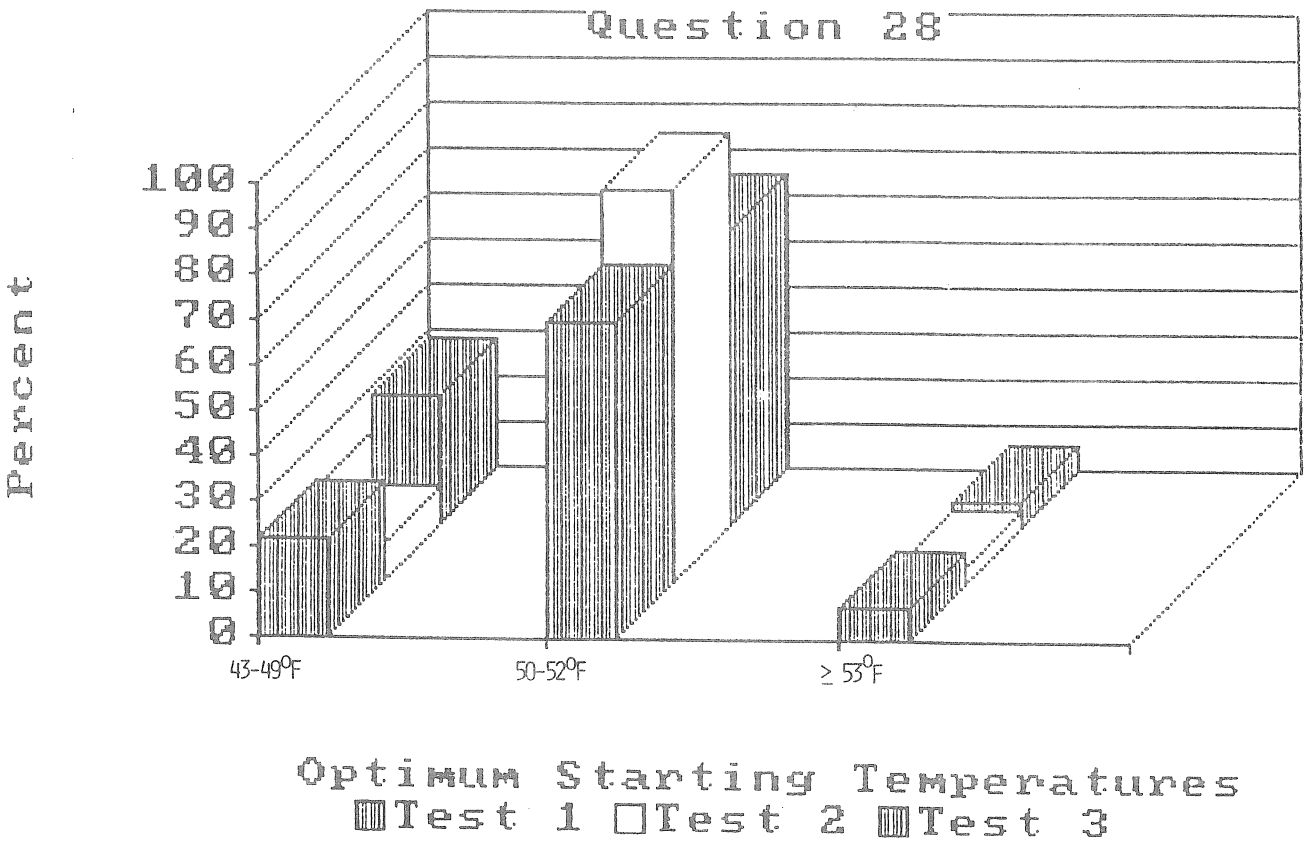
Response Rating Guide

1- 6	Most important
7-12	Important
13-18	Moderately important
19-24	Least important

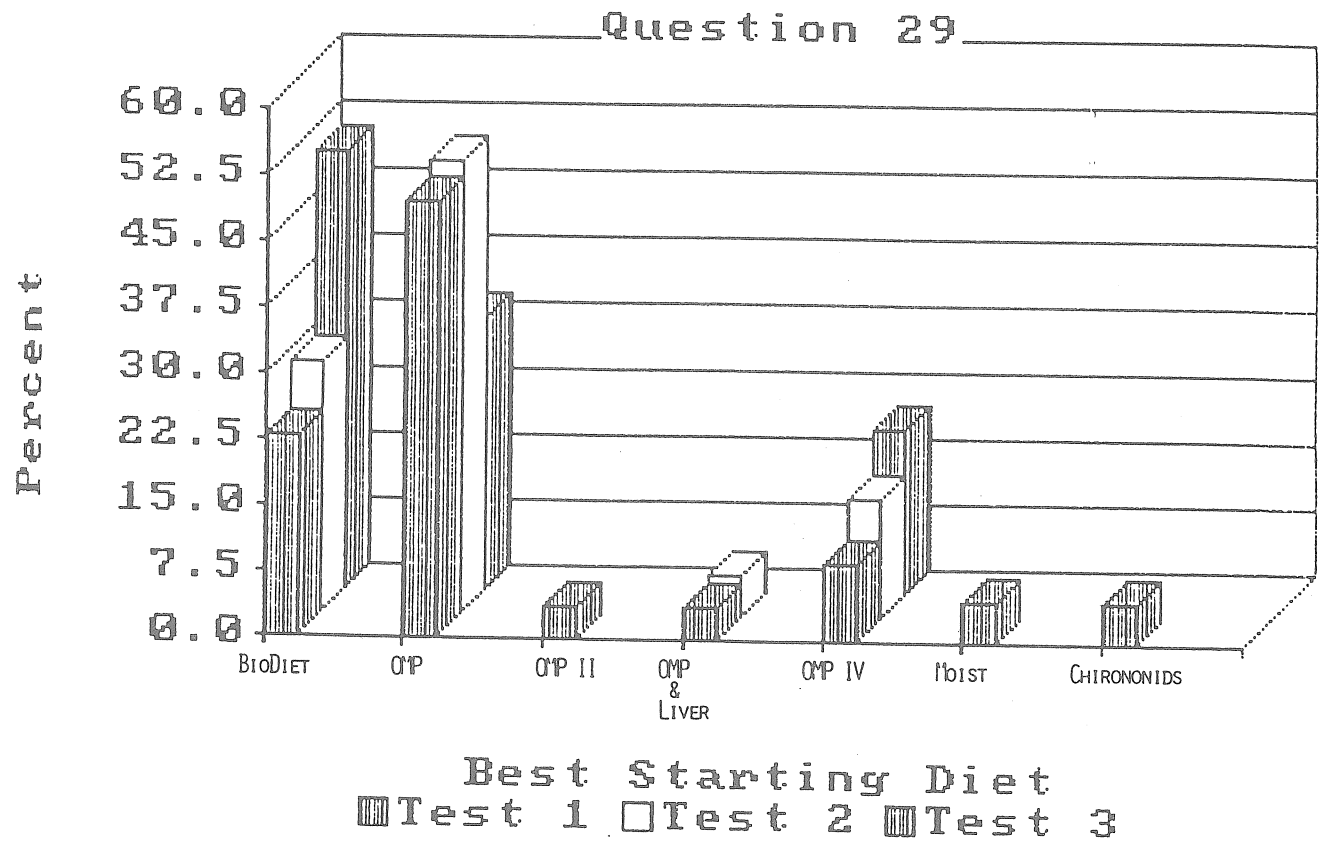
Question 27

There were few changes in opinion on this ranking question and four of the six factors were chosen as very important by the group: temperature, starting diet, loading density, and water quality. The questions that follow in this section give the experts opinions on how to optimize these factors.

QUESTION 28: WHAT DO YOU THINK IS THE OPTIMUM TEMPERATURE FOR STARTING SPRING CHINOOK?



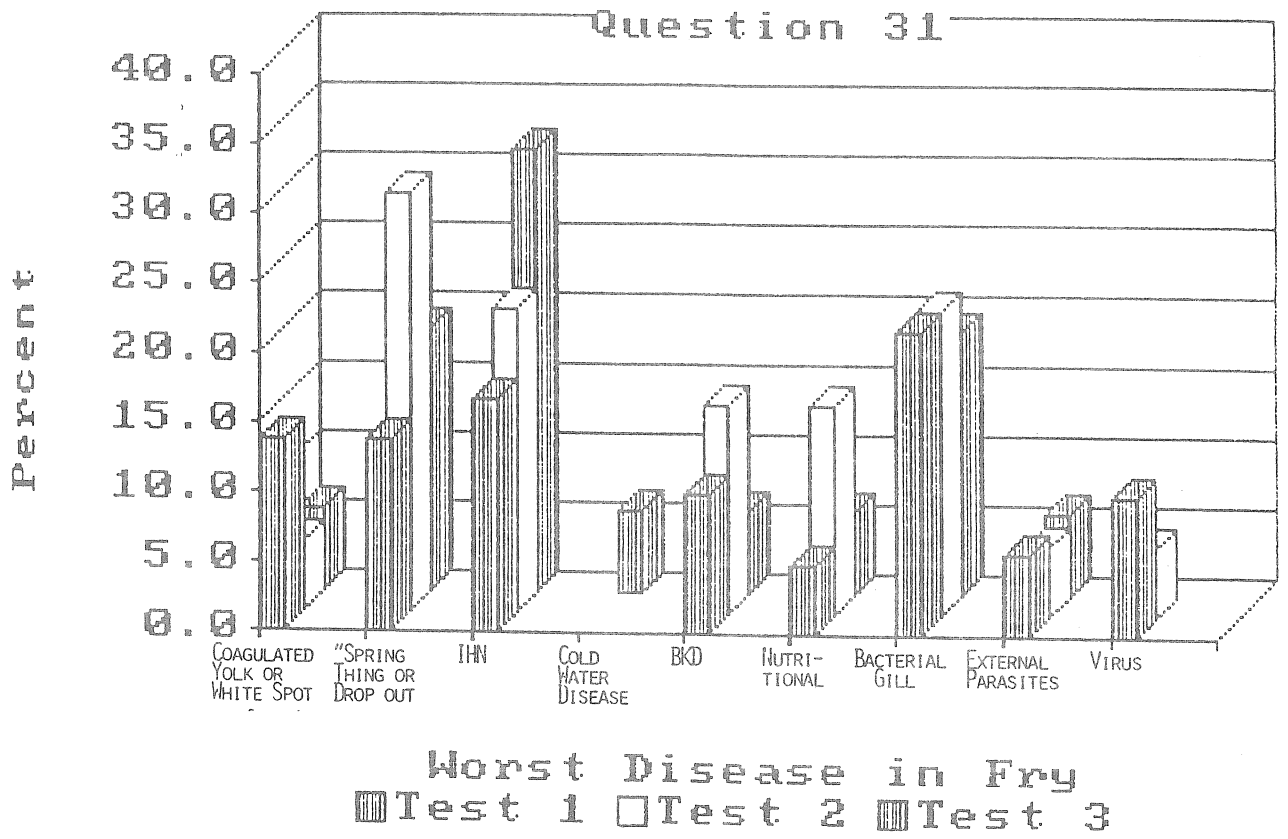
By round three, 65 percent of the respondents felt 50-52°F was the optimum starting temperature. However, 29 percent chose temperatures in the 43-49°F range. No strong consensus is apparent. We know salmon fry can grow in a range of temperatures from 40-60°F. In general, the colder temperatures will limit growth, and disease risks increase at higher temperatures. These relationships of temperature, growth, and disease are some of the better understood principles in fish culture. It would then seem that each expert chose a range which he has had success with under a set of conditions unique to an individual facility. Preference in temperature could vary depending upon total growth needed during nursery rearing and disease and parasite concerns.



There was no consensus as to one overwhelming favorite diet, but there was a major shift towards BioDiet away from OMP. Twenty-three percent chose BioDiet in round one; this increased to 50 percent by round three. OMP IV also picked up from 9 to 19 percent by round three. Although liver had dropped out by round three, Eagle Creek NFH has had succes in recovering from "drop out" disease by feeding mashed liver (Jim Holway, pers. comm.). It appears that there was a shift towards higher animal protein diets in general. An entire section on diet will have more discussion later.

Question 30

This question has been omitted due to variances in density units used by respondents which made comparisons impractical.



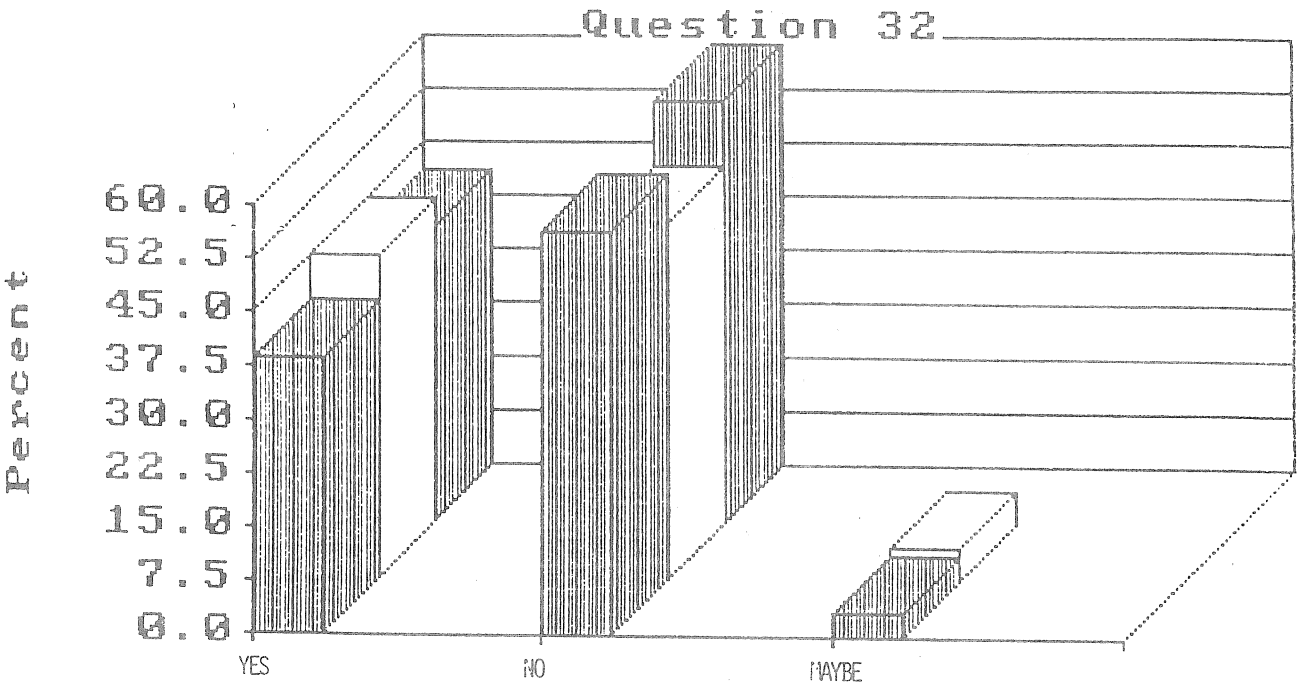
IHN, "spring thing" or drop out, and bacterial gill disease ranked one, two, and three in terms of percentage response. There was a significant movement towards IHN (from 17% to 32%) as the disease of concern at this stage. BKD most often occurs at a later stage and larger size during pond rearing and ranked low (6%) as a concern during nursery rearing. However, the Dworshak Fish Health Center documented a BKD outbreak at Hagerman NFH on fry at about 350/lb. in 1983.

"Spring thing" or drop out at this point may be best described as a chronic syndrome where young fry go off feed and drop back to the outflow end of the tank where they continue to lose condition until dying. A more complete description is provided by Wood (1974). It is suspected that diet may play a major role in preventing this event and one hatchery manager has said he was able to reverse the condition of drop out fish by feeding ground liver. I

Question 31 (cont.)

don't believe anyone can say at this point whether nutrition is the sole cause of drop out or if other factors such as water temperature plays a role, or even if these factors are just exacerbants to a true disease. The FWS Tunison Lab is now looking at the role of diet in drop out.

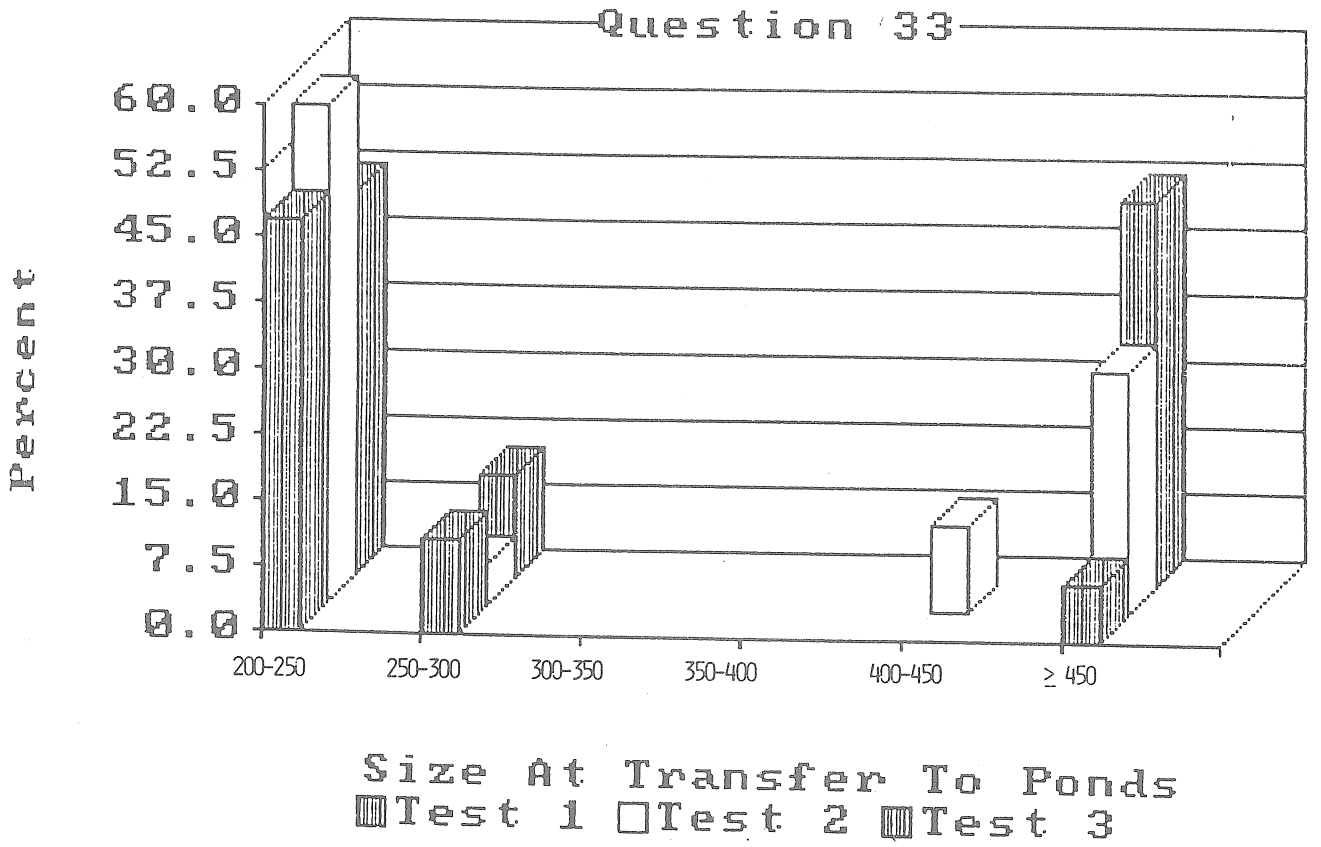
Given the unknowns about drop out and its potential effect, 20-30 percent fry loss at affected hatcheries (Jim Holway pers. comm.) it is surprising that it garnered only 19 percent of the votes as most feared disease in spring chinook fry.



The majority (59%) of the respondents felt cover was not important during nursery rearing; 41% felt it was. The most common reason given by those in favor was that it reduced sunburn and had a stress reducing effect. One respondent felt diet was more of a factor in sunburn prevention than cover itself.

In the wild, cover has long been associated with increased trout biomass (Hooper 1973; Mullan 1975; Hunt 1971; and Lorz 1974). Instream cover for salmonids provides an area for rest, safe from predators or adverse effects of the elements such as sun or ice. Through inside rearing or outside netting, predation is largely eliminated as an environmental risk. But, for those stations rearing fry outside, the effects of cover as a sun blocker should still be considered. There is also a possibility that cover provides an ameliorating or therapeutic effect by reducing any stresses created by rearing in a high density artificial environment. This is as yet unproven.

QUESTION 33: WHAT IS THE OPTIMUM SIZE THAT SCS SHOULD BE TRANSFERRED FROM NURSERY REARING TO FINISHING PONDS? (NO./LB.)

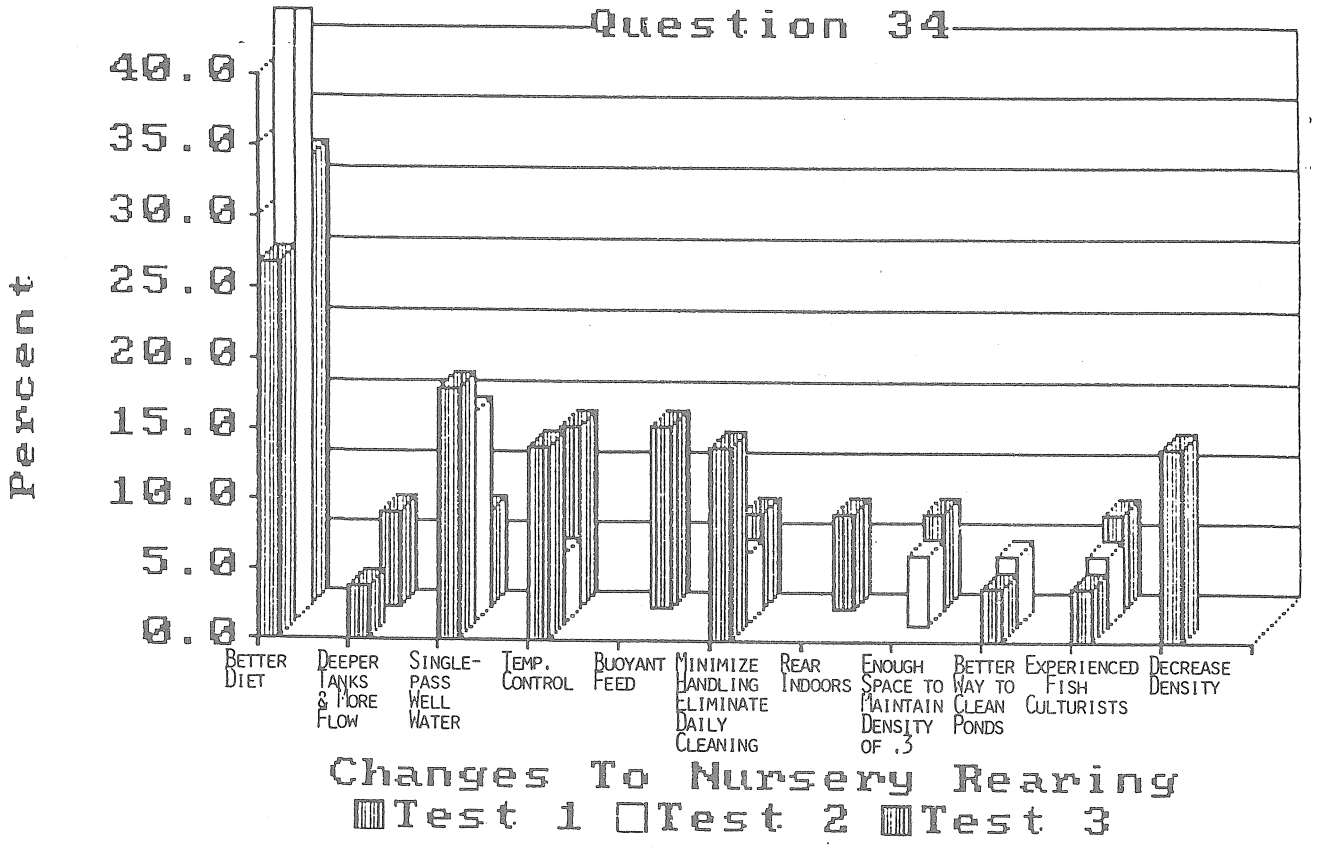


This is another question that could have been stated more clearly. We should have set up some theoretical guidelines such as "given pond space and availability and water quality were not limiting factors, what size would you transfer spring chinook from nursery tanks to rearing ponds?" As it was, there was a split in consensus with 56 percent choosing 200-300/lb. and 44 percent choosing greater than 450/lb. There was a vascillation of opinion in the 450/lb. category which started at 42 percent in round one, fell to 28 percent in round two and jumped back to 44 percent by round three. Many of the justification responses from those favoring transfer at greater than 450/lb. cited other factors in their decision such as tank density and space availability constraints or other physically limiting factors of the hatchery or water source. There was a strong contention by those favoring 200-300/lb. that better care and individual attention could be given to fish in the tanks and larger fry handle more efficiently once they are moved to rearing ponds. In general, the group

Question 33 (cont.)

