AQUAVET® CONFERENCE

PROCEEDINGS

20th Anniversary
1977 — 1996

AQUAVET®

A Program in Aquatic Veterinary Medicine

FOREWORD

This conference marks the 20th anniversary of the establishment of *AQUAVET®* - A Program in Aquatic Veterinary Medicine. In many ways, this milestone is of particular significance because it confirms attainment of the over-arching goal set in 1976-77 to foster development of a recognized specialty field of aquatic animal medicine within the veterinary profession. In 1976, there were essentially no opportunities for veterinary students to gain knowledge about aquatic animal medicine in a formal manner at the schools and colleges of veterinary medicine or at the local and national continuing education meetings sponsored by the various veterinary medical associations. Happily, this has all changed dramatically during the past 20 years.

These changes are the direct result of efforts made by many members of the profession including a significant number of alumni of this program. Many of those instrumental in these accomplishments are in attendance at this conference where the lifelong process of education continues through the sharing of information and experiences with one's peers. Over these few days we have an opportunity to add to our knowledge, renew old friendships, establish new friendships, revisit a very special place, and plan for the future advancement of our specialty field. On behalf of the Directors of *AQUAVET*, our thanks go out to each of you for having accepted the challenge offered by the creation of this unique experience. Furthermore, we are all indebted to those who have given so freely of their time and talent to make presentations at this conference that we may share and increase our knowledge and understanding of aquatic animal medicine and health.

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Thank you all for coming, have a wonderful time.

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AQUAVET® 20th ANNIVERSARY CONFERENCE
MARINE BIOLOGICAL LABORATORY
WOODS HOLE, MA
NOVEMBER 14 - 17, 1996

THURSDAY, NOVEMBER 14

3:00 p.m. - 9:00 p.m.	Registration - Swope Center Lobby
6:00 p.m. - 9:00 p.m.	Social Mixer/Dinner - Meigs Room

FRIDAY, NOVEMBER 15

7:00 a.m. - 8:30 a.m.	Breakfast - Swope Dining Room

Scientific Sessions	**Whitman Auditorium**
8:30 a.m. - 8:45 a.m.	Welcome and opening remarks
8:45 a.m. - 10:00 a.m.	Session I
10:00 a.m. - 10:30 a.m.	Refreshment Break
10:30 a.m. - 12:00 noon	Session II
12:00 p.m. - 1:30 p.m.	Lunch Break - Swope Dining Room
1:30 p.m. - 3:00 p.m.	Session III
3:00 p.m. - 3:30 p.m.	Refreshment Break
3:30 p.m. - 5:00 p.m.	Session IV
6:30 p.m. - 7:30 p.m.	Dinner - Swope Dining Room
Evening	Open social time - on your own

SATURDAY, NOVEMBER 16

7:00 a.m. - 8:30 a.m.	Breakfast - Swope Dining Room

Scientific Sessions	**Whitman Auditorium**
8:30 a.m. - 10:00 a.m.	Session V
10:00 a.m. - 10:30 a.m.	Refreshment Break
10:30 a.m. - 12:00 noon	Session VI
12:00 p.m. - 1:30 p.m.	Lunch Break - Swope Dining Room
1:30 p.m. - 5:00 p.m.	Open Time - Rediscover Woods Hole

Tours of the **L**aboratory of **A**quatic **A**nimal **M**edicine and **P**athology (**LAAMP**) and the **M**arine **R**esources **C**enter (**MRC**) will be available throughout the afternoon.