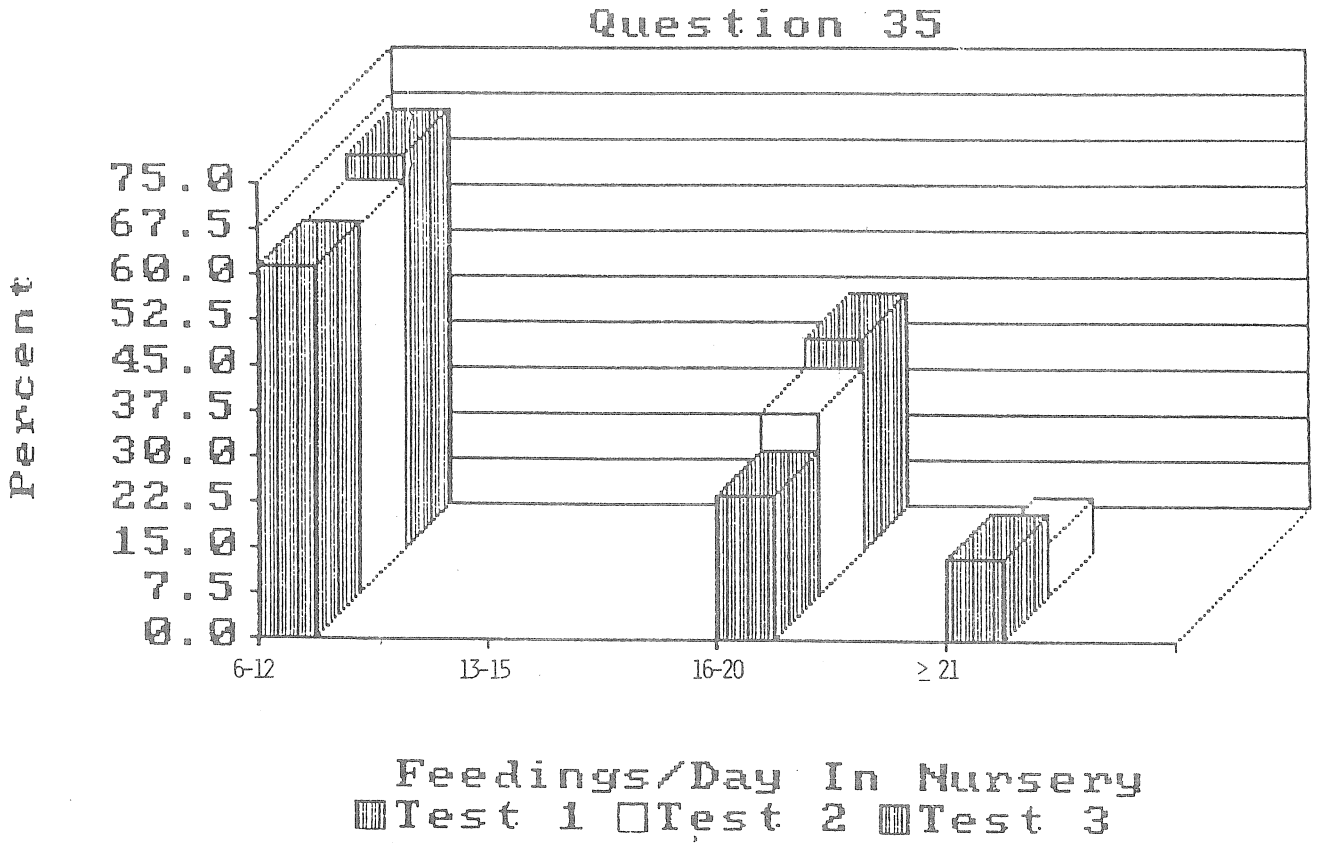
favoring movement at the smaller size were most often influenced by facilities constraints. Those who would hold until 200-300/lb. had the feeling they were doing what was best for the fish, i.e., they had more biological justification.

QUESTION 34: IF YOU COULD MAKE A SINGLE MODIFICATION IN NURSERY REARING TO IMPROVE IT, WHAT WOULD YOU CHANGE?



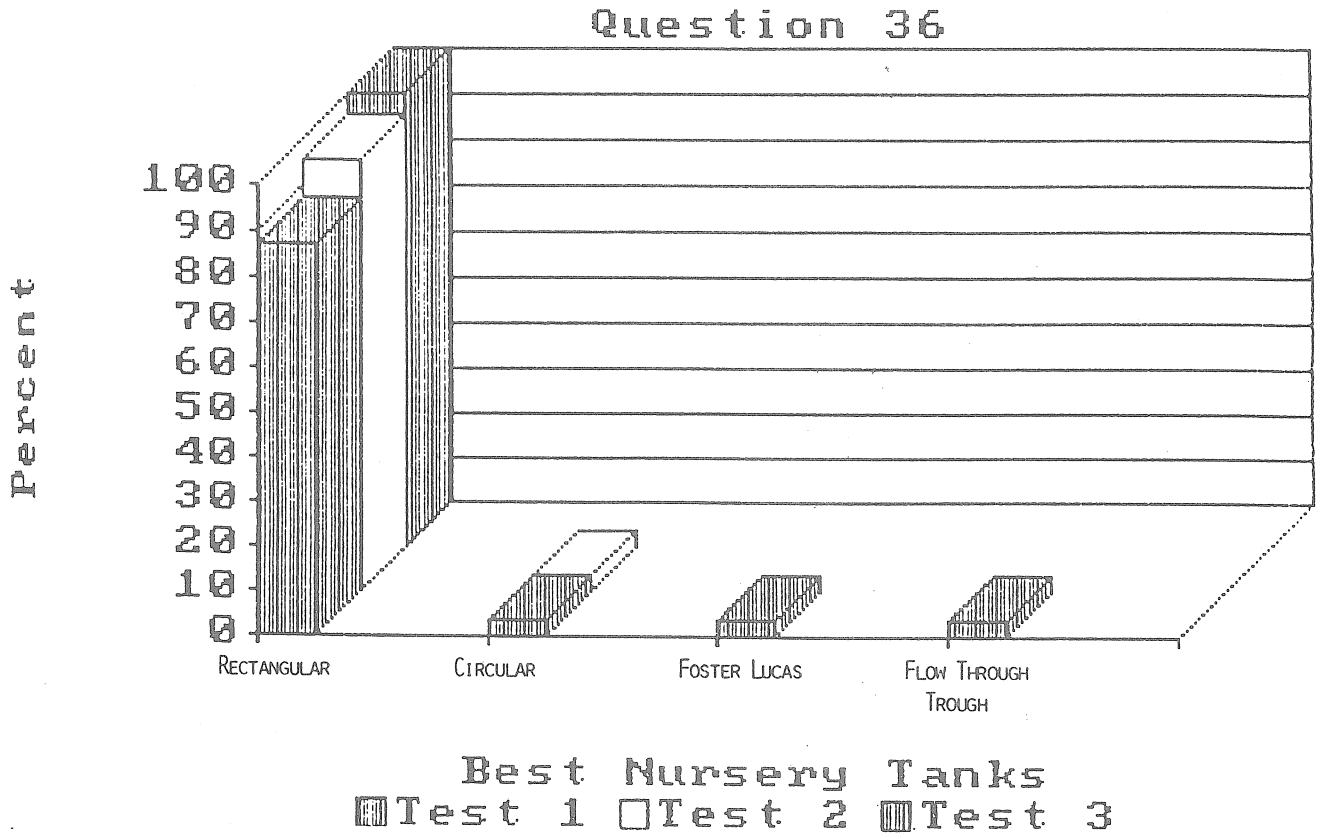
By round three there were still ten different suggestions. Diet modification did snag a 32 percent majority as the most popular modification. I can only guess that most experts suggested a modification for a pet peeve encountered at his station of experience. However, by including "buoyant feed" as a diet related problem nearly 50 percent of the respondents felt diet modifications were most needed.

QUESTION 35: HOW MANY TIMES PER DAY WOULD YOU FEED IN THE NURSERY STAGE?



The answers were put into two ranges: (1) 6-12 times/day and (2) 16-20 times/day. On round one, 14 percent of the respondents would have fed more than 21 times per day. Sixty-five percent favored 6-12 times/day by round three; 35 percent favored 16-20 times/day. After round two we asked the 16-20 times/day group to justify their response. All of them, in one way or another, said it was very important to keep food in front of the fish as much of the time as possible. This in effect is providing feeding opportunity on demand as it is available so often. I could find no literature showing a clear cut advantage to either type of feeding regime. Although the thought of food on demand sounds appealing, I have seen no proof it is necessary. In the end the production manager must design feeding frequencies around water temperature, type of feed, and fish size and avoid feeding at a rate which results in the accumulation of uneaten food which poses a threat to water quality.

QUESTION 36: WHAT TYPE OF TANK DO YOU THINK IS SUPERIOR FOR NURSERY REARING SCS (CIRCULAR, RECTANGULAR, ETC.)?



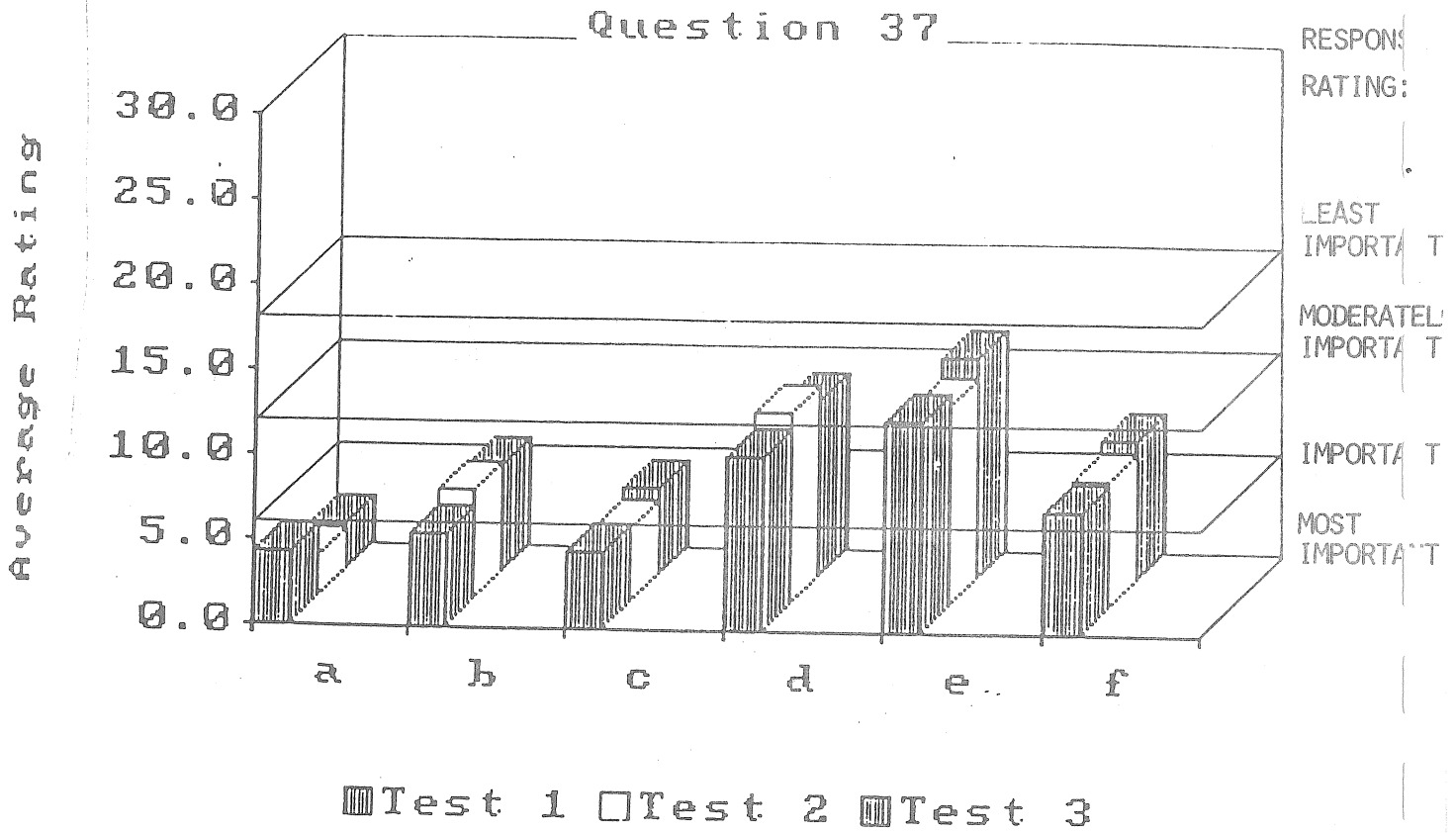
This was the only perfect consensus. Three unabashed experts suggested something other than a rectangular tank on round one but were convinced by round three for a 100 percent response. The comment heard most against circular tanks was the difficulty in keeping them clean and water circulation problems such as dead spots and inefficient exchange rates.

POND REARING (Parr Stage)

In most yearling programs, spring chinook will spend about 11 of their 19 rearing months in outside rearing ponds. Spring chinook have earned the reputation of being a skittish, difficult species to rear, seemingly oversensitive to treatments and conditions other mass cultured anadromous salmonids take in stride. Is the culture of spring chinook rife with unknowns at this stage? Are the secrets to successful culture still locked away? Or do we know what is best and are simply limited by facilities and technology in providing the best treatments.

The questions in this section are quite similar to those in the nursery section as diet, disease, and water quality continue to be areas of concern at this stage.

Suggested references: (2, 5, 20, 21, 33, 35, 37, 42, 44, 45, 51, 53)



Question 37. What are the most important factors involved in raising SCS parr? (Larger than 250/lb--approximately)

a. Water temperature
b. Type of diet
c. Loading densities
d. Disease history
e. Type of pond
f. Water quality (mineral content, pH, D.O., etc.)

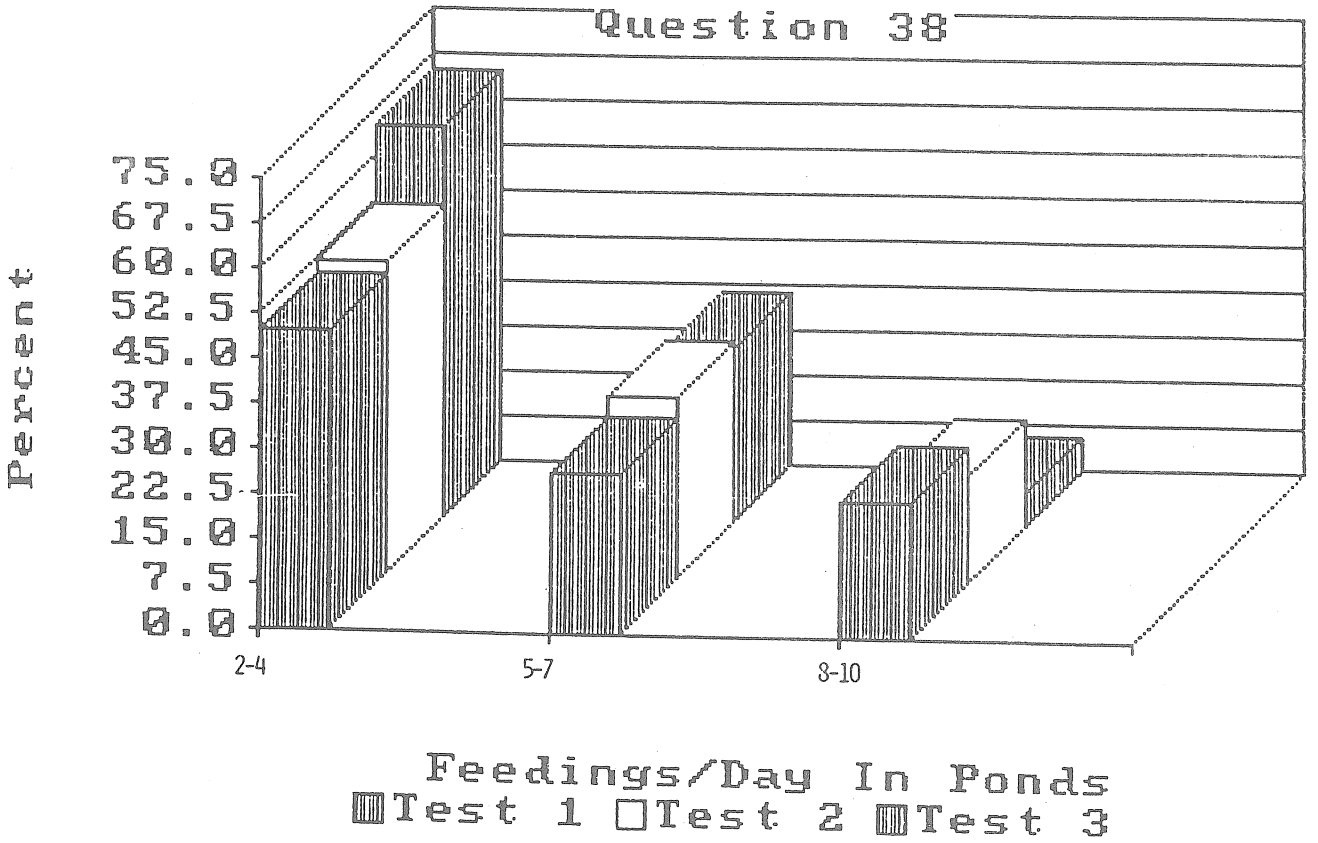
Response Rating Guide

1- 6 Most important
7-12 Important
13-18 Moderately important
19-24 Least important

Question 37

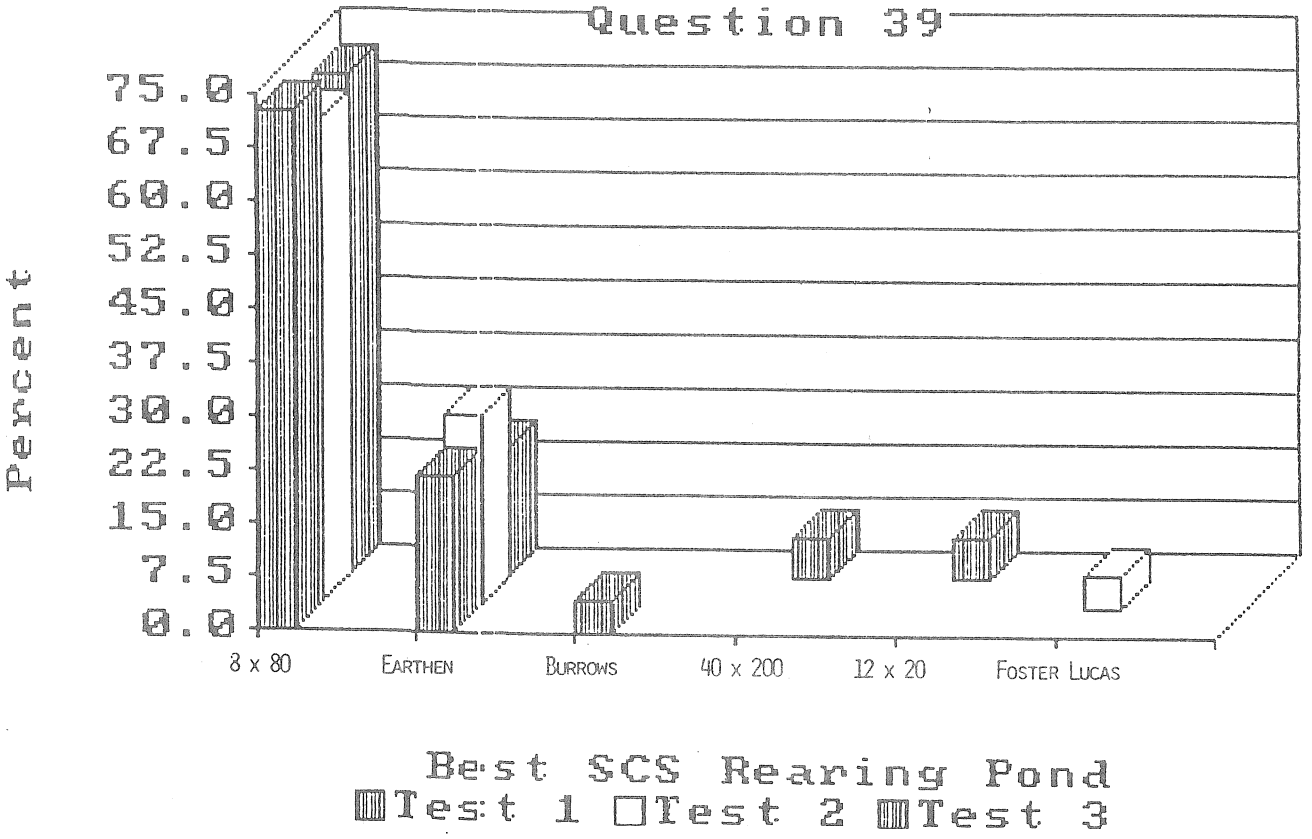
Few changes of any significance occurred through the three rounds. The average group rating for three of the six listed factors fell in the "most important" range. In order of ranking, they were water temperature, loading densities, and type of diet. Disease history and water quality were rated very important and pond type only moderagely important. Water temperature affects a multitude of factors including dissolved oxygen levels and consumption rates, metabolic activity, and growth of fish and disease potentials.

The overall high rankings of these factors emphasizes the fact that pond rearing success will not be bought with absolute control or perfection of any one or two factors. There are several technical and biological links in the pond production chain that if broken could result in a production crisis.

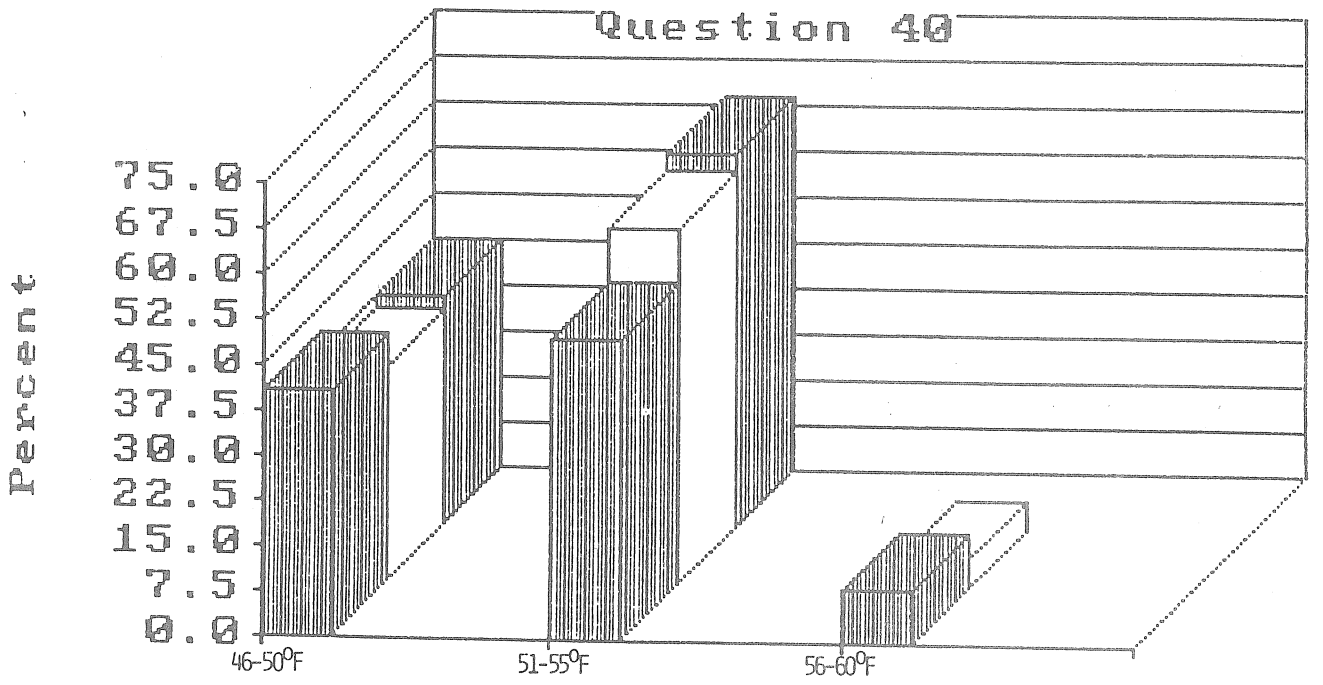


Responses varied from two to ten times per day with 65 percent favoring two to four feedings per day by round three. This was a 15 percent increase from round one and picked up the extra percentage points from the eight to ten times per day group; they fell from 23 percent to 6 percent response by round three. Several of the five to seven times per day respondents felt feeding more often put more feed in the fish and less on the bottom. That is, less feed given out more often, in the same daily ration as more food given at each feeding but less often, was a more efficient and cleaner feeding system. This crystal clear logic however did not persuade their peers as even more of them selected two to four feedings per day on round three after reading the justification.

QUESTION 39: ASSUMING YOU HAD SINGLE-PASS, FIRST SERIAL WATER, WHAT TYPE OF POND WOULD YOU SELECT TO REAR SCS PARR? (8 x 80, BURROWS, EARTHEN, ETC.)



No real change in this one as the old 8 x 80 received a strong vote of confidence with a 70 percent response by round three. Earthen ponds were the next choice, but by only 18 percent of the respondents. They cited better feeding response, no cleaning or sampling to induce stress, and lots of space for fish as positive factors for earthen ponds. The earthen ponds also do not easily lend themselves to controlled disease treatments (e.g. formalin for parasites), accurate pond accounting and raceway by raceway management. A raceway population can be treated individually according to its needs for food, disease or other special treatments while in an earthen pond, where perhaps one-half of all station production is being reared, you must treat the goose with the gander as there is no way to separate specific lots. Ponds would also be an increased risk when fighting horizontally transmitted disease. These disadvantages weighed against the potential advantages afforded by a more spacious rearing environment with fewer handling stresses apparently swayed our experts towards favoring the artificial home of the concrete pond.



Optimum Rearing Temp. For Parr
Test 1 Test 2 Test 3

By round three, 62 percent of the respondents had selected 51-55°F and 35 percent had selected 46-50°F. Both answers are well within the range suitable for growth.

In reality, water temperatures will be dictated by the spring or stream source. The 10°F range of water temperatures in the responses may be a reflection of the variation in individual rearing regimes as affected by available water temperatures throughout the basin. If so, we are left with an answer born out of the practical experience of having to rear fish in the water source and temperatures available; a situation which gives us little latitude to experiment in defining optimum rearing temperatures.

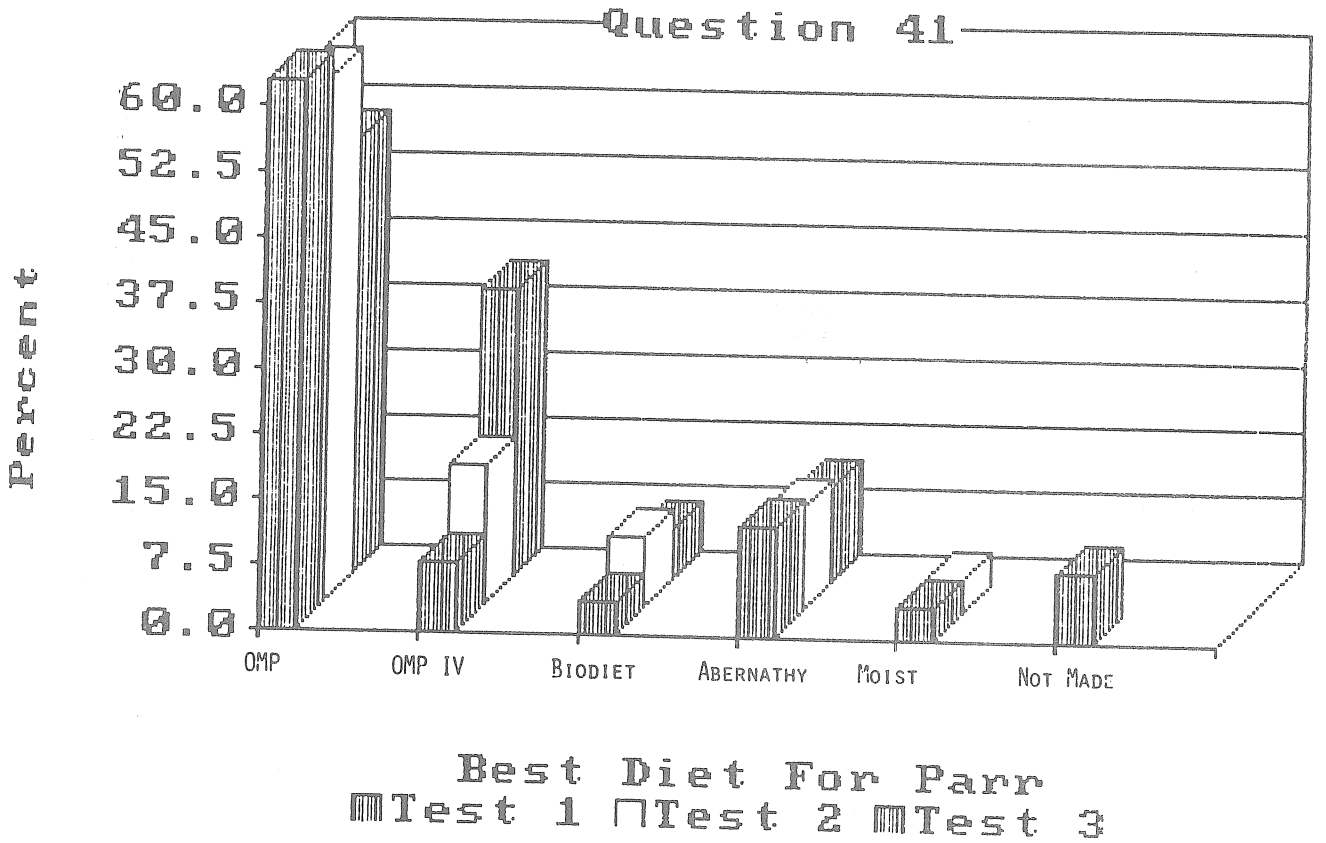
It is bothersome that the factor rated "most important" to successful rearing, a factor which affects growth, health, feeding rates, metabolism,

Question 40 (cont.)

and disease, cannot have an optimum range defined any closer than the 10°F range seen here. There are certainly drastically different results of fish reared at 46°F versus 55°F.

I would ask each expert reviewer to examine the results of this question closely and judge whether the 10°F range in the response is acceptable, or if a true narrower optimum range does exist where the most efficient balance of growth and disease control is realized.

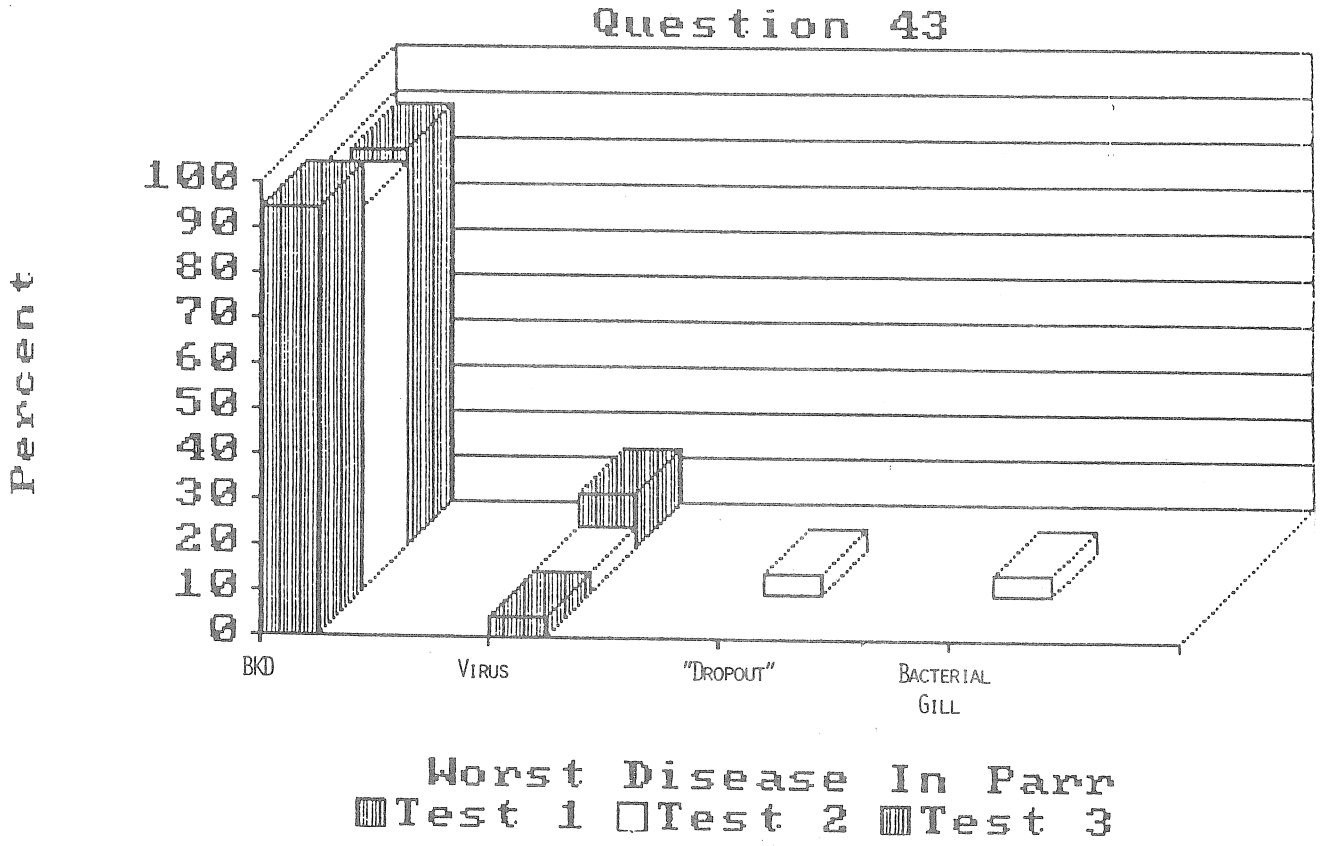
QUESTION 41: WHAT DIET WOULD YOU CHOOSE TO FEED SCS PARR?



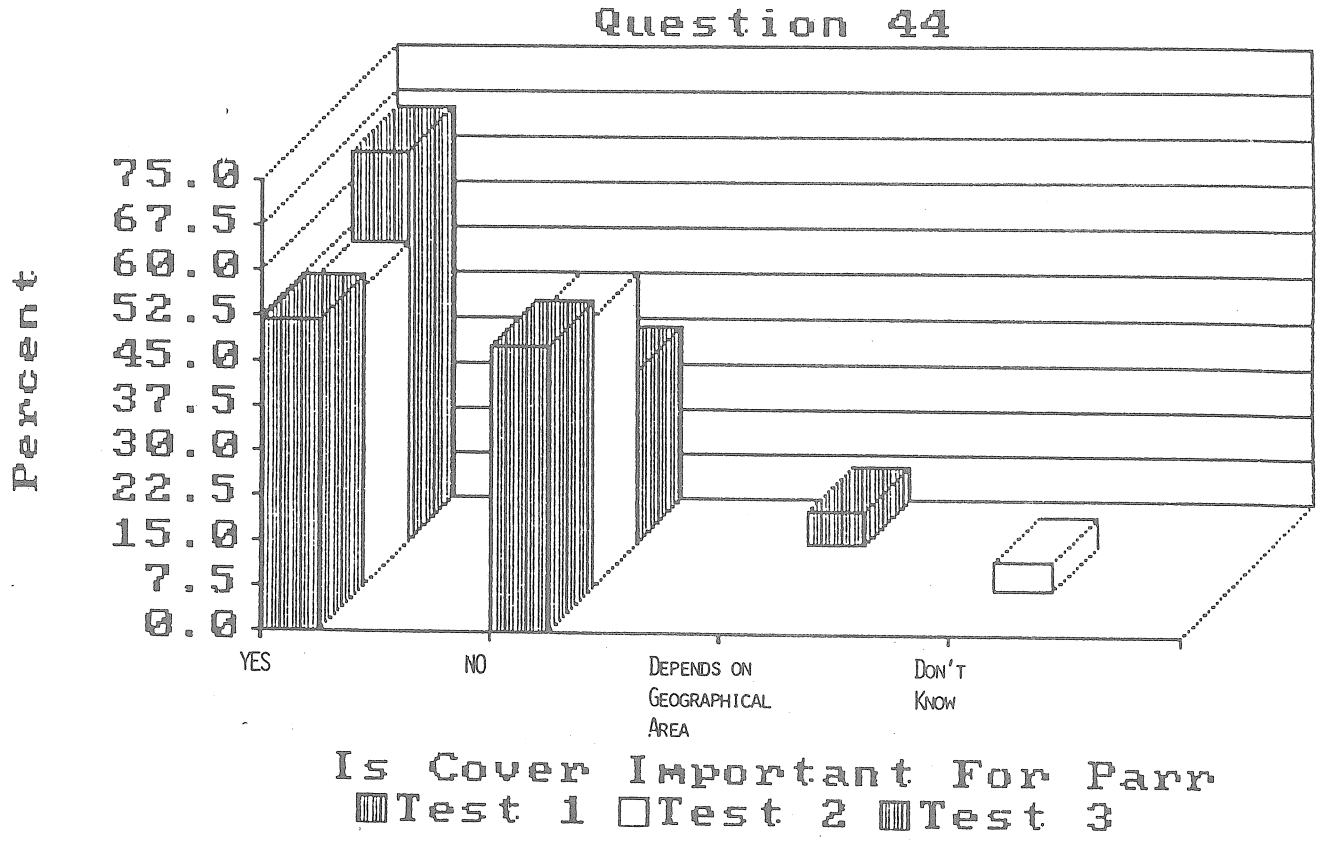
There was a split vote by round three with 50 percent favoring OMP II and 33 percent favoring OMP IV. BioDiet and Abernathy attracted six and eleven percent of the respondents respectively. There was a 25 percent increase in OMP IV as a choice from round one to three. A full one quarter of the experts saw something they like about OMP IV and switched. More discussion of diets will occur in the "Diet" section.

Question 42

Question 42 was omitted due to variations in units given by respondents in defining optimum density. The answers were therefore uncomparable.



A strong consensus of experts (88%) felt BKD was the most feared disease. Twelve percent chose "virus", but did not specify which one. Further discussion of BKD will be reserved for the "Disease" section.



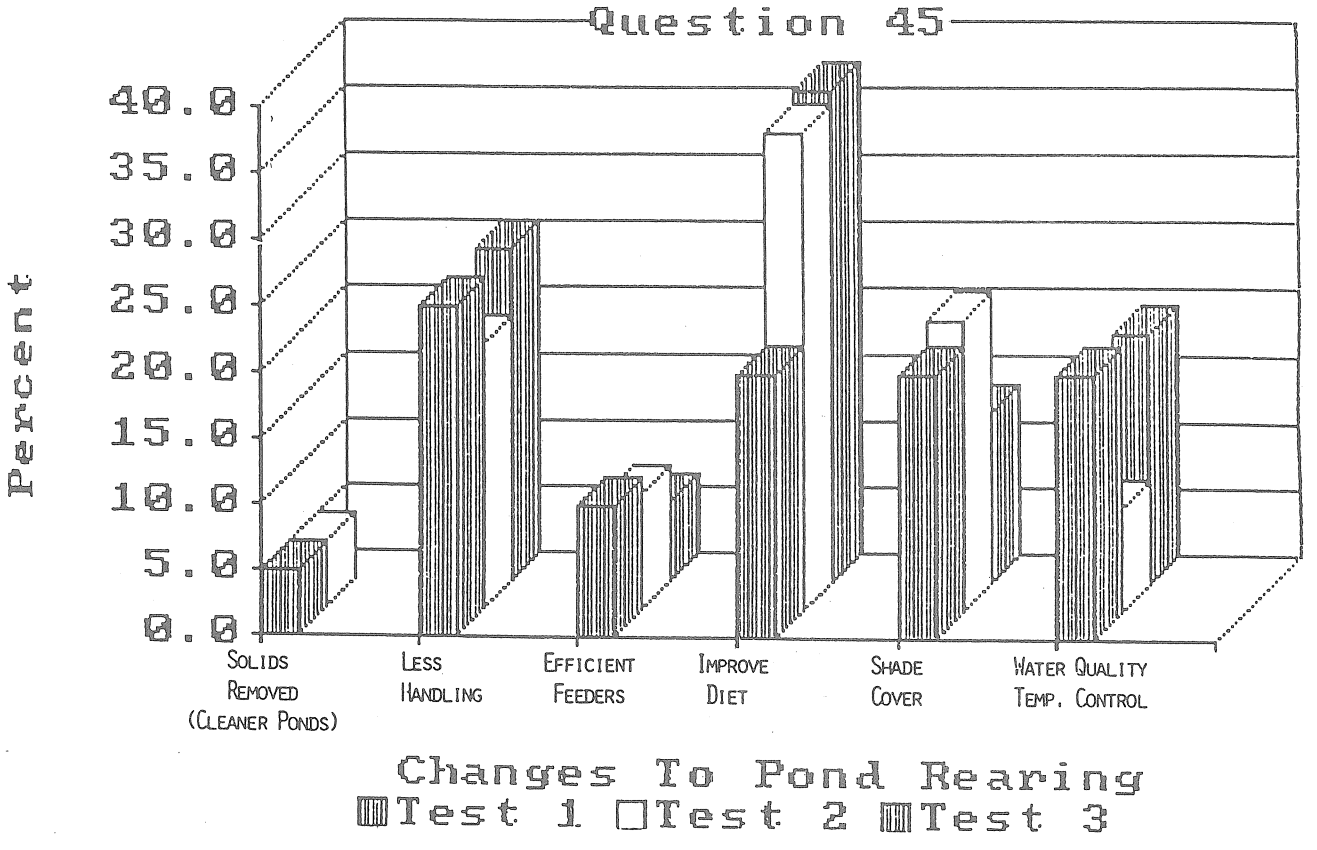
A 65 percent majority recognize cover as important to successfully rearing spring chinook parr. This represents a 13 percent increase over round one. Two explanations were given for its need: (1) to reduce the hazard of sunburn, and (2) to provide a less stressful environment by creating refuge from avian predation and providing shade which the chinook will select as resting areas if given a choice.

One respondent not favoring cover said he had tested it on spring chinook, rainbow trout, and Atlantic salmon and found it neither improved growth rates, food efficiency, disease incidence, or cured sunburn. Another felt that if predation and sunburn could be controlled by more efficacious means, there was no need for cover, i.e., the purely stress ameliorating effects of cover were not profound enough to warrant the expense.

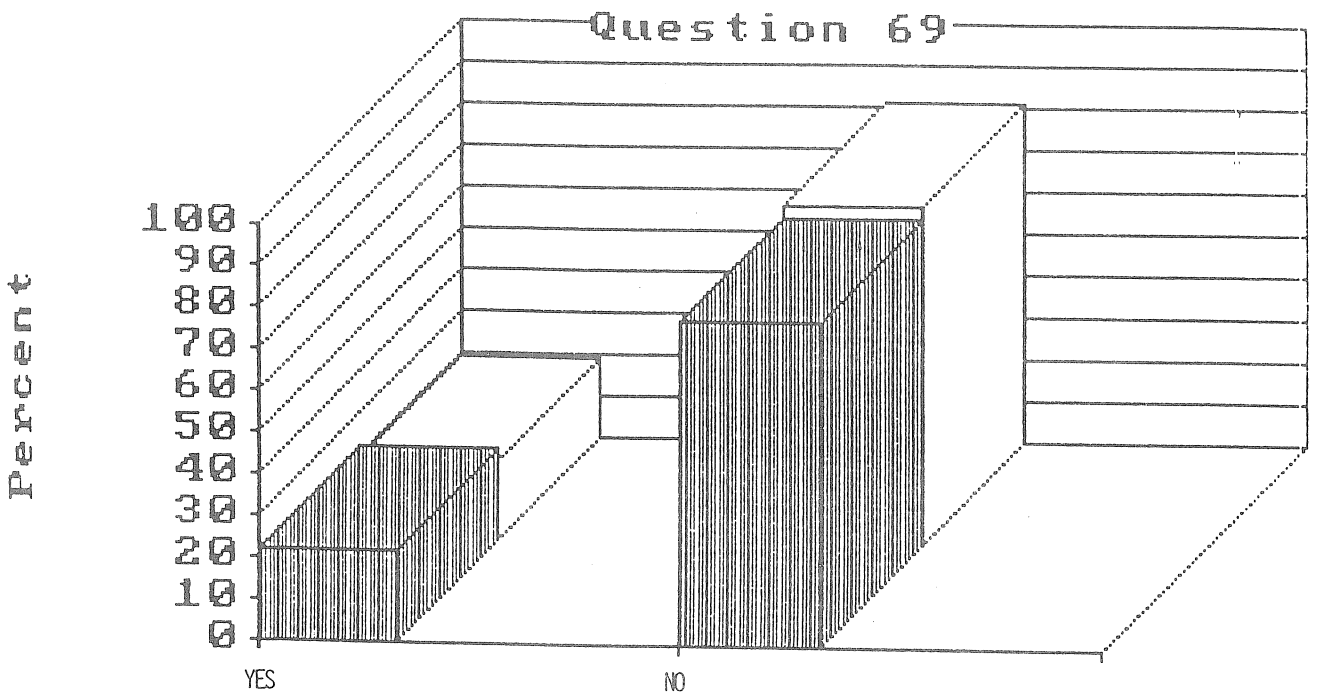
Question 44 (cont.)

In the end though, a significant majority felt cover was a necessity for the prevention of sunburn. If sunburn is a problem at a hatchery, some form of shade cover appears warranted. It is less clear whether cover provides ancillary stress reduction benefits and is probably not justified on this assumption alone.

QUESTION 45: IF YOU COULD MAKE A SINGLE MODIFICATION IN POND REARING TO IMPROVE IT, WHAT WOULD YOU CHANGE?



There was no consensus on this question which indicates a range of problems occur at different hatcheries. Improved diet received the greatest response (37%) and showed a 17 percent increase in respondents from round one to three. Twenty-five percent felt less handling would be an improvement to pond rearing. This question did little to uncover a single problem of overwhelming concern and probably points out the individuality of different facilities and programs.



The reasoning behind this question should have been more clearly stated. Bi-modal length frequency distributions are common in spring chinook programs and grading would serve to separate the groups and allow more individual fish cultural treatment. This may result in a release of more fish of optimum size and not a group with a reported size at release that is an artifact of averaging lengths from small and large fish groups. As the question was stated, a large majority (81%) felt handling stress was too great a risk to justify grading.