5:30 p.m. - 6:30 p.m.	Happy Hour - Meigs Room
6:30 p.m. - 8:00 p.m.	Conference Banquet - Swope Dining Room

8:00 p.m. ***AQUAVET®* 20th ANNIVERSARY CONFERENCE LECTURE**
Whitman Auditorium

Veterinary Medicine and the United States Space Program with special reference to STS-78, June/July 1996
Dr. Richard M. Linnehan, Astronaut
AQUAVET® I 1983, *AQUAVET®* II 1990

SUNDAY, NOVEMBER 17

7:00 a.m. - 9:00 a.m.	Breakfast - Swope Dining Room
10:00 a.m.	Check Out Time - Swope Center

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Woods Hole, MA
November 14-17, 1996

AQUAVET® 20th ANNIVERSARY CONFERENCE
PARTICIPANTS

	CLASS YEAR	
	AQUAVET I	*AQUAVET* II
Abt, Donald A.		
Armstrong, Karyn L.	1986	
Bebak, Julie A.	1990	1994
Bentz, Amy I.	1996	
Berzins, Ilze K.		1993
Borkowski, Rosemarie	1989	1990
Bowser, Paul R.		
Brown, Virginia G.	1988	
Brown, Rosanne I.	1983	
Bullis, Robert A.	1981	
Bullock, Christine D.		
Bullock, Graham L.		
Butterfield, Matt		
Calle, Paul P.	1980	
Carr, William H.	1989	1990
Cherry, Bryan R.	1994	
Clark, Terri R.		
Cook, Barbara		
Cooke, Susan Reed	1995	1996
Crawford, Sara Ann	1986	
Deveau, Mark A.	1984	
DiFilippo, Franca M.	1994	1995
Driscoll, Cindy P.	1992	1993
Evans, Erica		
Evans, Howard E.		
Falck, Carol L.	1994	1995
Ferraro, Linda A.	1977	
Fine, Deborah M.	1994	1995
Getchell, Rodman		1994
Hacker, Sander O.	1994	
Herman, Carol A.		
Herman, Roger L.		
Hershey, A. Elizabeth	1994	1995
Holden, Christine M.	1995	1996
Hung, Judy T.	1994	1995
Irwin, Julia W.		1996
Johnson, Michael R.	1983	1984
Kebus, Myron J.	1989	1990
Krum, Howard N.	1990	1991
Land, Miller		
Land, Alec E.	1983	
Landeau, Laurie J.	1981	1983
Latson, F. Edgar	1978	1983
Leids, Pepi F.	1979	
Levin, Eve M.	1989	
Lewbart, Gregory A.	1986	
Linnehan, Richard M.	1983	1990

	CLASS YEAR	
	AQUAVET I	*AQUAVET* II
Loretz, Catherine		
Loretz, Christopher A.		
Manyin, Eileen C.	1989	
Matlock, Jr., John W.		
Matzkin, Zachary P.	1996	
McKenna, Thomas St. C.	1986	
Merrill, Peter L.	1995	
Mizell, Merle		
Mullican, Timothy J.	1982	
Mumford, Sonia L.		1995
Murphy, Lisa A.	1994	1995
Olkowski, William F.	1980	
Opitz, H. Michael		1984
Phipps, Chris		
Pierce, Virginia	1985	
Rach, Michael P.	1980	
Schulte, Diane G.		
Smith, Stephen A.		1992
Smolowitz, Roxanna M.	1979	
Steward, Cheree		
Steward, Duane Allen	1979	
Stiles, Franklin N.	1983	
Swanson, Kristen L.	1994	
Tabor, Gary M.	1984	
Tighe, Ellyn K.	1992	1993
Vanek, Vicki A.	1985	
Watson, Karen L.	1994	1995
Weisse, Charles W. C.		1996
Whaley, Janet E.	1989	1990
Whitaker, Brent R.		1986
Willard-Mack, Cynthia L.	1983	
Williams, III, C. Rogers		1992
Williams, Michele L.	1994	1995
Willsey, Amy L.	1993	
Yamamoto, Polly S.	1979	
Yanong, Roy P. E.	1989	1990

AQUAVET® **20th ANNIVERSARY CONFERENCE**
SCIENTIFIC SESSIONS
WHITMAN AUDITORIUM
MARINE BIOLOGICAL LABORATORY
WOODS HOLE, MA

Session I - Friday, November 15
8:45 - 10:00 a.m.