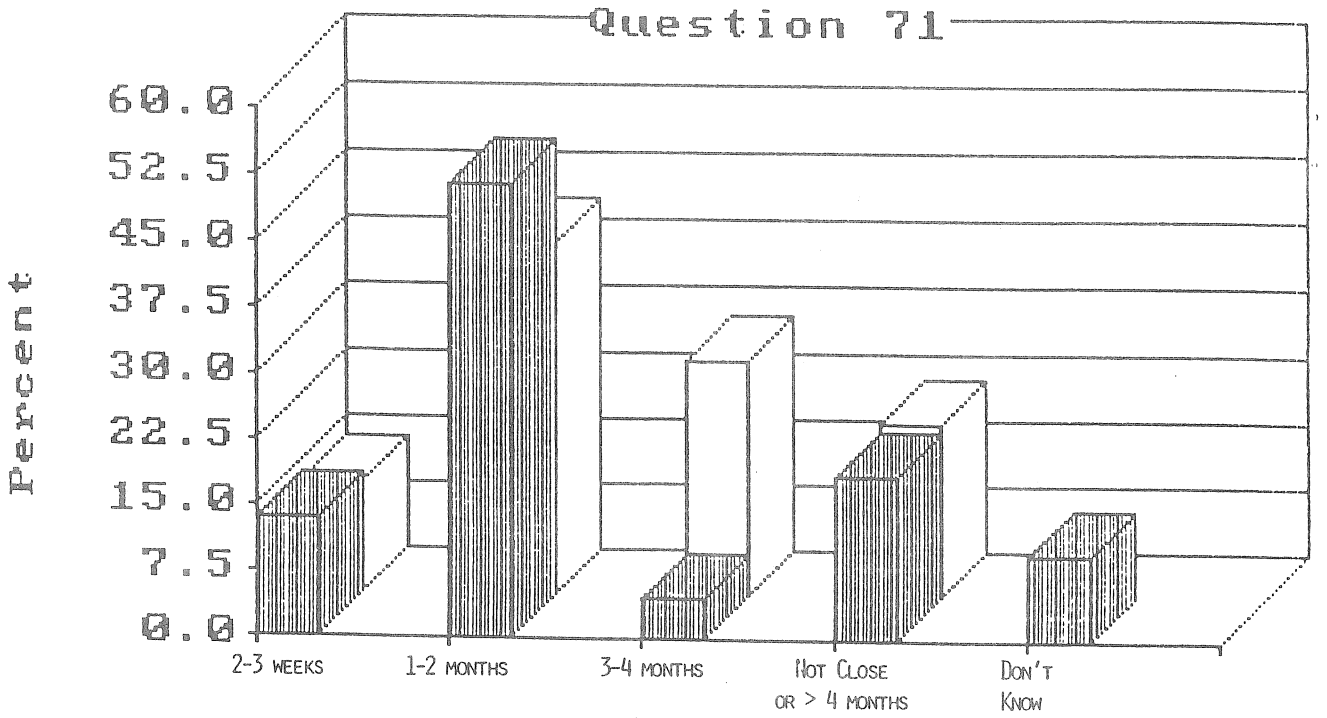
Some hatcheries have graded chinook in order to separate the faster growing (larger) fish from the rest. These are usually smolt size fish by their first fall and are released then. This imitates the natural situation where downstream movement of large numbers of smolt-size fish have been obsered in the fall (Bjornn, 1978 and Diggs, 1980). Warms Springs National Fish Hatchery

Question 69 (cont.)

has seen better return rates on one group of large (8-9/lb.) chinook graded and released in the fall versus cohorts held and released the following spring (Brian Cates, pers. comm.). Some Oregon Department of Fish and Wildlife (ODFW) Willamette Valley Hatcheries have similar grading and fall release programs, but feel a minimum size of 150 mm (16/lb.) is necessary to have good returns (Max Smith, pers. comm.).

Bi-modal length frequencies in pond populations may be genetically based or caused by cultural practices. Cultural practices that could cause bi-modality include: (1) mixture of fish from widely separated egg takes, (2) overcrowded ponds, and (3) feeding levels below satiation which could be a result of feeding methods or the feed itself. If bi-modality is controllable through other cultural practices, then the stress of grading for separate groups may be unnecessary.

QUESTION 71: HOW CLOSE TO SMOLTING OR RELEASE IS IT SAFE TO HANDLE SCS?

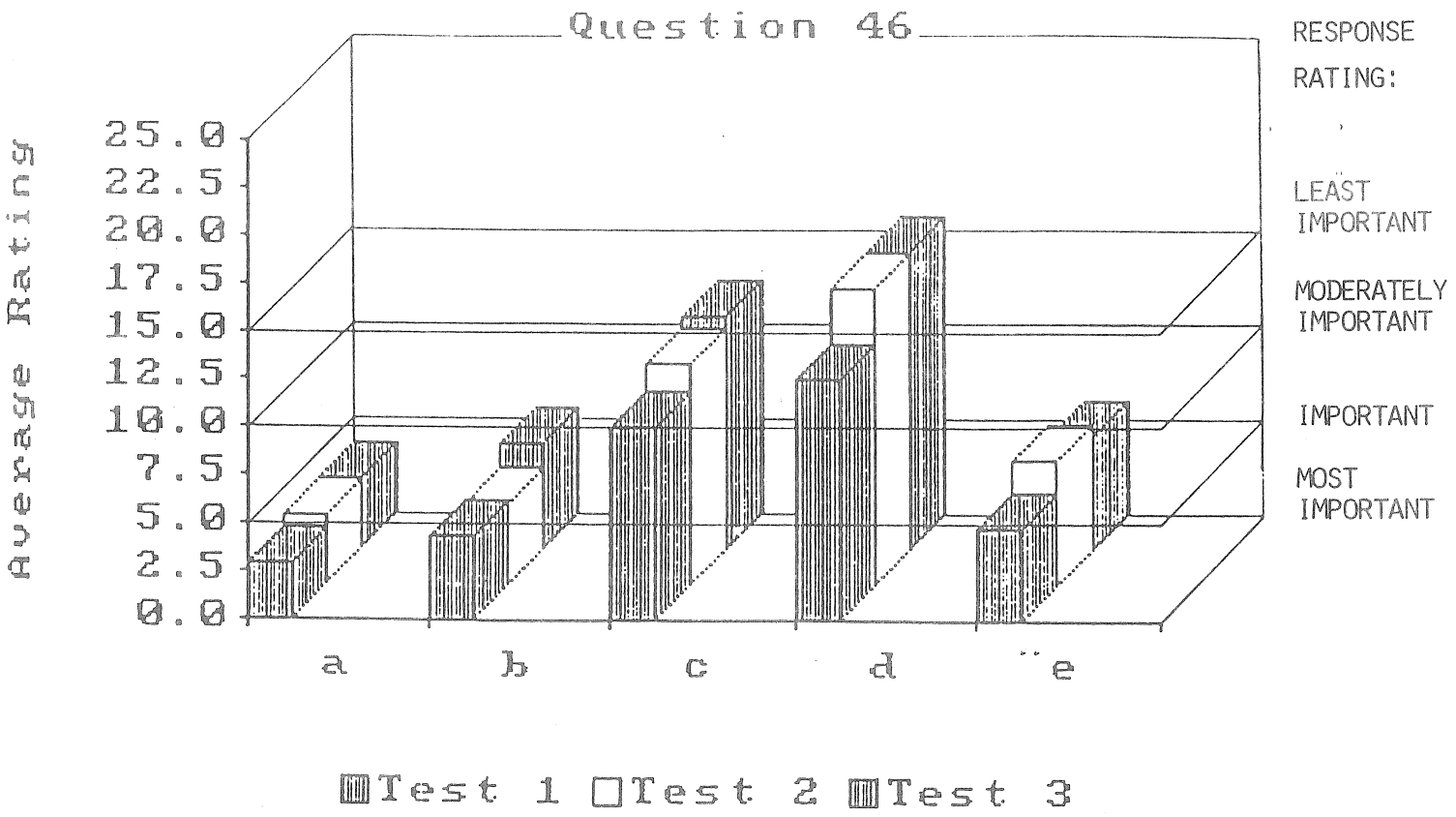


Few respondents (13%) felt you could safely handle spring chinook close to smolting (2-3 weeks). Forty percent felt you could within 1-2 months. A total of 80 percent would feel safe in the 3-4 month range which would have to be qualified. There is little doubt that handling stresses the fish. Therefore their health and condition is a paramount consideration before large handling programs, such as movement or marking, is finalized.

DIET

All salmon diets are not created equal as protein levels, vegetable matter, and vitamin packs can differ drastically. Foods available to fish in the streams are not available in the hatchery situation and may not provide the nutritional requirements needed to support them in the artificial environment even if they were. Salmonid species differ in their nutritional needs. Fish as closely related as steelhead and rainbow trout have different vitamin needs as steelhead require double the vitamin pack for optimum growth in the hatchery (Klontz et al., 1983). There may be even wider variances in nutritional requirements between steelhead and spring chinook. Protein content, vitamin pack and palatability are key words mentioned several times in this section as we asked the experts to evaluate the feeds and feeding methods they now use and would like to see in the future.

Suggested references: (22, 23, 31, 32)



Question 46. Overall, which feed would you choose for rearing SCS?

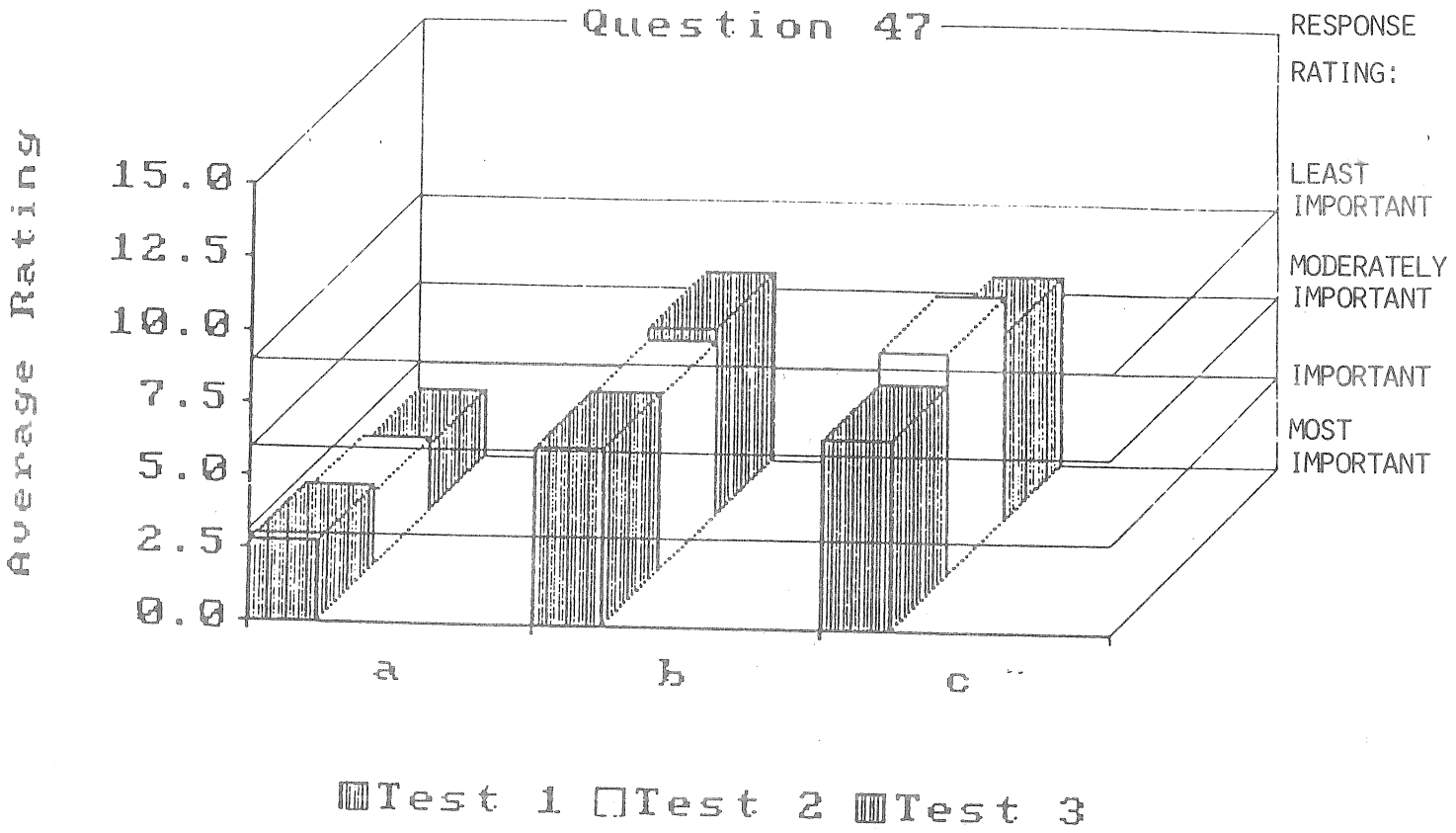
a. OMP-2
b. OMP-4
c. Abernathy
d. Silver Cup Salmon
e. Biodiet

Response Rating Guide

1- 5	Most important
6-10	Important
11-15	Moderately important
16-20	Least important

Question 46

OMP II ranked first among diets by the respondents with an average group rating of 3.6. It held this position through all three rounds. OMP IV and BioDiet were a close second and third with ratings of 5.5 and 5.9 respectively. Although FWS specifications call for the same minimum crude protein levels in OMP II and OMP IV, OMP IV has a higher minimum fish meal and viscera allowance, and less vegetable protein. Abernathy dry diet received only a moderately favorable ranking. One respondent cited a 3 to 4 fold increase in BKD in fish fed Abernathy dry versus OMP II. Wedemeyer and Wood (1974) list dry diets as a predisposing factor to kidney disease. The results of this question would rank OMP II and IV and BioDiet all as satisfactory with Abernathy and Silver Cup clearly second choices.



Question 47. Which method of feeding would you choose to rear SCS?

a. Hand feeding
b. Automated feeders
c. Demand feeders

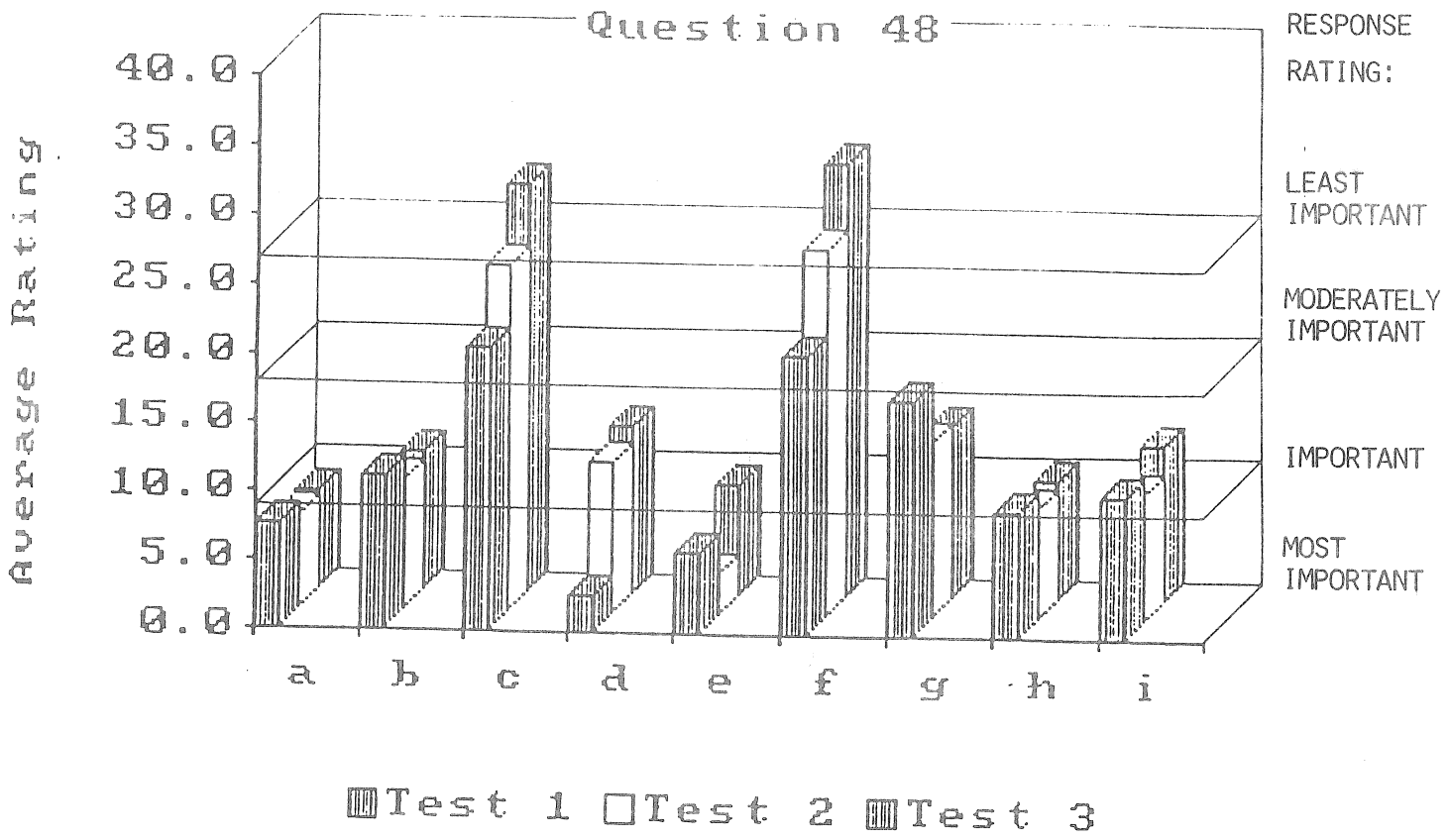
Response Rating Guide

1- 3 Most important
4- 6 Important
7- 9 Moderately important
10-12 Least important

Question 47

Hand feeding was rated as most favored method with automatic and demand feeders receiving moderate ranking. The personal touch of hand feeding and observation by feeders seems quite important to the experts. Demand feeders are becoming more popular and probably warrant a close evaluation for feeding efficiency and effects on fish length bi-modality.

One interesting quote was found in some diet literature pertaining to feeding. It was made by L.G. Fowler of the FWS, Abernathy Salmon Cultural Development Center, "Feeding of fish is often given to the newest and least experienced feeder which may be a poor practice since feeding is probably the most important aspect of fish culture and should be given top priority". Superior feed and feeders may go a long way in producing successful rearing programs.



Question 48. Assuming something is missing from an optimum SCS diet, in your judgment, what would it be?

a. Vitamins missing
b. Minerals missing
c. Too little vegetable protein
d. Too much vegetable protein
e. Too little animal protein
f. Too much animal protein
g. Pellet size problems
h. Pellet texture problems
i. Manufacturer quality control

Response Rating Guide

1- 9 Most important
10-18 Important
19-27 Moderately important
28-36 Least important

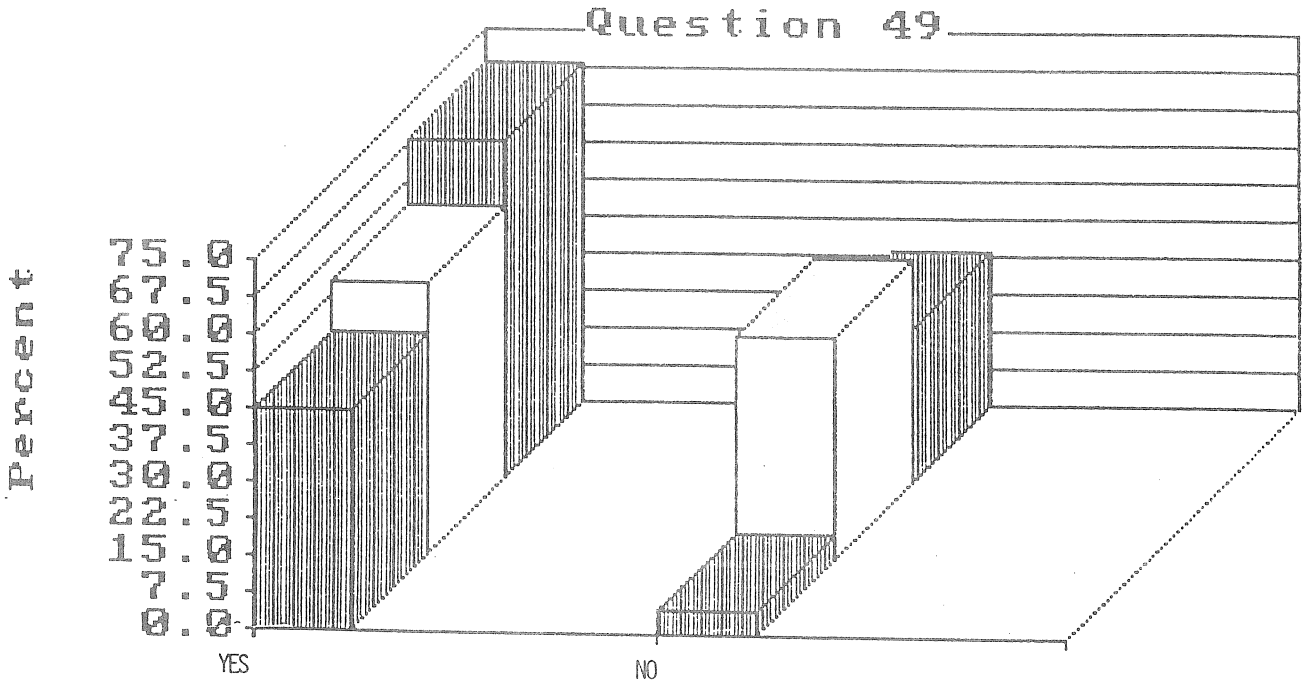
Question 48

Three factors ranked as most important: vitamins missing, too little animal protein, and pellet texture. Manufacturer quality control and too much vegetable protein ranked very important. The respondents showed good judgment in selection of critical diet factors as the literature backs up the importance of high protein and vitamin supplements in salmon diets.

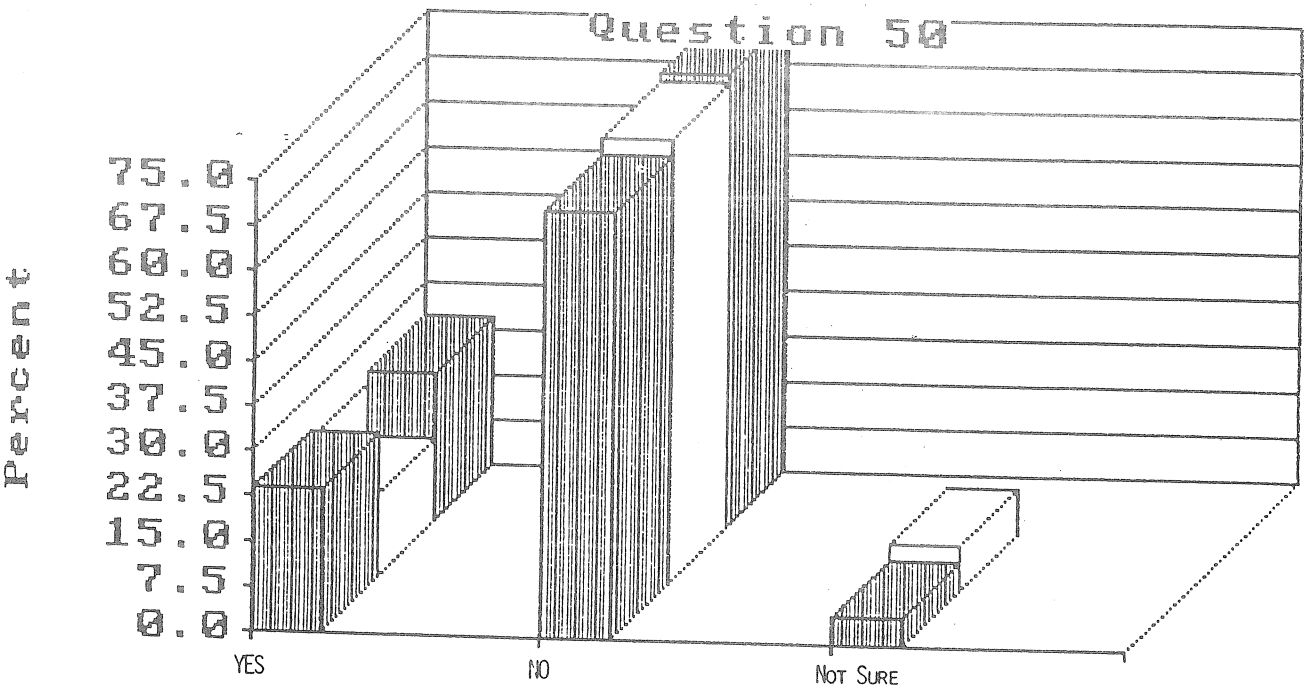
In the wild, about 70 percent of the energy in natural foods is supplied by protein with most of the remainder as fat (McNeil and Bailey, 1975). McNeil and Bailey (1975) also state most nutritional disease in fish are overcome by including vitamin supplements (unspecified) and assuring energy sources are at least 50 percent protein (mostly animal protein). Klontz (1983) states that trout and salmon diets should contain at least 55-80 percent of the total protein source as fish protein.