Some slides I forgot to show you twenty or fewer years ago
Howard E. Evans

Whirling disease in the hatcheries and native waters of the Commonwealth of Virginia
Stephen A. Smith and Jennifer Cardinale

Advances in shrimp health management
William H. Carr

Identification of retroviruses associated with unaffected green sea turtles and turtles with fibropapilloma
R. N. Casey, S. L. Quackenbush, T. M. Work, G. H. Balazs, P. R. Bowser, and J. W. Casey

The Age of Aquaria
Roy P. E. Yanong

Session II - Friday, November 15
10:30 a.m. - 12:00 noon

Veterinary Aspects of the Navy's Marine Mammal Program
Richard M. Linnehan

Clinical approach and diagnosis of copper toxicity in marine teleosts
"Sea" Rogers Williams III

Marine Mammal and Sea Turtle Health Stranding Programs at NMFS
Cindy P. Driscoll

Quahog Parasite Unknown, an emerging disease of the hard clam, *Mercenaria mercenaria*
Roxanna M. Smolowitz and Dale F. Leavitt

Wisconsin Aquatic Veterinary Service
Myron J. Kebus

Session III - Friday, November 15
1:30 - 3:00 p.m.

Experimental Catfish Health Management Program
Michael R. Johnson and David Wise

Risk factors for bacterial gill disease in young rainbow trout in North America
Julie Bebak, Mona Baumgarter, and Gary Smith

Use of the stress induced furunculosis test to detect *Aeromonas salmonicida* in asymptomatic rainbow trout cultured in a recycle system
G. L. Bullock, R. C. Cipriano, and R. Kretschmann

Efficacy and safety of Cypermethrin for treatment of salmonid sea lice
H. M. Opitz, B. Pahl, C. Bartlett, D. MacPhee, and J. Pitts

Session IV - Friday, November 15
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Pharmacokinetics of enrofloxacin in the red pacu (*Colossoma brachypomum*) after intramuscular, oral and bath administration
G. Lewbart, S. Vaden, J. Deen, C. Manaugh, D. Whitt, A. Doi, T. Smith, and K. Flammer

Safer seafood through HACCP: An overview of the Seafood Hazard Analysis and Critcial Control Point (HACCP) program
Janet E. Whaley

Natriuretic peptide production in the intestine of the Japanese eel
Christopher A. Loretz, Catherine Pollina, Hiroyuki Kaiya, and Yoshio Takei

The use of clove oil as an anesthetic in rainbow trout (*Oncorhynchus mykiss*)
Deborah M. Fine

Special imaging and preservation techniques in marine animal medicine
Ilze K. Berzins, Brent Whitaker, Gary March, Ron S. Wade and Grover Hutchins

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Stephen A. Smith, Steven D. Holladay and John L. Robertson

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Merle Mizell, Roxanna Smolowitz, John Stegeman, Eric Romig, and Rajesh Katayani

Aquatic Wildlife Medicine
Rose Borkowski

Clinical Veterinary Medicine of Aquatic Species at the Wildlife Conservation Society
Paul P. Calle, Mark D. Stetter, William B. Karesh, and Robert A. Cook

How wet is the World Wide Web?
Duane Steward

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Howard N. Krum and Connie Merigo

Wildlife rehabilitation during an oil spill in the Arabian Gulf
Virginia Pierce

Pathophysiology of a failed Petshop
Alec E. Land and Rona P. Shepiro

Detection of illegal egg removal in the American Lobster, *Homarus americanus*
Robert A. Bullis

Anesthetic agents for use in the invertebrate sea snail, *Aplysia californica*
Terri R. Clark, Patricia C. Nossov, James P. Apland, and Margaret G. Filbert

Public policy and the Gulf of Maine ecosystem: Update
Gary Tabor

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G. A. Wooster, H. M. Hsu, and P. R. Bowser

Hawaiian monk seal recovery efforts - disease investigation
Cindy P. Driscoll and Robert Braun

1996 right whale mortalities investigation
Cindy P. Driscoll

Some slides I forgot to show you twenty or fewer years ago

Howard E. Evans

As a faculty member of Aquavet for the past twenty years I look back with pleasure on the many interesting things I have seen, and the 500 plus enthusiastic students of all ages I have met. This course was first given in the Spring of the 1976-1977 academic year and I was invited by Director Donald Abt, V.M.D. (Prof.of Epidemiology and Biostatistics, Dept.of Clinical Studies, Univ.of Pennsylvania) and Associate Director Charles Rickard, D.V.M. (Prof.of Pathology, New York State College of Veterinary Medicine) to take part in the first week of the four week program.

The proposal and request for funds was made to Dr. Donald Squires, Director of the New York Sea Grant Institute in Albany. It was supported by Dean Edward Melby of Cornell and Dean Robert Marshak of Pennsylvania. The grant was approved and the first course began on the evening of May 22, 1977.

I have shown quite a few slides over the years to illustrate invertebrate and vertebrate morphology but now I find that there are some I have forgotten to show you and there are others that came along after you had finished the course. I will try, time permitting, to fill in the blanks.

Whirling disease in the hatcheries and native waters of the Commonwealth of Virginia

Stephen A. Smith and Jennifer Cardinale

Whirling disease, caused by the myxosporidian parasite *Myxobolus (Myxosome) cerebralis*, can be a serious problem in both cultured and feral salmonid populations throughout the country. Recently, this protozoan parasite has gained considerable attention as the agent possibly responsible for complete year class losses of wild trout in the western United States. Concern about the possibility of contamination of healthy native populations through the stocking of infected fish has resulted in many states initiating investigations into the natural occurrence and distribution of the organism in trout populations. This study examined fish from private and state trout culture facilities, stocked trout populations, and native trout populations from Virginia. Groups of fish from each location were evaluated using the plankton centrifuge detection method recommended by the American Fisheries Society. Results of this study will help determine the range and effect of this parasite

Advances in shrimp health management

William H. Carr

Both nationally and internationally, marine shrimp culture has experienced significant economic losses due to disease. With the development of new technologies, such as molecular probes for viruses and selective breeding, alternative strategies in shrimp health management are available. This talk will focus on recent advances in cultured marine shrimp health management. In particular, methods and procedures applied at The Oceanic Institute, a center of applied aquaculture research, will be discussed. In cooperation with other institutions of the U.S. Marine Shrimp Farming Program (Gulf Coast Research Laboratory Consortium) The Oceanic Institute is currently developing a selective breeding program for specific pathogen free (SPF) Pacific White Shrimp, *Penaeus vannamei*. In this program broodstock selection is based on both growth performance and disease resistance. This talk will focus on shrimp health management for the most significant pathogens (e.g. White Spot Syndrome Virus, Yellowhead Virus, and Taura Syndrome Virus, etc.), pathogen screening protocols, disease prevention measures, and preliminary results in selective breeding for disease resistance. Preliminary date from the current SPF shrimp populations suggest that there is significant variation in susceptibility to Taura Syndrome Virus and that this trait is heritable.

Identification of retroviruses associated with unaffected green sea turtles and turtles with fibropapilloma

R.N. Casey, S.L. Quackenbush, T.M. Work, G.H. Balazs, P.R. Bowser, and J.W.Casey

Unaffected green sea turtles, *Chelonia mydas*, and those displaying fibropapillomas collected in Hawaii have been analyzed for infection by retroviruses. Strikingly, all samples tested from both affected and unaffected turtles were found to be positive for reverse transcriptase (RT) by the polymerase enhanced reverse transcriptase (PERT) assay and had high enough levels to quantify by conventional RT assays. Samples of skin from unaffected turtles proved to be RT positive although the levels of enzyme activity present in healthy captive turtles hatched and raised at Sea Life Park, Hawaii were much lower than that observed in free-ranging turtles. Turtles with fibropapilloma displayed variable levels of RT activity. Skin and eye fibropapilloma and a heart tumor were further analyzed