It has been suggested elsewhere in this report that diet may be an important contributing factor in the control of such diseases as dropout, sunburn, and BKD. It may be the single most important factor in rearing a high quality spring chinook as it ranked in the most important category in both nursery and pond rearing. Diet research is a complex and time consuming process. The sooner it is begun in earnest, the better.

QUESTION 49: IS THERE NOW AVAILABLE A SATISFACTORY DIET FOR REARING SCS?



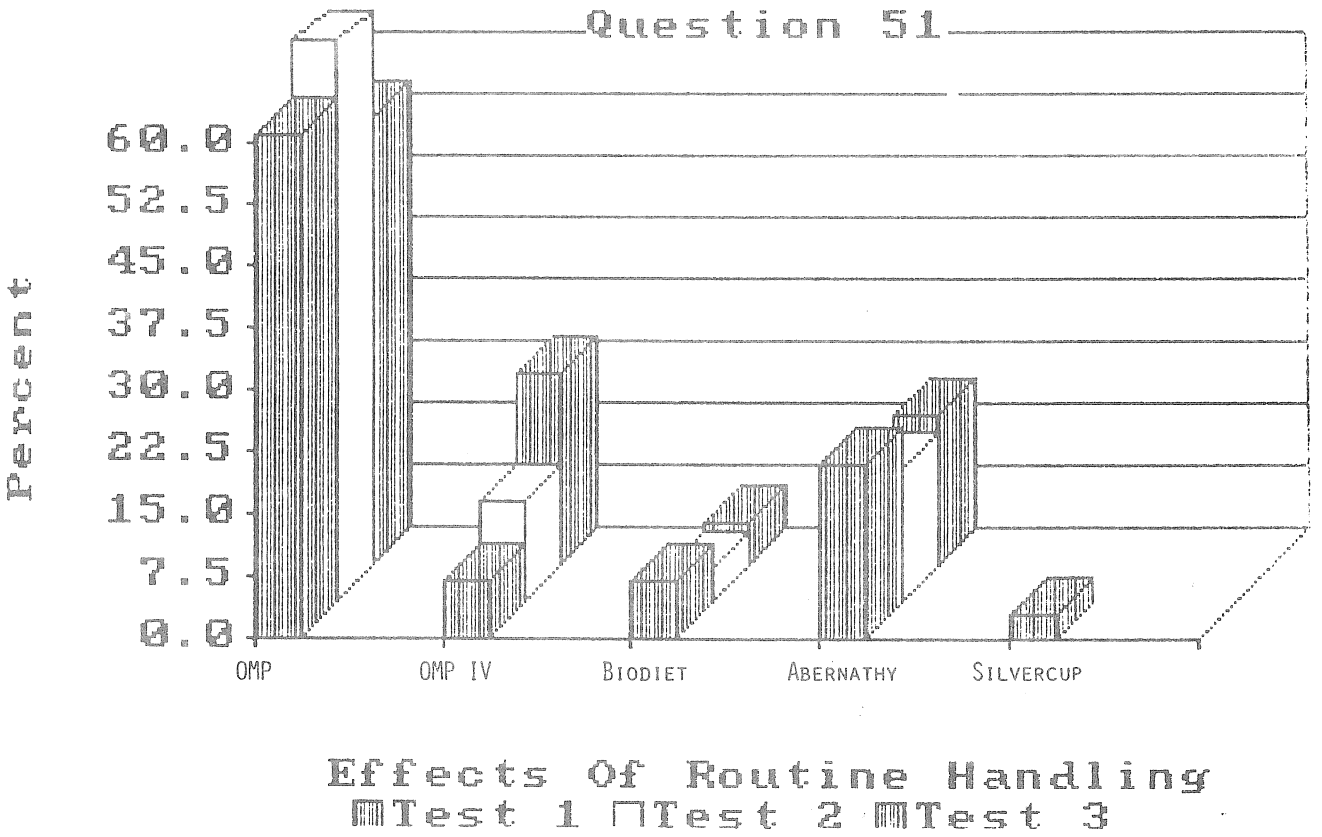
QUESTION 50: IS THERE NOW AVAILABLE ANY OPTIMUM DIET FOR REARING SCS?



Questions 49 and 50

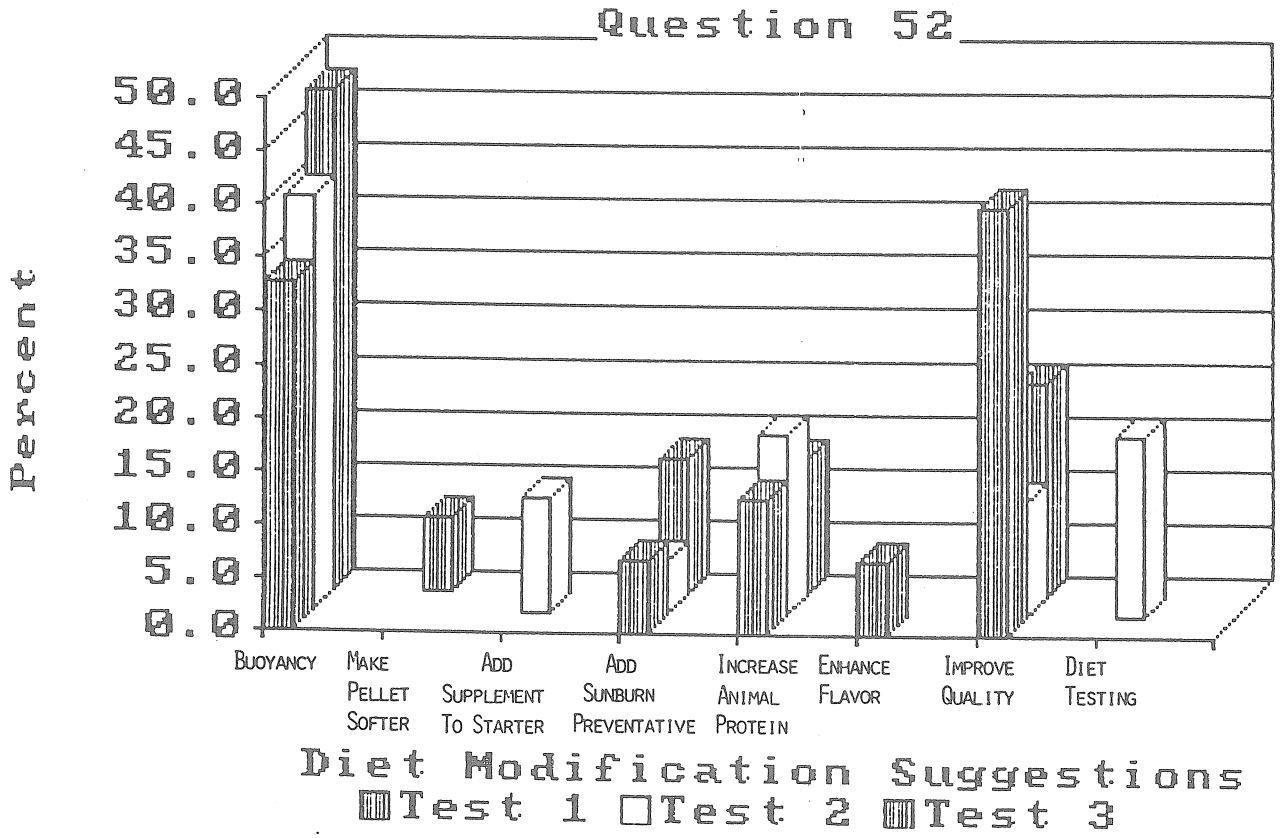
By round three, 69 percent of the respondents felt there was a satisfactory diet available for spring chinook. However, 75 percent felt there was not an optimum diet available. The round two justification responses indicated the respondents felt comfortable with OMP II and IV feeds as we have been able to rear spring chinook with some degree of success for years. One respondent felt that OMP had been "revolutionary" for rearing salmon in the beginning, but was now slipping from adequate to mediocre. Most of the 31 percent who felt that present diets were not satisfactory cited specific problems they felt were diet related. These included sunburn, pinheading, and soreback.

A 75 percent response that there is no optimum diet available is a strong vote for intensive diet research. In addition to determining the optimal nutritional package and addressing palatability concerns, the efficacy of the diets will likely require testing on spring chinook reared at stations with widely varying water chemistry. This is clearly a large task that will take a major dedicated effort to complete.



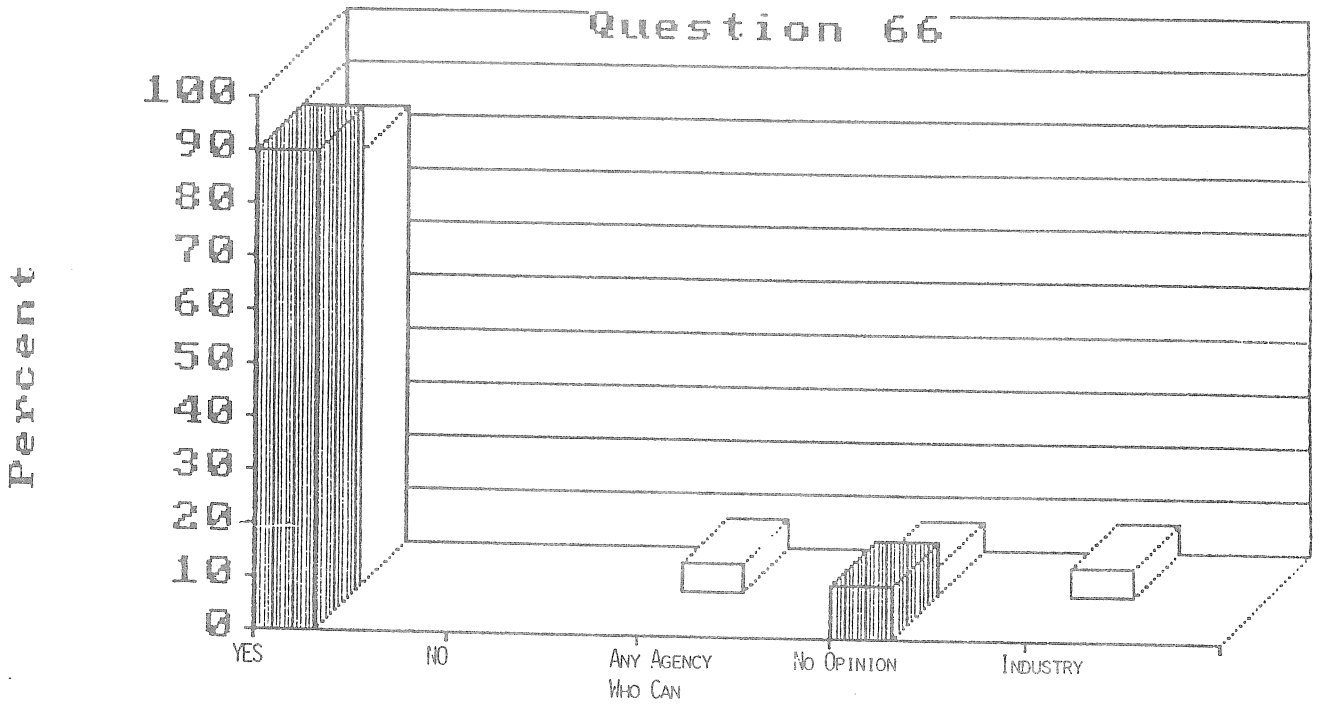
Seventy-seven percent of the respondents were using OMP II and IV at their facilities. This result is congruous with the ranking of these feeds as first and second choice in Question 46. BioDiet was also rated highly favorable in Question 46, but is in use by only 5 percent of the respondents. This may be a result of expense, as BioDiet is about a third more expensive.

QUESTION 52: IF YOU COULD MAKE ONE MORE SINGLE MODIFICATION TO YOUR FAVORITE DIET TO IMPROVE IT, WHAT WOULD YOU DO?



The results of previous diet questions made the popular choice for this question somewhat surprising. There was an expressed concern about protein levels, vitamins, and nutrient requirements in general in previous questions, but buoyancy was the choice of nearly one-half of the respondents as the factor they would modify first to improve spring chinook diets.

Buoyancy initially attracted 33 percent of the respondents in round one and increased to 48 percent by round three. The reasoning given by many respondents in justifying this answer makes eminent common sense. Basically, they felt before any diet can be effective, it must be injested, which if the feed falls to the bottom this becomes less likely. Chinook being surface feeders would make better utilization of the feed if it was suspended in the water column. Diet researchers take note!



A strong consensus felt that the U.S. Fish and Wildlife Service (FWS) should take the lead in spring chinook diet research. This question has the chance of being extremely biased as over 90 percent of the respondents were FWS employees. The most popular diets presently in use, OMP II and IV, were originally developed in cooperative research between Oregon State University and private industry, yet only two respondents felt industry should take the lead and no one mentioned university involvement.

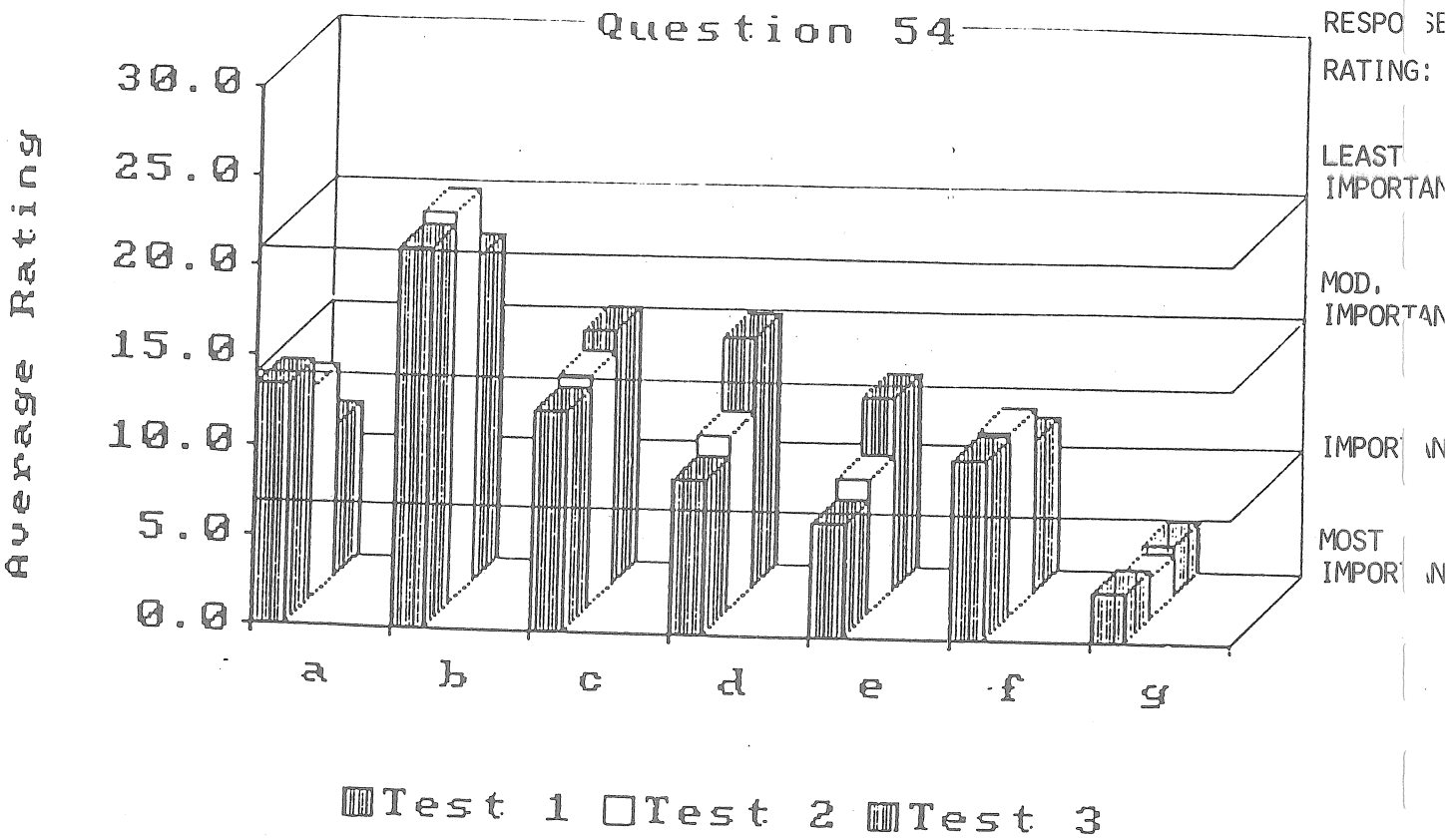
The task of determining what is an optimum spring chinook diet may involve much more than feeding trials of available diets and new modifications. It may take intensive basic research into the nutritional and physiological needs of spring chinook at various life stages over a range of artificial environments and water qualities they are reared in. The FWS's Tunison Laboratoyr at Hagerman, Idaho has initiated spring chinook diet research in

Question 66 (cont.)

1984 and will spend about $100,000 in the effort this year. Perhaps this is the lead necessary to bring about a concerted and coordinated effort utilizing the expertise at the state, university, and private levels.

DISEASE

Suggested references: (19, 25, 26, 27, 29, 36, 38, 39, 43, 49, 50, 52, 54, 55)



Question 54. In reference to your highest ranked choice listed in question 53, which avenue would you pursue to correct this disease problem?

a. Oral vaccine
b. Injectable vaccine
c. Prophylactic medication
d. Symptomatic medication
e. Selective breeding for natural resistance
f. Culling for disease-free progeny
g. Optimize fish cultural parameters, i.e. water quality, nutrition, pond management

Response Rating Guide

1- 7 Most important
8-14 Important
15-21 Moderately important
22-28 Least important

Questions 53 and 54

The format for Question 53 was changed from a fill-in to a ranking question by round three. Instead of presenting two different graphs for this question, we chose to present the results in the discussion with Question 54.

BKD and nutritional problems were the first and second choices in the fill-in responses with a 70 percent response for BKD by round two. On the third questionnaire, as a ranking question, BKD and general nutrition again ranked as most important. BKD was not a surprise and the general nutritional ranking confirms diet as a key issue which we saw develop in the last section.

In Question 54, the experts felt the control of BKD was in their hands. They did not ask first for high technology research in medications or genetics. They felt that optimization of rearing techniques and cultural parameters were the key to overcoming the disease. Culling for disease free progeny, which probably fits into the first category, was ranked second and very important also. They did feel a need for research into an oral vaccine was necessary and ranked this as an important avenue to pursue.

As we know, BKD, like many diseases, can be exacerbated by stress (Wedemeyer and Wood, 1974). Improvement of potentially stressful fish cultural conditions would seem to be an important first level of attack. Other methods presently receiving considerable attention are various Erythromycin treatments such as injection of adults, water bathing eggs in solution, and periodic additions to feeding regimes. The Oregon Department of Fish and Wildlife (ODFW) has seen a four fold return rate (0.41%) of Erythromycin fed groups over unfed controls at Cole Rivers Hatchery (Everson et al., 1982). Atlantic salmon researchers have found reduced BKD incidence in fish reared on iodine and flourine supplemented groups had only an 0.8 percent BKD infection rate as diagnosed by indirect fluorescent antibody diagnosis.

Klontz (1982) states BKD is one of the most, if not most, difficult systemic bacterial diseases to treat chemotherapeutically and that more effort has gone

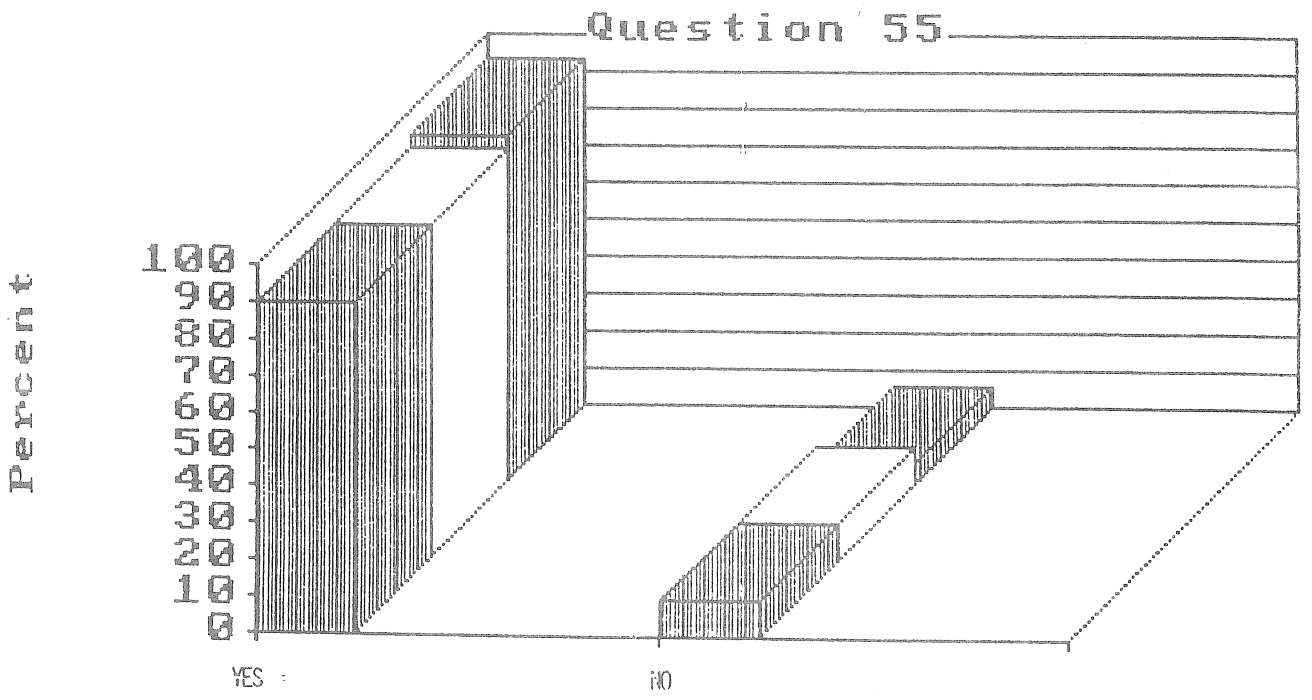
Questions 53 and 54 (cont.)

into the search for effective antibacterials for BKD than probably any other. Besides Erythromycin only sulfamerazine and sulfamethazine feed supplements have shown any success in reducing BKD.

Vaccines in Atlantic salmon have reduced the prevalence of BKD lesions, but have not provided long term immunological protection (Paterson et al., 1981). It appears that BKD bacteria are not as antigenic in fish as some other disease causative agents (Paterson and Fryer, 1974).