and show to harbor a retrovirus which banded in sucrose at a density of 1.17g/cc, displayed a temperature optimum of 30°C and showed a Mn++ ion preference. Sucrose gradient fractions having elevated levels of reverse transcriptase contained retroviral size particles (110 nm) when negatively stained and examined by electron microscopy. Sodium dodecylsulfate-polyacrylamide gel electrophoresis (SDS-PAGE) analysis or sucrose gradient purified virions displayed three prominent low molecular proteins consistent with Gag protein profiles obtained with other retroviruses, like walleye dermal sarcoma virus (WDSV) and avian leukemia viruses (ALVs). The collective data presented in this study shows that retroviral infections are widespread in green sea turtles and warrants a comprehensive investigation to address the possibility that these agents may be involved in the genesis of fibropapilloma.

THE AGE OF AQUARIA
(or One Wet Pet Vet Pond-ers Life on the Farm)

Roy P.E.Yanong

INTRODUCTION

"It was the best of times, it was the worst of times. . ." After graduating from Penn, with no job in sight, I received a tip from Wet-Pet-Vet-Mafia don, code name: glewbart, the ivory hunter. In that distinctive low-pitched, yet thunderous voice of his and while holding a water gun to my head, he said "Be a man. Work with little fishies. Get a job. . .in Florida. . .or I swear, you'll be swimming with them. . ." Out of fear for my life, I obliged. In July of 1992, I began work with the folks at 5-D Tropical, Inc.

THE AGE OF AQUARIA

The ornamental fish industry IS big business. In 1994, retail sales for pet fish and related products were estimated at 1.34 billion dollars, with $463 million spent on live fish and $88.4 million spent on over-the-counter fish medications.(1) The heart of the industry in the U.S. is Florida, which boasts 95% of domestic production by approximately 200 producers. Imports from South America, Africa, and the Far East round out overall species availability.

5-D Tropical is one of the largest producers, importers, and wholesalers in the country. 5-D's two farms encompass 200 acres with approximately 800 ponds. In addition to breeding the "bread and butter" species, that is, the more common varieties of tetras, gouramis, barbs, and danios, we also produce several species of catfish including several Corydoras species, the common plecostomus, and Pangasius sutchi ,the iridescent shark; livebearers; freshwater sharks; rainbowfish; cichlids; and

others. Breeding protocols vary from species to species, and although most fish are spawned naturally, a growing number of more difficult to breed species are being cracked using hormonal injections of carp pituitary extract, HCG, and/or LHRH analogues to trigger ovulation and spermiation. 5-D also imports directly from South America, the Far East, and Africa.

I'VE GOT A HEADACHE. . .

Working at the ornamental producer/wholesaler level is challenging for many reasons. Here are just a few, in no particular order. . . Species variability is staggering. The small size of most ornamentals limits work up and treatment to a large extent, especially at the fry stage. The numbers of fish on the line can be quite high--one pond may hold close to 200,000 fish and one spawning run may produce several hundred thousand fry. Ornamental fish virology is a relatively new field. Antibiotic dosages are, in most instances, empirical, and species differences have not been comprehensively elucidated. There are really no labeled chemicals or antibiotics for ornamentals. The role of specific water quality parameters in treatment effectiveness is not completely understood. Historical information on imported fish is often lacking and adds more variables. Nutritional requirements for broodstock conditioning of new species is poorly understood, nor are optimal nutritional requirements for maximum grow out efficiency of even commonly bred species. Governmental regulations add more spice. . . . . .

. . .BUT I KINDA LIKE IT.

But it is precisely these challenges which make the field fascinating. Bottom line: the intrinsic beauty of a well-planted aquarium stocked with any of a number of ornamentals, brings a closeness to nature and a serenity which cannot otherwise be obtained for so small a price.