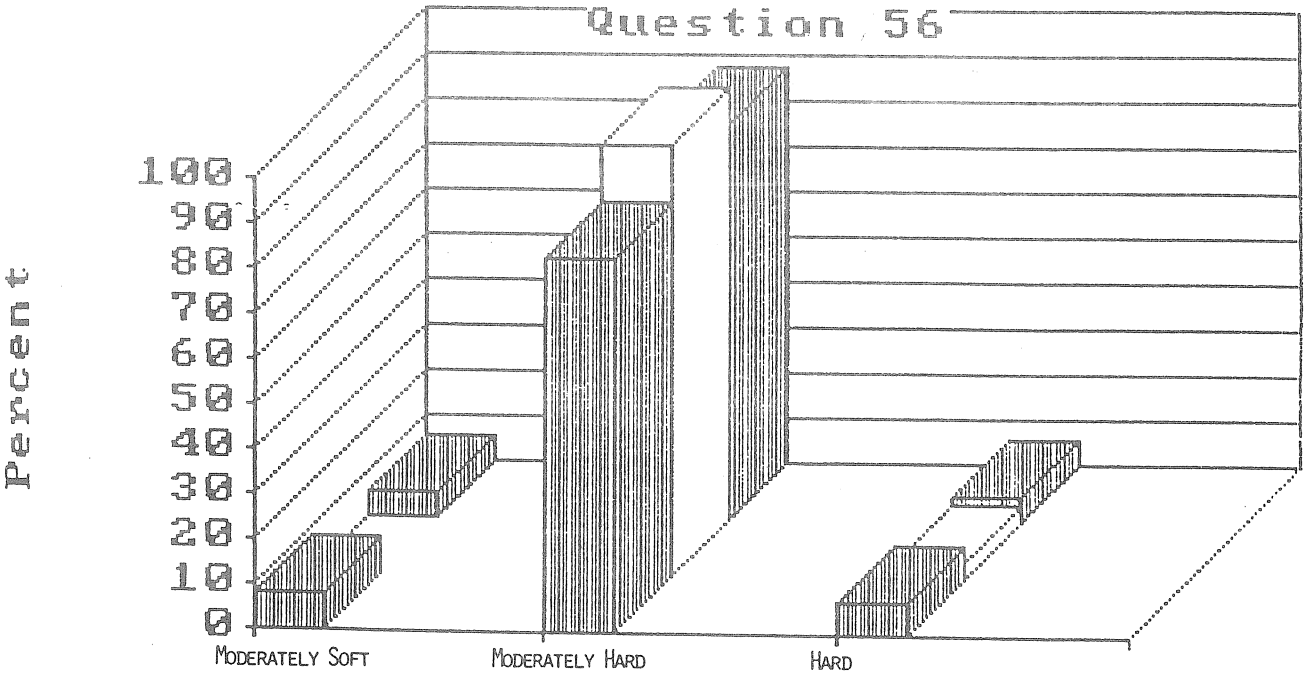
This brief review of various BKD control methods indicates there are several important avenues to pursue: vaccination, antibacterials, nutrition, and fish cultural techniques. The choice we have the immediate ability to implement is the one the experts have chosen; development of optimum stress reducing fish cultural techniques.

QUESTION 55: DO YOU THINK NATURAL MINERALS (HARDNESS, CARBONATES, SULPHATES, ETC.) IN HATCHERY WATER SUPPLIES INFLUENCE FISH HEALTH?



H2O Minerals Effect On Health
Test 1 Test 2 Test 3

QUESTION 56: IF YOU HAD YOUR CHOICE, WOULD SCS REARING WATER BE: SOFT, MODERATELY SOFT, MODERATELY HARD, OR HARD?



Choice of Water Hardness
Test 1 Test 2 Test 3

Questions 55 and 56

A strong censensus of opinion for the importance of natural minerals in hatchery water supplies was seen in these two questions. In Question 55, 94 percent felt water quality influenced fish health, and 88 percent chose moderately hard water as optimum for rearing in Question 56. Warren (1963) indicated BKD was less severe in hatcheries with harder water and much of the hatchery water quality literature discusses minimum water quality requirements (Klontz, 1983 and Liao, 1971). At softwater stations, addition of certain minerals is feasible in re-use systems where 90 percent recirculation greatly reduces the amount of additive needed. But supplementing single-pass soft water supplies with some of the more expensive additives such as calcium become cost prohibitive. The softwater of many anadromous fish hatcheries will therefore likely remain a relatively uncontrollable, although not totally limiting, factor which may have to be offset indirectly with diet supplementation.

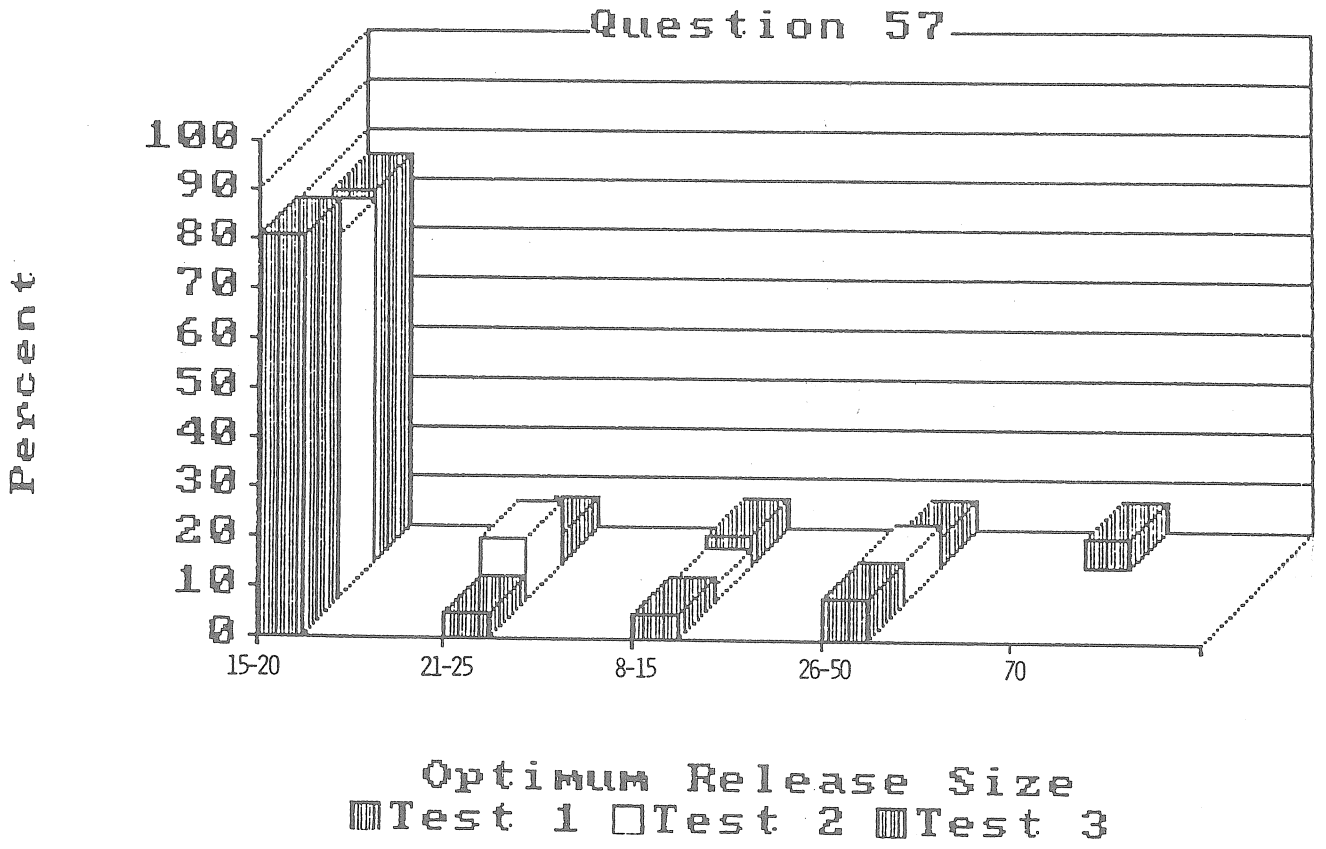
RELEASE

Perhaps the greatest artificial aspect of hatchery rearing of anadromous fish is the release strategy. Simply stated, the plug is pulled after about a year and a half of rearing and all fish in a ponds are released at once. This is not done haphazardly and is usually based upon some indicator of smolt readiness and evidence that the timing of the mass release results in satisfactory adult returns. But it is well known that some fish in that pond may not be ready to migrate while others may have been readier much sooner. The release is based on a general pond population readiness (i.e., most are ready) rather than when individuals are ready. The situation in the natural stream is just the opposite; each fish leaves of its own volition when the right combination of size, time, and physiological readiness occurs.

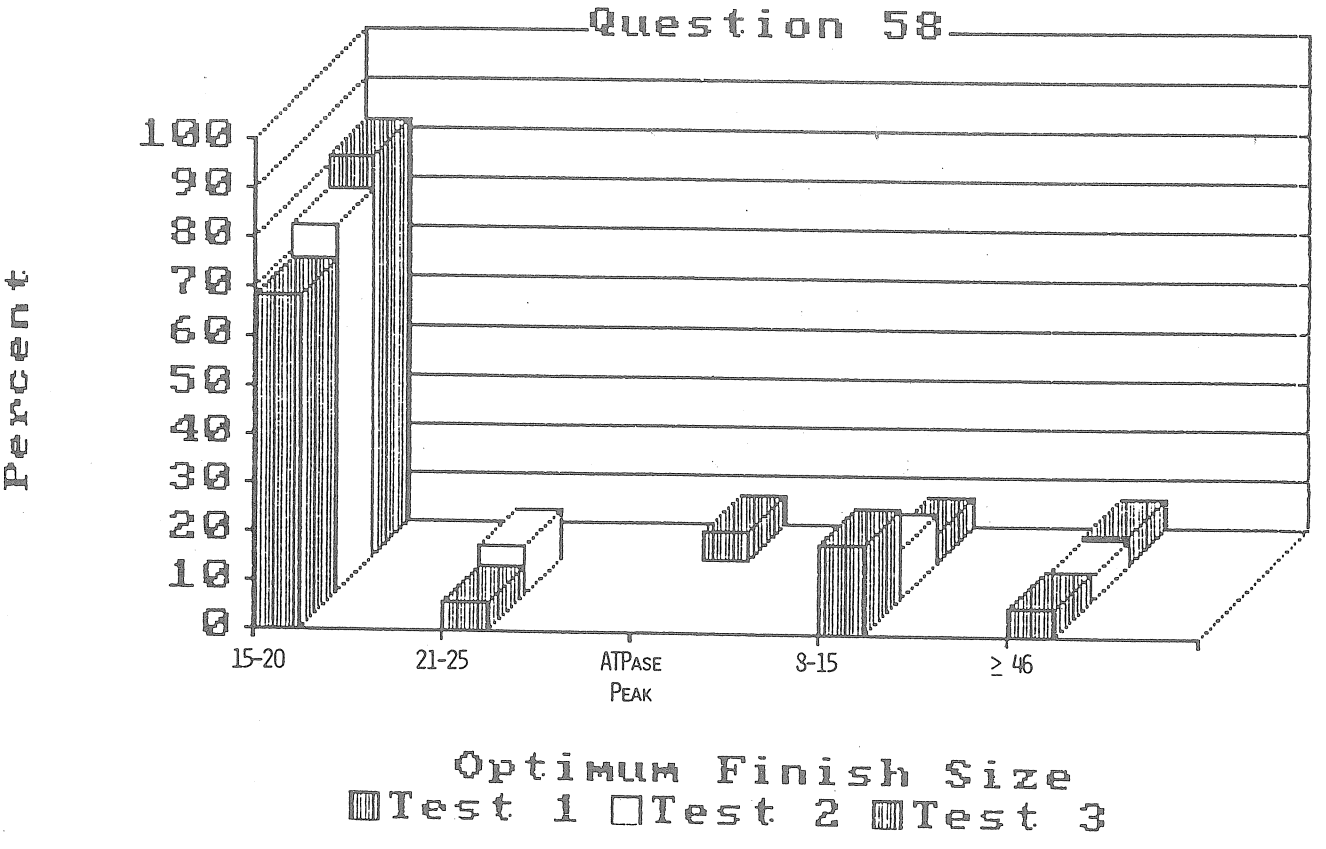
As we are unable to emulate the natural stream situation, we must develop release strategies we feel will provide good survival and optimal returns. These questions in this section seek to determine the size and time of release which we feel encompasses a period of maximum smolt readiness.

Suggested references: (6, 7, 12, 15, 16, 17, 30, 34, 40, 47, 48)

QUESTION 57: FROM A FISH CULTURAL POINT OF VIEW ONLY (IGNORING FACTORS LIKE RIVER AND OCEANIC CONDITIONS, DAMS, ETC.), WHAT DO YOU THINK IS THE OPTIMUM RELEASE SIZE OF SCS? (NO./LB.)



QUESTION 58: BORROWING A TERM USED IN THE LIVESTOCK INDUSTRY, AT WHAT SIZE DO YOU THINK SCS REACH THEIR OPTIMUM "FINISH"? (NO./LB.)

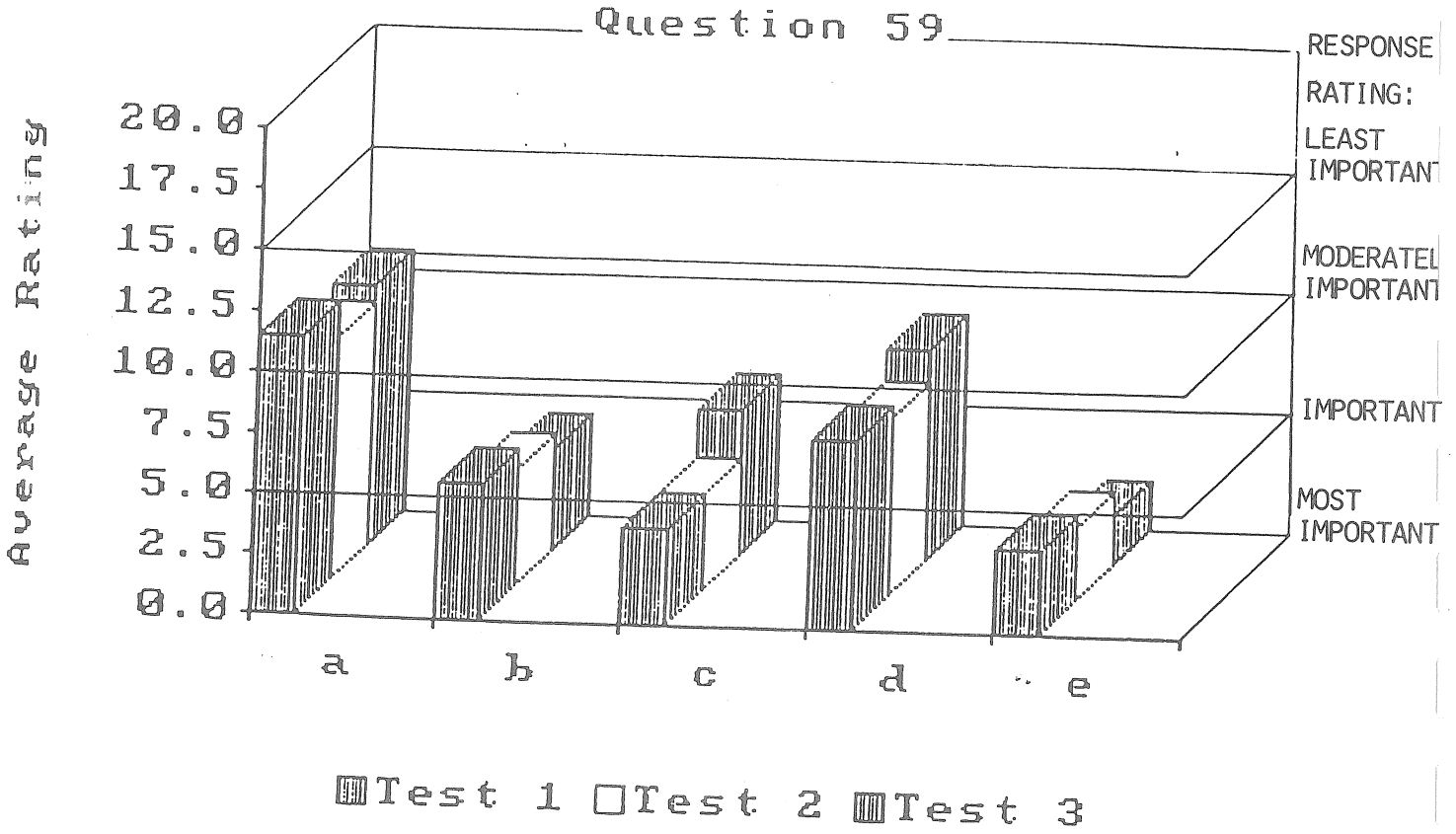


Questions 57 and 58

The respondents felt there was no difference between optimum release size and size at optimum finish, as no significant differences occurred between the two answers. We originally wondered whether the experts felt fish reached a stage where health, condition factor, and general hardiness occurred before size coincided with the traditional optimal release time in the spring. They apparently did not as 75-80 percent felt 15-20/lb. was optimum release size and finish size.

There was a strong majority (60%) that felt the optimum release month was in April, although there was a range of responses covering March through May. Release times are presently somewhat artificially regulated according to river conditions, windows of dam spill and bypass operations, and transportation programs.

In many anadromous fish stocks, adult survival increases (although at a decreasing rate) as the size of juveniles at release increases (Reisenbichler et al. 1982, Wagner et al. 1963, and Hallock et al. 1961). In the experience of Idaho spring chinook hatcheries, spring chinook reared beyond 15 fish/lb. down to 7-8 fish/lb., for example, deteriorate in quality and health and are usually prime candidates for BKD epizootics. Willamette Valley spring chinook hatcheries on the other hand have obtained successful returns with fish in the 6-7 fish/lb. range. Environmental and genetic differences could play a role in the variance of sizes that perform successfully in different geographical locations. The response of our experts would indicate that overall 15-20 fish/lb. is an appropriate target. The variation in success at different sizes throughout the basin would suggest individual size at release studies may be necessary to fine tune the optimum size appropriate for individual stations.



Question 59. SCS try in various ways to tell us they are ready to migrate. Which of the following smolting indices would you choose as being the most reliable?

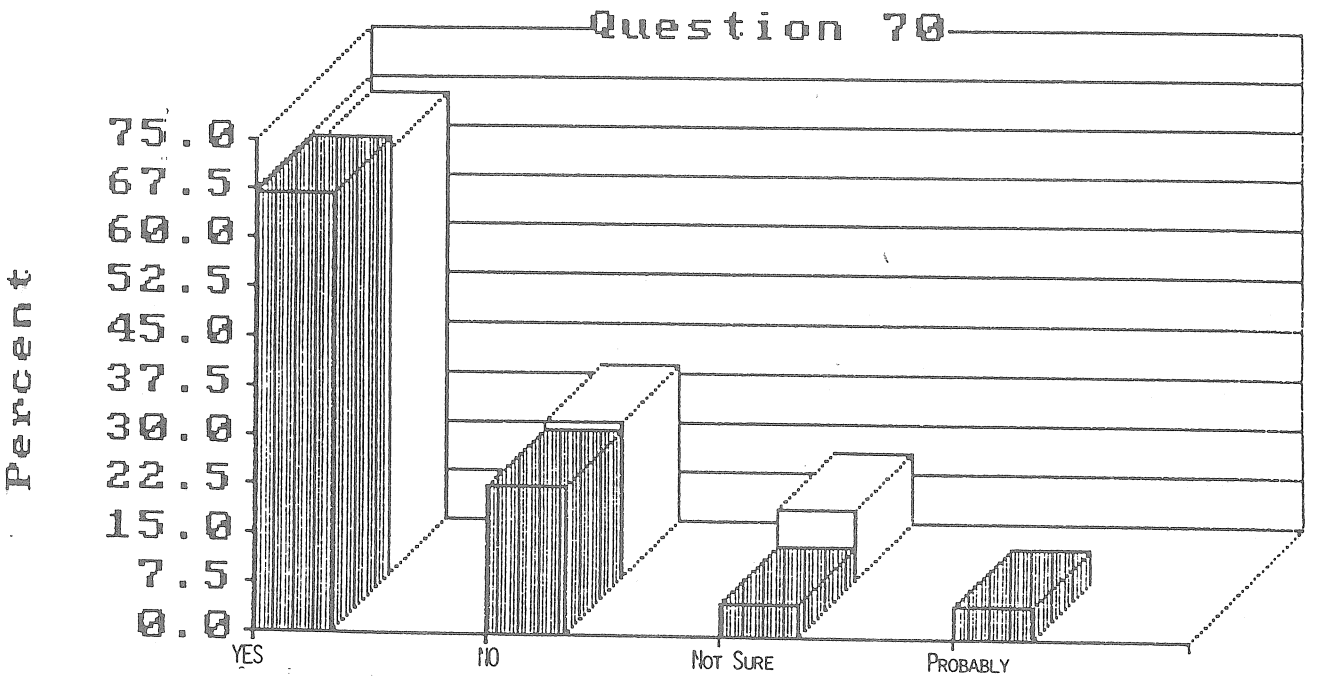
a. Condition factor
b. Scale changes
c. ATPase
d. Blood parameters
e. Behavior changes

Response Rating Guide

1- 5	Most important
6-10	Important
11-15	Moderately important
16-20	Least important

Question 59

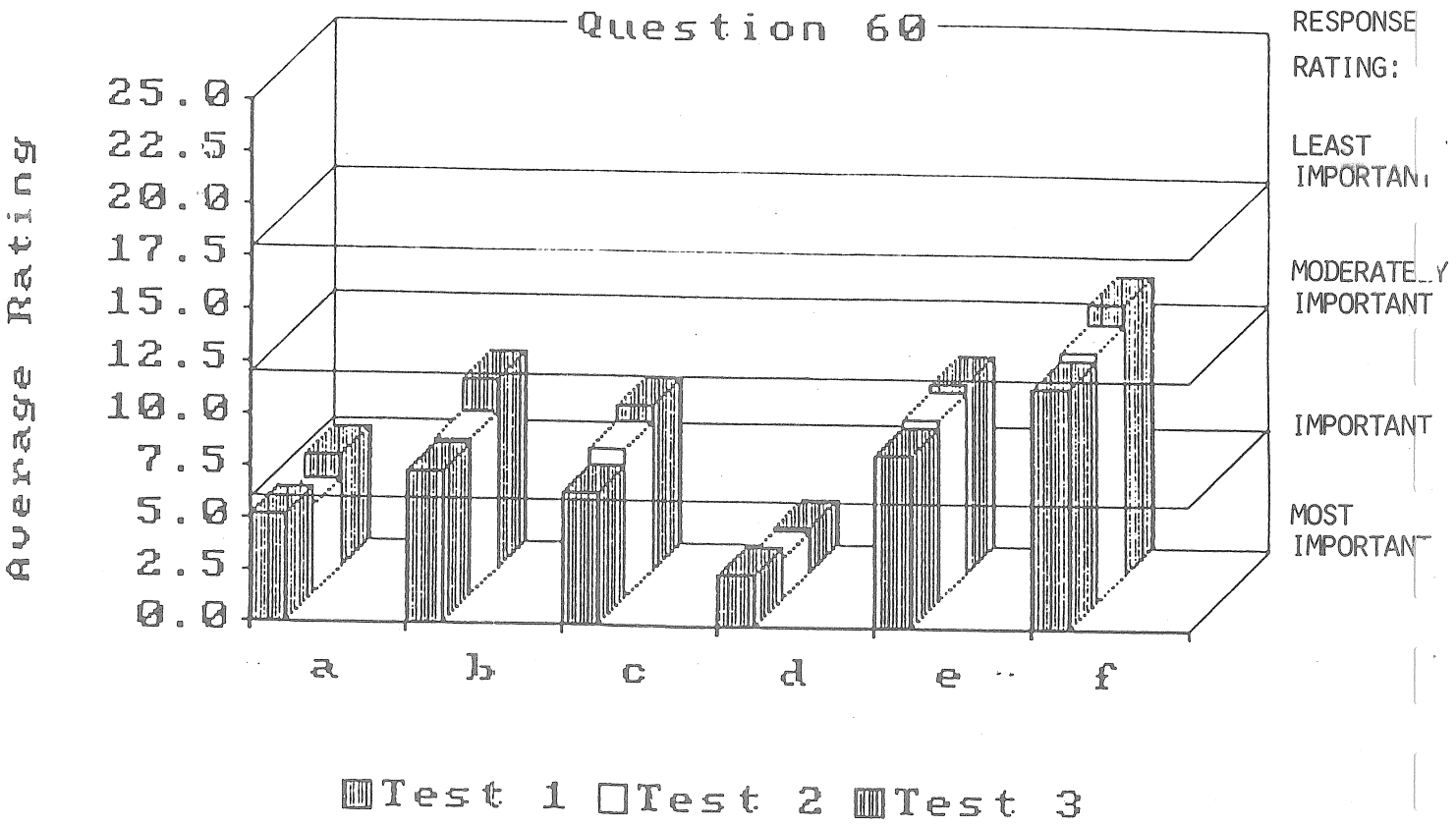
There were two factors which rated most important: (1) behavior changes and (2) scale changes. ATPase level fell from a most important factor to an important factor by round three. This response may seem surprising to a fish physiologist as the experts forgo an empiracally measurable factor (ATPase) in favor of two factors based on subjective visual observation. The rating difference between ATPase and behavior changes is only two points which says the respondents have not thrown ATPase out the window. They do feel strongly though, that an experienced eye is as good as the chemist's analysis in determining smolt readiness.



No shifts between rounds as those favoring use of salt in transporting spring chinook held at 65-67 percent. The National Marine Fisheries Service (NMFS) tested salt on spring chinook transported by truck from Lower Granite to Bonneville Dam in 1976. Fish hauled 8 hours in five parts per thousand un-iodized NaCl had a 4-5 percent mortality rate 24 hours after being artificially stressed. Fish transported in fresh water and treated similarly had a 30 percent mortality rate after 24 hours (Long et al., 1977). The majority of respondents are convinced of the beneficial effects of salt in transportation.

MISCELLANEOUS

Suggested references: (6, 7, 12, 21, 30, 33, 34, 36, 40)



Question 60. Over most of their range, SCS are probably in the worst shape they have ever been. Rank the relative importance of this list of factors as contributors to the problem.

a. Disease
b. In-river harvests
c. Ocean harvests
d. Dams
e. Rearing diets
f. Cultural techniques

Response Rating Guide

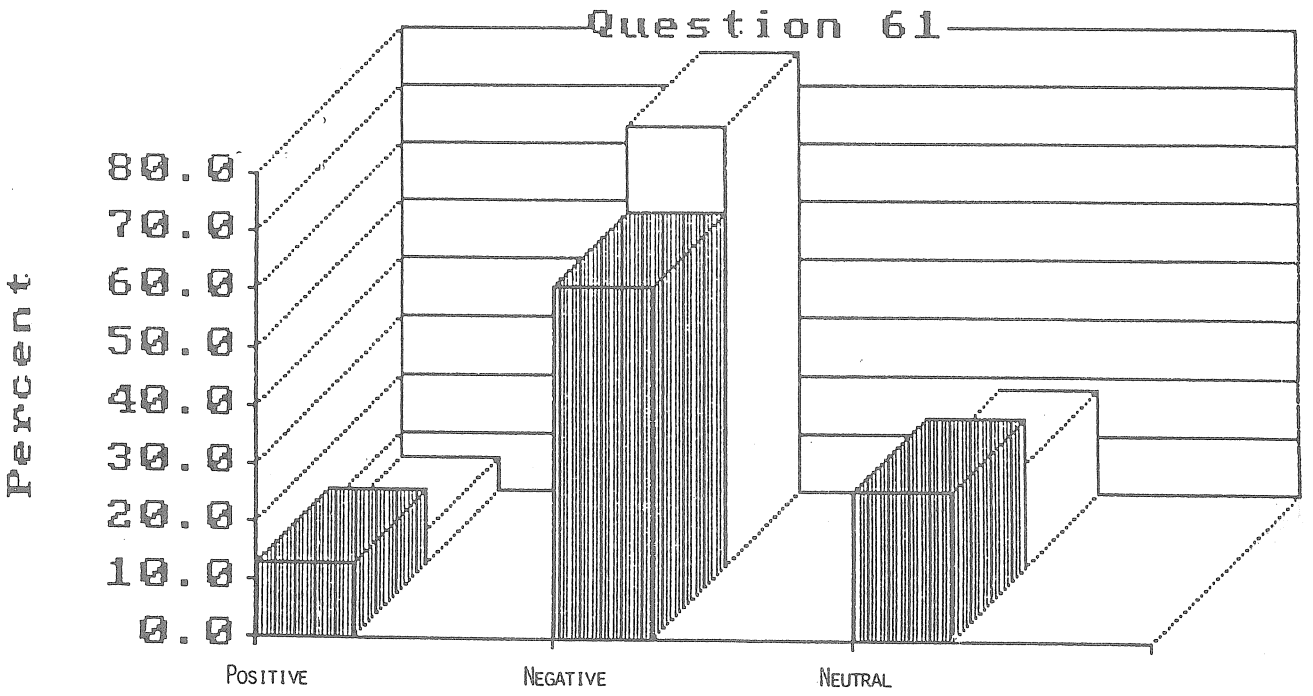
1- 6 Most important
7-12 Important
13-18 Moderately important
19-24 Least important

Question 60

Only one respondent in round one felt the reason spring chinook were in dire straights was related to hatcheries. By round three, the choice was unanimously selected as "other" factors. Dams and disease ranked as the most important factors in the opinion of the respondents and cultural techniques as only a moderatley important factor.

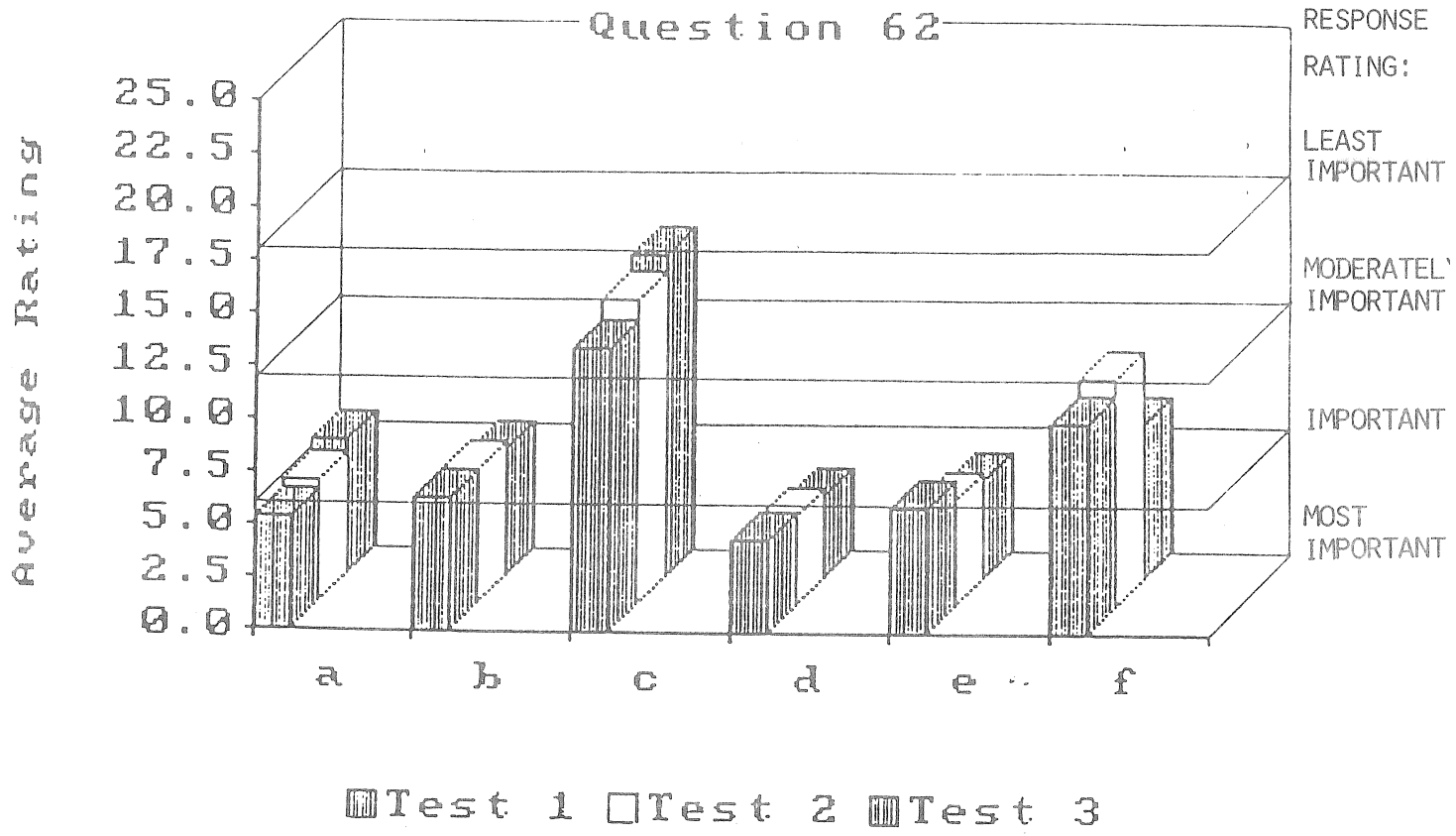
If diseases are ranked as a most important problem in chinook declines, the associated role of hatcheries and management can not be overlooked. The potential for decimating epizootics and increased geographical distribution of disease have become greatly enhanced since the advent of basin-wide hatchery development and stocking programs. This problem has recently gained basin-wide recognition and resulted in an inter-state/inter-agency effort to develop basin-wide hatchery disease management policy.

QUESTION 61: WOULD YOU VIEW THE ROUTINE HANDLING OF SCS AS A POSITIVE REARING FACTOR (E.G. WEEDING OUT THE WEAK, AS IN SHOCKING EGGS), A NEUTRAL FACTOR, OR A NEGATIVE FACTOR (E.G. INCREASED STRESS)? 100



Effects Of Routine Handling
Test 2 Test 3

Nearly 80 percent of the respondents felt routine handling was a negative factor. This would include such tasks as pond sampling and tank and pond splitting. This would also include handling to provide institutional and research needs for basic pond information such as lengths, weights, densities, health, etc. There is a minimum amount of this information that is needed in order to properly plan pond management, make feed projections, etc. With the proper coordination, selected index ponds may provide the informational needs for both production and research and significantly reduce the number of ponds scheduled for routine sampling. Another technique being used to reduce handling is to load rearing ponds at a level so fish grow into their final rearing densities without splitting. It suffices to say that handling and stress go hand in hand and should therefore be minimized.

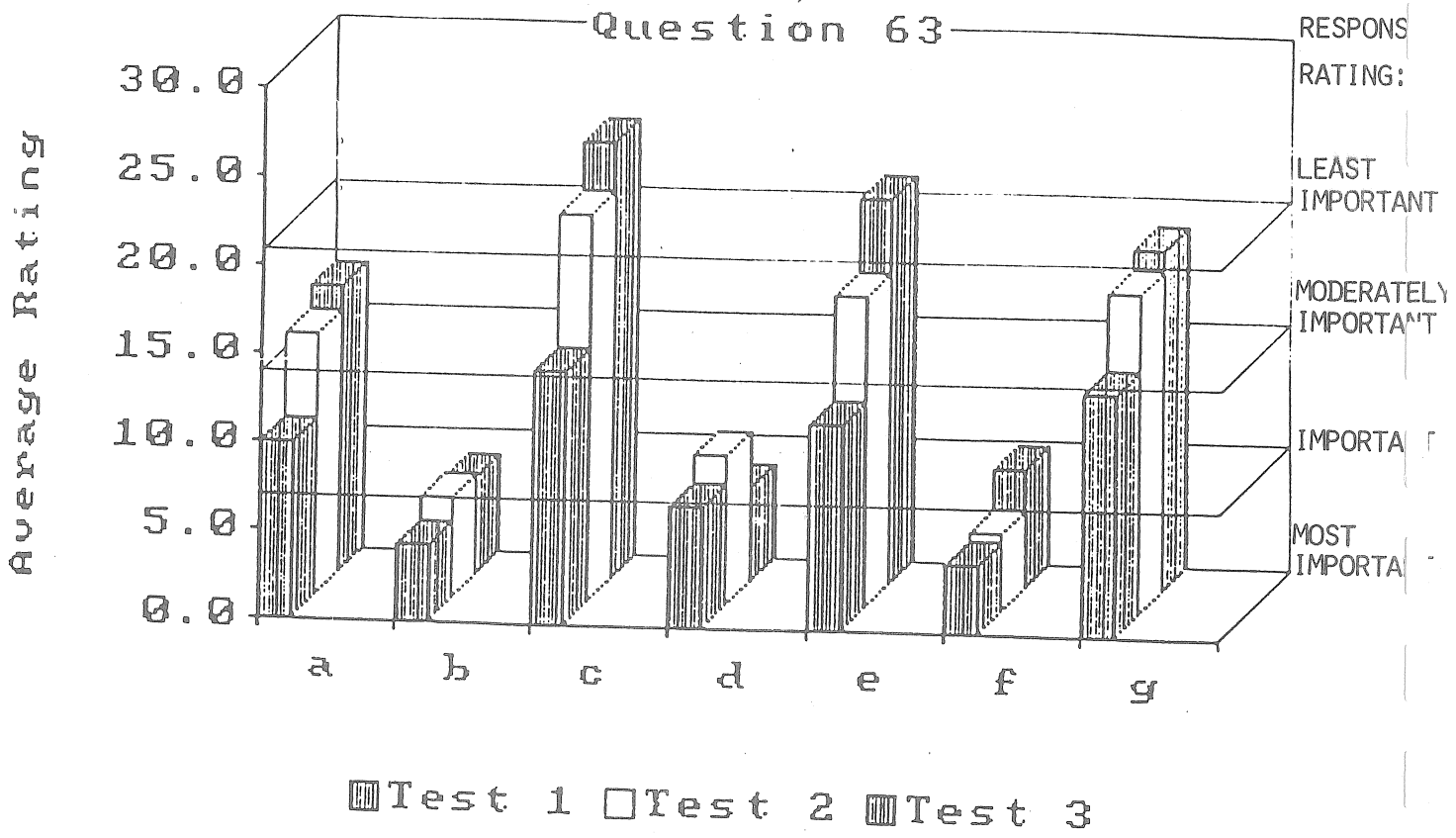


Question 62. There is some evidence that stress is a more common trait of SCS than other salmonid stocks. What would you choose as being the most important factors involved in creating stress?

a. Disease epizootic
b. Poor diets
c. Lack of cover
d. Handling
e. High pond density
f. Smolting periods

Response Rating Guide

1- 6 Most important
7-12 Important
13-18 Moderately important
19-24 Least important



Question 63. If you believed you had a group of SCS already in a stressed condition, that was not caused by a disease epizootic, what would your order of action be to alleviate the stress?

a. Add salt
b. Remove feed (amount)
c. Increase feed (amount)
d. Reduce feedings
e. Reduce pond densities
f. Give medications

Response Rating Guide

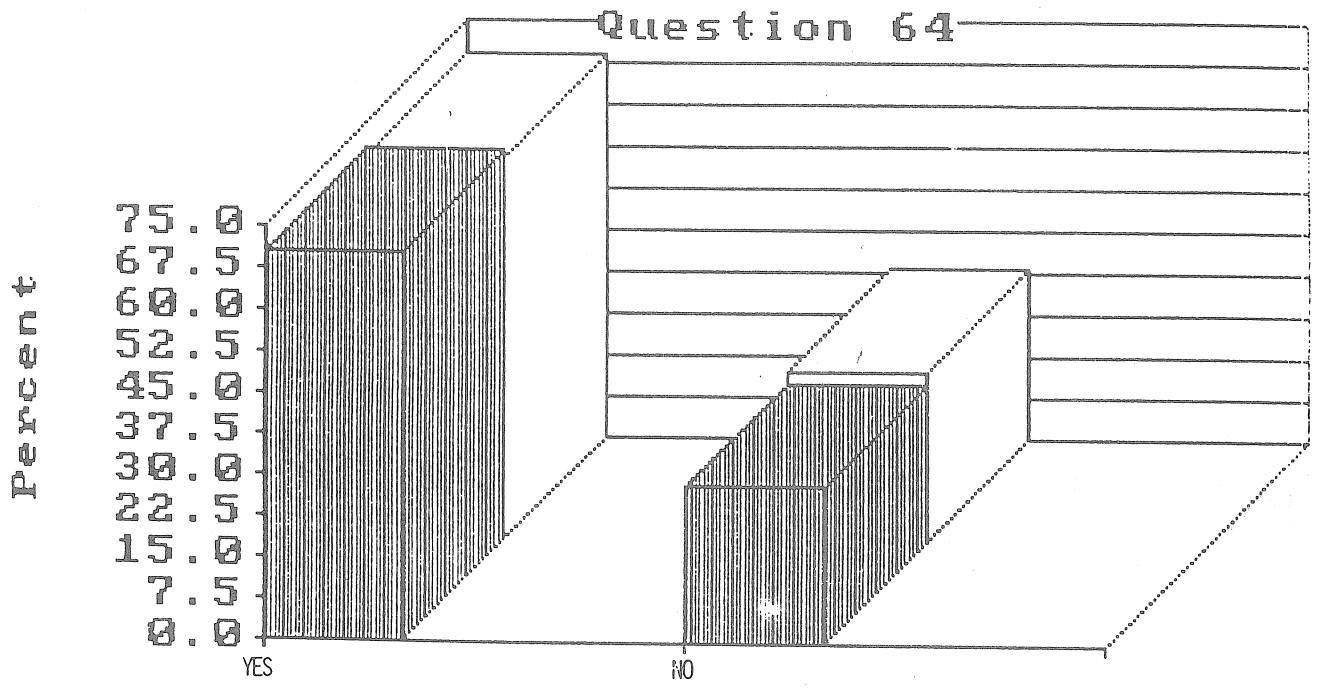
1- 7	Most important
8-14	Important
15-21	Moderately important
22-28	Least important

Questions 62 and 63

There were no significant shifts between rounds on Question 62 as handling, high pond density, and poor diet ranked as the most important causes of stress. Previous responses and discussion of these factors makes these choices unsurprising.

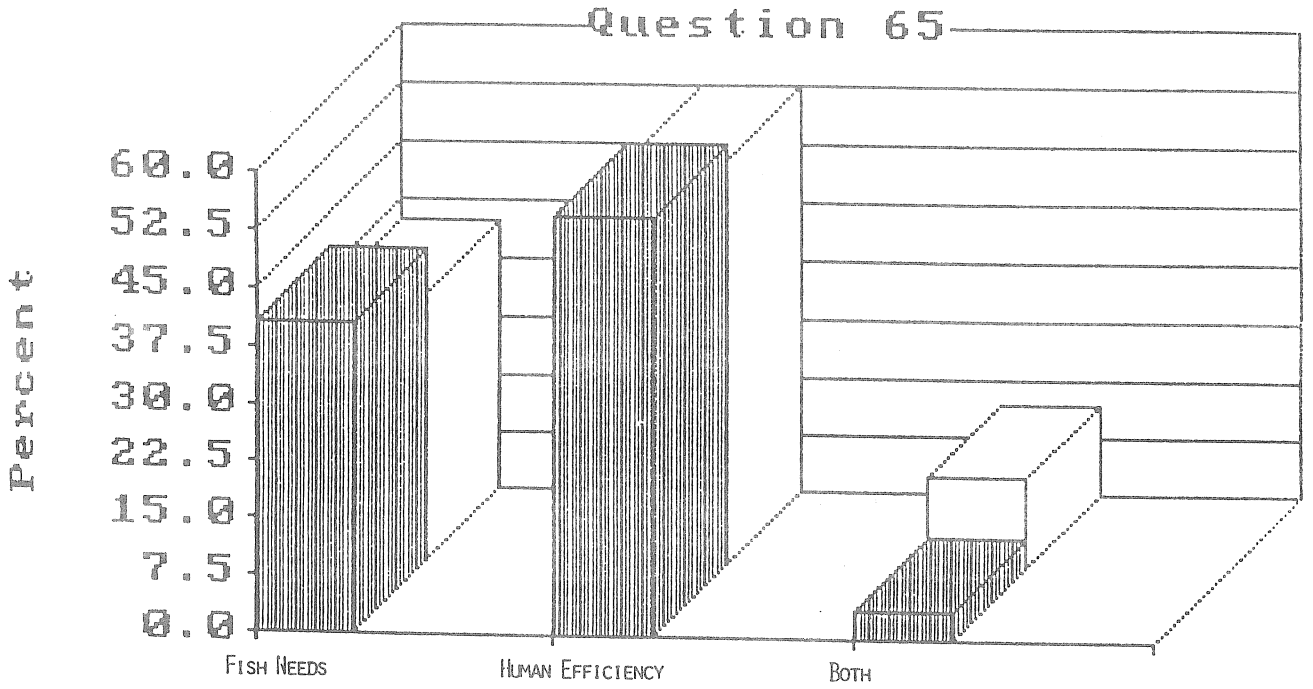
There were significant rating changes between rounds on Question 63. Four factors: add salt, increase feed, increase feedings, and give medications all lost ground and fell into the moderately or not important category. Removing feed, reduced feedings, and reduced pond densities all ranked most important in rounds one and three. The result of these actions to reduce stress would be a reduction of metabolic rates, thereby lowering production of the attendant waste products of ammonia and fecal material. This sounds like some of the basics our respondents learned in fish culture 101 and probably will not qualify as new technology, just sound fish culture.

QUESTION 64: IS CULTURE OF SCS COST EFFECTIVE (NMFS PRESENTLY CALCULATES THE WORTH OF ONE RETURNING SCS AT 550 DOLLARS)?



The majority of respondents (69%) felt rearing of spring chinook was cost effective if the net worth represented by one returning adult was $550.00. There were no significant changes between rounds. The following example displays the estimated costs of an actual spring chinook program rearing about 800,000 fish to 15 fish/lb.: This program is run on about $175,000 per year. At $550 per returning adult, 318 adults must return to break even. On 800,000 fish, this equates to a .04 percent smolt-to-adult return rate necessary to be on the positive side of a cost benefit ratio. This is a low return rate as .1 percent is generally accepted as attainable in a successful program. Costs of this particular program would probably rank as average and the return rate necessary to recover this amount as below average. It appears that most programs should be able to show a positive cost/benefit ratio.

QUESTION 65: DO YOU BELIEVE THE MOTIVATION BEHIND FISH CULTURE DECISIONS ARE THE NEEDS OF THE FISH OR EFFICIENCY FROM THE HUMAN STANDPOINT?

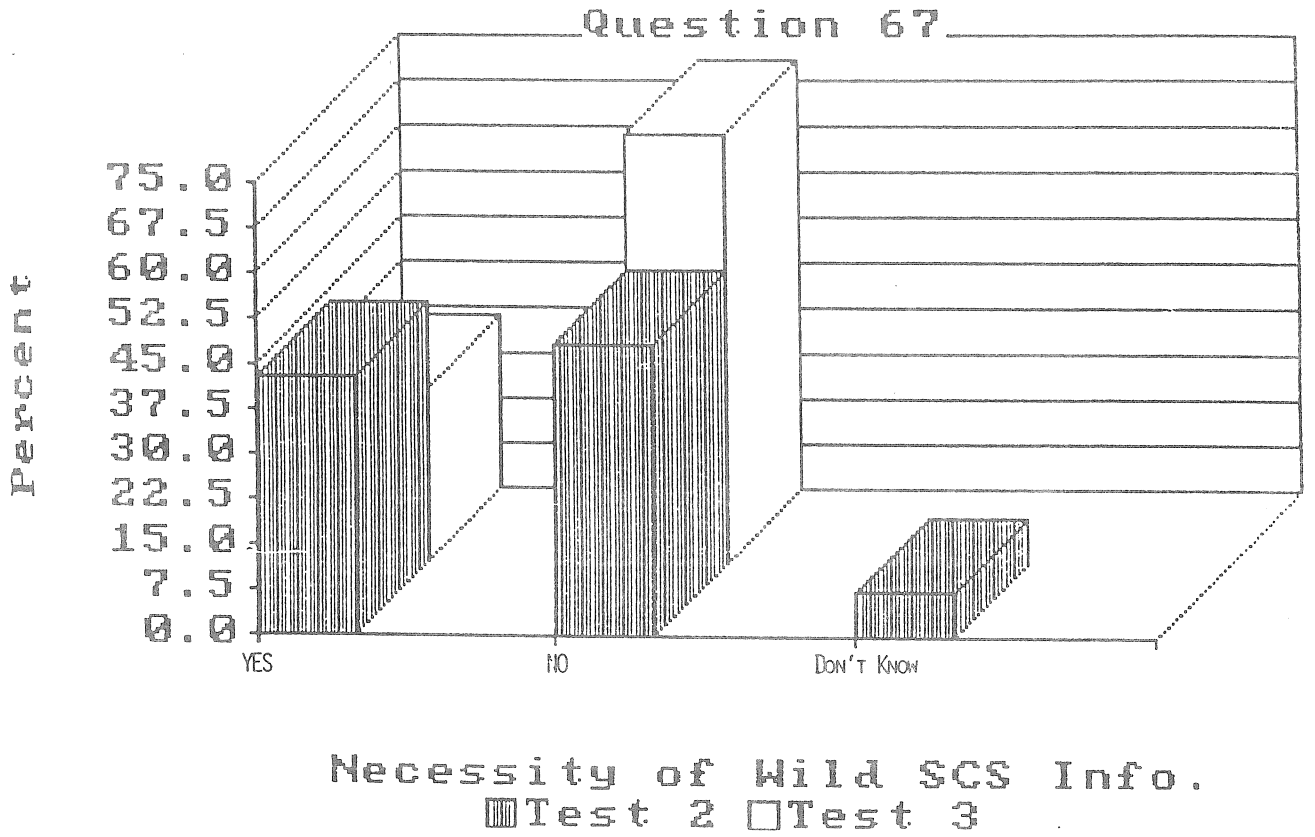


Although not a strong consensus, I would call it a "disturbing" majority which said present fish culture decisions are motivated more by concerns for human efficiency than the needs of the fish. The response was 53 percent to 35 percent human over fish needs with 12 percent feeling both were involved. A reading of the round two justification responses indicates people are not happy about this, but quite often feel administrative pressures (funding, manpower restraints, etc.) force them into less than optimum decisions for fish. However, about one-fourth of the respondents felt that the human efficiency decisions were not motivated by some economic practicality, but simply by convenience. Some of the specific concerns included use of old feed when it should not be, spawning practices easier for spawners than good for fish and eggs, high loadings on distribution trucks to reduce trips, release on an artificial schedule to fit dam spill and transportation programs, and continued research to develop feeding devices that reduce human effort but do not feed as well as hand feeding.

Question 65 (cont.)

Perhaps this question can best serve as a reminder to all involved in spring chinook culture to closely analyze the motivations behind our decisions. A little extra effort may be able to convert a decision motivated by human convenience into one that is also best for the fish.

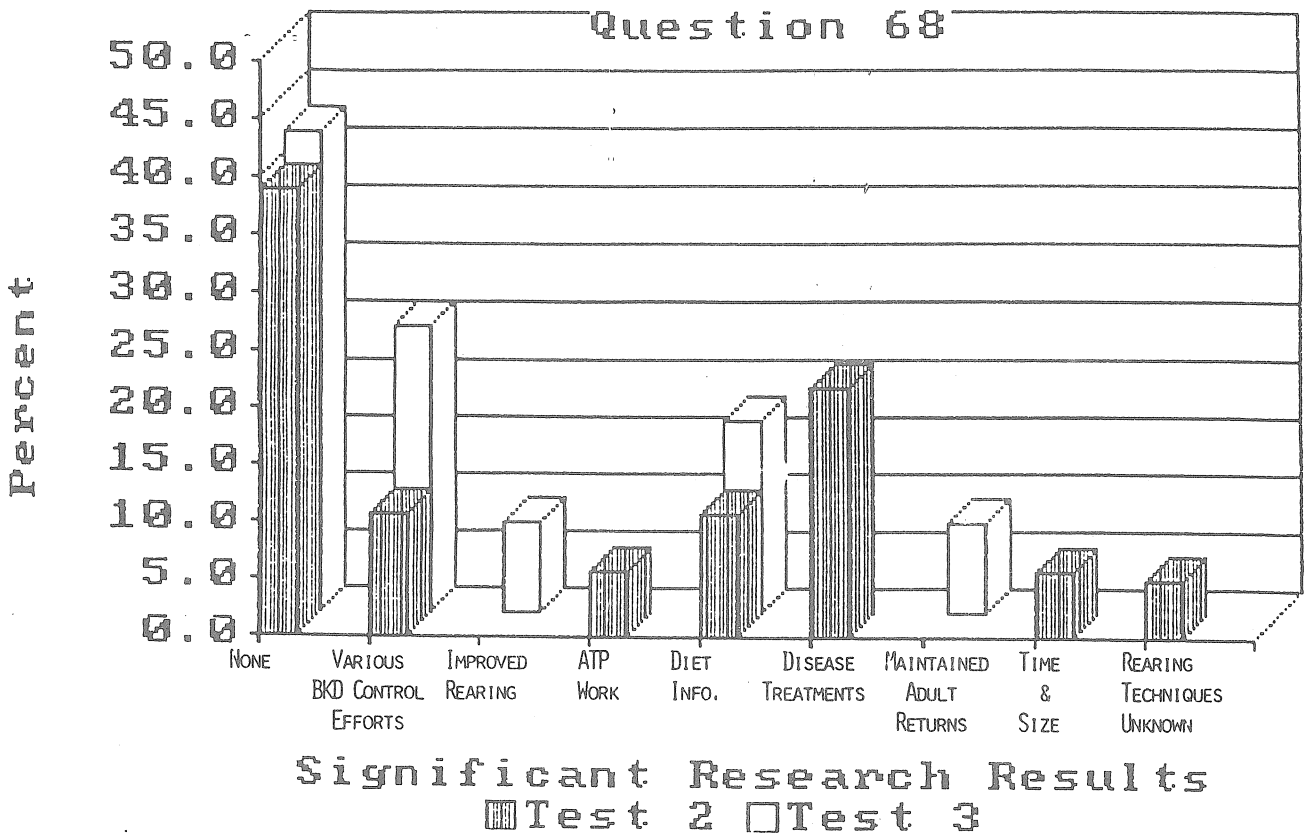
QUESTION 67: DO YOU FEEL THAT MORE INFORMATION ON THE BIOLOGY AND BEHAVOIR OF SPRING CHINOOK IN THEIR NATURAL ENVIRONMENT WOULD GIVE FURTHER INSIGHTS INTO THE HATCHERY CULTURAL ASPECTS OF THIS SPECIES?



Seventy-one percent felt research into the biology and behavior of spring chinook in the wild could not give further insights into hatchery culture of the species. They argue we have created an environment so artificial that there would be very little translatable into beneficial hatchery application. New sets of problems are faced in the hatchery environment that they felt were necessary to overcome. We should learn to manage the species in the environment in which we raise it.

Subject areas where respondents felt there were still unknowns to benefit spring chinook culture were natural diet/nutritive characteristics, early ocean life history information, and more information on the causes of natural timing and size at migration. The 71 percent majority, however, would prioritize fish cultural research first.

QUESTION 63: WHAT SIGNIFICANT DEVELOPMENTS, IF ANY, HAS SCS SALMON RESEARCH BROUGHT TO THE CULTURE OF THIS SPECIES?



No consensus on this question, but there were 42 percent who felt research has brought no significant developments to spring chinook culture. There was a jump from 11 percent to 25 percent who felt research has brought useful information to bear on kidney disease problems. Diet research garnered a 17 percent vote. These responses indicate there is a significant need for research to address problems specific to spring chinook culture. In the summary, we will list some of these research grey areas as indicated by this questionnaire.

SUMMARY

The results of the three rounds of questionnaires show that a 100 percent consensus on an issue will be rare. In fact, Zuboy's Delphi experiment (1981), to estimate Florida spiny lobster catch, came to a consensus after five rounds of 520,000 to 1,000,000 pounds. This demonstrates that an exact point estimate is not usually the end point of a successful Delphi question. Rather, a condensed range formulated from the available knowledge of expert opinion is; and in the absence of sufficient empirical data, this expert opinion can represent the best possible estimate available. It would be naive to purport that we could define an exact and infallibly true answer to questions we would admit to having limited factual or experimental basis to analyze. Even the most rigidly controlled experiments will present a statiscal range of confidence with a point estimate, e.g. plus or minus 10 percent.

Linstone, as quoted by Zuboy (1981) said: "The Delphi designer who understands the philosophy of his approach and the resulting boundaries of validity is engaged in the practice of a potent communications process. The designer who applies the technique without this insight or without clarifying these boundaries for his clients or observers is engaged in the practice of mythology". So we too must understand the context from which these Delphi responses came and may eventually be applied.

The most important fact to point out in this regard is that we are not dealing with a question that can be framed within tight temporal, physical, or geographical boundaries. I would venture to say that spring chinook are not reared from egg to smolt at any two hatcheries under the exact same

conditions. Each station will have certain affecting factors and considerations creating specific limits for a number of fish cultural techniques. This individuality had two effects to this Delphi questionnaire. First, it resulted in considerable variation and range in the responses (fewer consensuses) in early rounds; a manifestation of the technical and physical differences between spring chinook stations in the Columbia River basin. Secondly, this site specific individuality had a tendency to slow down the consensus development process. In the early rounds, the responses often reflected the experts most recent experience, which may not have reflected his complete knowledge from past experience. Although we tried to phrase the questions to diminish this effect (e.g. given unlimited resources or given no limiting factors what is your optimum choice?), the tendency for the respondents answers to reflect practices at the present station were still evident. However, once the respondents had feedback in terms of reviewing the results, the group meeting before the second questionnaire, and the justification responses, convergence towards consensus began and less bias was evident. I feel, however, it may have taken four or five rounds and continued feedback to completely eliminate this effect and reach an even closer group consensus. In light of the potential for site and experience specificity to bias the consensus process, it is logical to assume any question which obtains a strong majority or rating of importance is trully an important or critical factor that should hold true over a broad range of spring chinook programs. The experiment is not lost if no consensus forms on specific questions. Divergent opinions may suggest new avenues for successful rearing, areas needing research, or imply simply that SCS are adaptable enough to be successfully reared in a variety of different conditions.

Table 1. Summary of final high factor ratings for Delphi spring chinook questions.

Subject	Question Number	Description	Response	Percent Response or Rating
ADULT HOLDING AND SPAWNING	1R*	Important factors reducing holding mortality	Water temperature Minimize handling	2.1 4.7
	2	Best adult holding pond	Deep rectangular	94%
	3	Optimum holding temperature	48-50°F	59%
	4a	Adult chemical treatment, first choice	Malachite	65%
	4b	Adult chemical treatment, second choice	Erythromicin	75%
	5	Adult handling prior to spawning	No	71%
	6a	Adult tranquilizer, first choice	MS-222	65%
	6b	Adult tranquilizer, second choice	MS-222	47%
	7	Omitted		
	8	Optimum number of males to fertilize one female	Two	65%
	9	Optimum number of females/bucket	Three	71%
	10	Best method of obtaining eggs	Cutting	94%
	11	What portion of run to obtain eggs	All portions	88%
	12	Best egg disinfectant	Iodine or Wescodyne	70%
	13	Would you recommend erythromycin egg baths?	Yes	59%
	14	Importance of sterile (clean) spawning techniques	Moderately important	41%

Subject	Question Number	Description	Response	Percent Response or Rating
ADULT HOLDING AND SPAWNING (cont.)	15	Is adult density in ponds important?	Yes	94%
	16	Optimum holding density	Less than 1 lb/ft^3	47%
EGG STAGE	17R	Most important factor to obtain high quality egg	Handler's experience Spawning techniques	4.5 6.8
	18R	Most important factor in obtaining good eye-up	Temperature Minimum handling Water Quality	2.6 4.5 5.4
	19	What is a good eye-up percentage?	91-95%	59%
	20	Best incubation temperature	49-50°F	53%
	21	Best incubator	Heath	47%
	22	Disease potential in eggs	BKD	76%
	23	Optimum Heath tray egg density	5,000-7,500	73%
	24	Overall effect of egg chemical Treatments	Positive	76%
	25	Favorite chemical treatment for eggs	Malachite	44%
	26	Need for artificial substrates in incubation	Yes	50%
NURSERY REARING	27R	Most important factors for good start in nursery	Temperature Starter diet Water quality Loading	2.1 3.9 5.4 5.8
	28	Optimum starting temperature	50-52°F	65%
	29	Best starting diet	BioDiet	50%
	30	Omitted		
	31	Worst disease in fry	IHN	32%

Subject	Question Number	Description	Response	Percent Response or Rating
NURSERY REARING (cont.)	32	Importance of overhead cover	Not important	59%
	33	Size at transfer to ponds	200-250/lb ≥450/lb	44% 44%
	34	Suggested changes to nursery rearing	Better diet	32%
	35	Feedings/day in nursery	6-12	65%
	36	Superior nursery rearing tank design	Rectangular	100%
POND REARING (Parr Stage)	37R	Most important factors in rearing parr	Water temperatures Loading densities Diet	2.8 5.2 6.3
	38	Recommend number of feedings/day in ponds	2-4	65%
	39	Best single-pass spring chinook rearing ponds	Rectangular 8' x 80'	70%
	40	Optimum rearing temperature	51-55°F	62%
	41	Best diet for parr	OMP II	50%
	42	Omitted		
	43	Worst problem disease in parr	BKD	88%
	44	Is rearing with overhead cover important?	Yes	65%
	45	Recommended changes to pond rearing	Improve diet	37%
	69	Is stress of handling worth effort to grade?	No	81%
	71	How close to smolting is is safe to handle fish?	1-2 months	40%
DIET	46R	Best diet to rear parr	OMP II BioDiet OMP IV	3.6 5.4 5.5

Subject	Question Number	Description	Response	Percent Response or Rating
DIET (cont.)	47R	Best feeding method	Hand feeding	2.3
	48R	Estimate of what may be missing in diet	Vitamins	7.3
			Too little animal protein	8.0
			Proper texture	8.7
	49	Is there a satisfactory diet available for parr?	Yes	69%
	50	Is there an optimum diet available for parr?	No	75%
	51	Diets used by questionnaire respondents	OMP II	54%
	52	Diet modification suggestions	Buoyancy	47%
	66	Should USFWS lead diet research?	Yes	82%
DISEASE	54R	Most important avenue to pursue in BKD treatment	Oral vaccine	2.8
	55	Effect of minerals in water on fish health	Important	94%
	56	Choice of water hardness	Moderately hard	88%
RELEASE	57	Optimum release size	15-20/lb	75%
	58	Size at optimum finish (condition)	15-20/lb	82%
	59R	Best smolting indices	Behavior changes	2.1
			Scale changes	4.2
	70	Should salt be used during transportation?	Yes	65%
MISCEL-LANEOUS	60R	Causes of spring chinook decline	Dams	2.2
			Disease	5.4
	61	Effects of routine handling	Negative	76%

Subject	Question Number	Description	Response	Percent Response or Rating
MISCEL-LANEOUS (cont.)	62R	Important stress creating factors	Handling Pond density Poor diets	3.9 4.7 6.0
	63R	How to best alleviate stress?	Reduce feedings Remove feed Reduce densities	5.3 5.5 6.5
	64	Is spring chinook culture cost effective?	Yes	69%
	65	Basis of fish culture decisions	Human efficiency	53%
	67	Necessity of additional wild spring chinook information	No	81%
	68	Most important spring chinook research results	None	42%

*Ranking questions indicated with an "R"; all factors with a "most important" ranking are shown.

Table 2 shows 23 (41%) of the 54 fill-in questions had their highest rated factors in the 70-100% response range by round three. Eleven of these were ranked in lower categories in rounds one and two. Movements within the other two response ranges are also displayed. Of the 54 questions, 21 (37%) had significant respondent opinion shifts in the highest rated factor as indicated by movement into different response ranges by round three.

TABLE 2. Summary of round three response ranges for fill-in questions.

	Response Range			
	70-100%	50-69%	1-49%	Totals
Number of questions in response range by third round	23	21	12	56
Number moved into range since round one	11	7	3	21

Of 81 parameters in the 13 ranking questions, 15 of the round three responses had made response range shifts since round one. In fill-in and ranking questions combined, 26 percent showed significant inter response range shifts by round three.

Twenty-two percent of the fill-in questions did not have one factor that was selected by even 50 percent of the respondents. This may indicate there is no singular best treatment or most important factor identifiable as several have shown efficacy. Or, there exists an uncertainty due to lack of trial or empirical proof. From the questionnaire results, discussion, and earlier justification responses, it is clear that grey areas in spring chinook culture still exist. It is these areas where further production trials or research are needed. A brief summary of these lingering unknowns is given below:

ADULT HOLDING AND SPAWNING

Erythromycin Injection - This ranked only moderately important with the experts as they preferred reducing stress and maintaining adult survival through control of pond environment and minimal handling. Controlled experiments on inoculated and uninoculated adults are needed as is evaluation of any benefits carried through to their progeny.

There is concern among some researchers that BKD may develop resistance to erythromycin if used extensively throughout its range and intensively in hatchery programs, i.e., egg treatments, adult injections, and feedings.

Use of Iodophore on Eggs - Although a popular practice (70% response level), further research on effects on egg viability and fry success are needed. The FWS will be conducting tests with Argentyne this year.

Individual/Clean Spawning - Considerable effort and expense is involved in this type of spawning program. The driving impetus behind most of these is disease control which may have tremendous benefits if the primary mode of transmission is vertical. If horizontal spread of the disease later negates all the effort to interrupt the disease at spawning time, the benefits may be less profound. Regardless of disease considerations, clean spawning may just be plain good fish culture.

Enough programs of this type are in place to warrant an agency evaluation. Is it merely appropriate for disease control programs or is it important enough to be a standard practice? Are the effects of vertical and horizontal disease transmission compounding enough to warrant individual clean spawning when you can expect a horizontally transmitted infection later? What are the real costs in terms of money, manpower, equipment, and re-fitting? Let's find out.

EGG STAGE

Eye-Up Percentage - Any facility consistently obtaining only 80-85 percent eye-up should be examining ways to increase this to 90-95 percent. Factors to consider are water temperature, handling routines, and chemical treatments.

Incubators - Believe it or not, the experts do not consider the Heath tray as the ultimate! Troughs, jars, baskets, and gravel boxes seem to have their individual advantages. Are there modifications we can implement to these systems to optimize their function and produce more fry of optimum condition. It appears that the perfect incubator has not been developed yet.

Artificial Substrate - A split vote on this subject lead into a brief literature search on the issue. The literature was overwhelming in its support for the value of incubating salmon on artificial substrates. This may be a key missing factor in present incubating systems. We need to research this subject area in depth and set up pilot evaluations of various incubator/substrate systems.

NURSERY REARING

Causes of Drop out - A 20-30 percent loss of fry is not uncommon when drop out occurs and should categorize it as a major problem in fry rearing. Possible causes include diet related conditions which can be exacerbated by certain factors such as temperature. The FWS's Tunison Laboratory is presently looking at drop out in Lower Columbia and Snake River basin stations. This research needs to continue in earnest.

Tank to Pond Transfer Size - Two major size groups were suggested as optimum by the respondents; 200-300/lb. and 450/lb. or smaller. Those selecting the smaller sizes often cited physical limitations of the facility

to necessitate the move. Are we losing anything by moving at smaller sizes or not? Fifty-six percent of the experts felt we were. A production test seems warranted.

POND REARING

Density - Unfortunately all of the density questions were discarded as the respondents replied in different units when describing optimum density. As a result, we were unable to accurately compare them. Density did, however, rank as a most important factor in pond rearing.

The Oregon Department of Fish and Wildlife (ODFW) has found a strong inverse relationship between pond density and adult return rates (Max Smith, ODFW, pers. comm.). It should be noted that no radical differences in hatchery performances were seen in the ODFW studies. The only pre-release indicator noted was a visual observation of poorer condition in fish from denser ponds. It was not until adult returns were analyzed that the density effects were noted with increasing survival from lower density ponds. Similar results were seen in Sandercock and Stone's (1980) studies on coho. At present we have what appear to be satisfactory guidelines, but no definitions of optimum. Eventually, optimum densities in spring chinook rearing ponds must be determined.

DIET

Optimum Diet - The experts said there is no optimum spring chinook diet. The experts said general nutrition was one of the most important areas needing research in the control of disease. The experts did not come to a strong consensus on which OMP formulation was better. The experts and literature said diets are directly tied to several spring chinook disease problems such as sunburn, drop out, and BKD. The majority of experts said

buoyancy was the factor they would modify first to improve spring chinook diets. No other factor identified in the questionnaire was tied to fish quality as often and as strongly as diets. Need more be said? A comprehensive effort in spring chinook diet research seems mandatory.

Feeding - There is still considerable uncertainty over the efficiency of automatic feeding systems. The experts preferred hand feeding, but automatic or demand feeders are gaining in popularity. We need to determine who this is better for, the fish or the feeders.

DISEASE

BKD - Obviously, BKD was the disease of greatest concern to the experts. As a stress mediated disease, it may be the limiting factor to maintaining adequate adult returns to up-river stations, as they are put through the stress of eight dams and or their collection and transportation systems. As the discussion in Question 54 states, research into all avenues of BKD control should continue, especially fish cultural parameters. Optimization of their environment, rearing techniques, and reduction of stress may put BKD into the manageable disease category.

RELEASE

Size at Release - There exists widespread variation in size and time of release strategies for spring chinook. To categorically state there is a universal optimum size and time for release is fallacy. There continues to be a need for site by site evaluation of optimum size and time of release windows for both spring and fall releases and yearling and large sub-yearling sizes.

MISCELLANEOUS

Handling Stress - Everybody agrees it's not good. Yet, we live with the need to handle the fish for basic production information and research. We need to develop handling guidelines which clarify: (1) minimum production/health data needed for planning, informational, and administrative purposes; (2) specific time frames when large scale handling programs such as grading and marking programs should be conducted; and (3) protocols for coordinating and planning research sampling and marking programs with hatchery managers.

Water Temperature - In the ranking questions for adult holding, egg incubating, nursery rearing, and pond rearing, water temperature ranked as the "most important" factor to success. It affects virtually every factor in rearing: feeding, growth and metabolism, diseases, and parasites. Yet, when asked to define optimum temperatures for these phases, concensus in the 70-100 percent response range was not achieved. Considerable variation was evident, with answers by round three still spread over a 10°F range for most of the question. The effects of 4° or 5° temperature shift can be dramatic on growth; and from this non-fish culturalist's viewpoint, this seems to be an area where a standardized optimum should be defined.

The interpretation of results to these four questions is best left to the experts. Do they feel the variation in optimum temperatures is a residual effect of site-specific bias in response? Or, is there really a gray area in defining optimum temperature ranges? Are the ranges given in the answers significant enough to worry about? Hopefully some discussion and feedback will be generated among us on this issue.

The results of this questionnaire would seem to indicate that culture of spring chinook salmon has not reached the level of an exact science.

Consensus problems such as unavailability of optimum diets and BKD control still do not have remedies waiting in the wings. For those questions with low response ratings, we are faced with deciding whether there is really "more than one way to skin a cat" (rear a spring chinook) or have we identified one of the true unknowns? We have attempted using this structured technique to aid us in this task and have made recommendations on those areas needing further research. However, I cannot stress enough that the interpretation of results will be carried to a higher magnitude of resolution only through careful analysis by the expert participants. There certainly are subtleties in the responses that only their experienced eyes and minds will recognize; hopefully, these will be communicated to us.

There should be no disappointment that we did not develop a "cookbook" to spring chinook culture; and in fact, this was not the purpose of this study. What have we learned? In thirteen rating questions, we have attempted to identify the most important factors to success in every phase of spring chinook rearing programs. In its simplest use, these most important areas are a guide as to where the greatest effort should be directed in endeavoring to optimize the culture of spring chinook. In 41 percent of the questions, we were able to define with a strong consensus (70-100%) the optimum or limiting range of those factors. We were also able to define 15 areas where further research or evaluation production trials are still necessary.

On the whole, perhaps the greatest value of this Delphi exercise and report will be to elevate the issue of optimizing spring chinook salmon culture and management, and to stimulate us to review and evaluate our present efforts. As long as spring chinook runs hover on a precarious edge, with spawner recruitment near 1:1, maintaining the status quo will not suffice. Management, production, and administrative programs must strive for innovation, creativity, and measurable results. If this report acts as a thought stimulator and an idea generator to lend direction in this effort, then it has fulfilled one of the most important functions we originally envisioned.

LITERATURE CITED AND SUGGESTED REFERENCES

The following citations were either referenced in the report or given as suggested subject reference material at the end of each section.

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