1. Pet Supplies Marketing's State of the Industry Report, Spring, 1995.

Veterinary Aspects of the Navy's Marine Mammal Program

Richard N. Linnehan

An overview of the history, operations, husbandry, and research programs of the Naval Research and Development (NRaD) Laboratory in San Diego, CA. The Veterinary Sciences Department at NRaD has developed a broad-based health maintenance program encompassing all cetacean and pinniped naval mobile marine mammal systems as well as on-site research populations. Methods of animal restraint, clinical diagnosis and treatment, new anesthetic techniques, and antibiotic pharmacokinetic studies will be discussed.

Clinical approach and diagnosis of copper toxicity in marine teleosts

"Sea" Rogers Williams III

A case study and literature review of copper toxicity caused by excessive treatment by primary care clinicians, hobbyists, or warehouse personal. Physical exam, hematology, serum chemistry and biopsy results will be reviewed with an emphasis on definite diagnosis base on liver copper analysis (quantitative analysis). Diagnosis and therapy are discussed and recommendations made.

The Marine Mammal and Sea Turtle Health and Stranding Programs at NMFS

Cindy P. Driscoll

Marine Mammal and Sea Turtle Health and Stranding Response Programs are multi-agency efforts to provide baseline data on health, human interactions and contaminants affecting marine mammal populations. The Marine Mammal component was developed under Title IV of the Marine Mammal Protection Act in response to the 1987-1988 bottlenose dolphin die-off along the Mid-Atlantic Coast. The Sea Turtle component is an ongoing effort. Both programs involve stranding response, biomonitoring through tissue analysis and archiving, and unusual mortality response. Investigation methods include the use of examination and sampling of live and dead marine mammal and turtle species. Information gained from these programs is used in management decisions by the National Marine Fisheries Service and the Fish and Wildlife Service - federal agencies having joint jurisdiction over both populations.

Quahog Parasite Unknown, an emerging disease of the hard clam, *Mercenaria mercenaria*

Roxanna M. Smolowitz and Dale F. Leavitt

In July 1995, Drs. Smolowitz and Leavitt attended a meeting of clam culturists in Provincetown, MA. The culturists had experienced increasingly severe mortality in sub-market sized animals on their leases over the last six years. Regulatory officials had attributed the increased mortality to increasing severe crab predation on clams. However, the signs shown by affected clams sampled from the leases and examined at this meeting suggested another possible cause for the mortality.

Fifty affected clams, which exhibited poor growth and focal nodules or diffuse swellings of the mantle and mantle edges, were examined. Thirty animals from the same lease but without gross signs were also examined. Ninety percent of the affected clams were infected with a protist named Quahog Parasite Unknown (QPX), while only 10% of the control clams were infected with QPX. A month later, QPX was again identified in another lease on the other side of the Cape Cod Bay.

QPX was first identified in Canada in clams from the St. Lawrence River in the early 1970's, then in a nursery in the late 1980's. This is the first observation of QPX in clams in the United States. Characteristics of the disease are largely unknown and are being investigated by this laboratory.

Wisconsin Aquatic Veterinary Service

Myron J. Kebus

Wisconsin Aquatic Veterinary Service (WAVS) is a private veterinary practice devoted exclusively to finfish. Clients include foodfish and bait fish producers, and ornamental fish wholesalers, retailers, and hobbyists. On-site service is provided to clients in Illinois, Indiana, Michigan, Minnesota, and Wisconsin. The practice was established in 1993 and is expanding beyond the Midwest.

Experimental catfish health management program

Michael R. Johnson and David Wise

Freedom from disease is an important factor channel catfish producers use to evaluate the health and success of their channel catfish production farm. However management that minimizes the effects of disease on productivity, feed conversion and production numbers lost may be a more profitable measure of their farm. In order for a channel catfish producer to incorporate management practices that eliminate or minimize specific disease problems such as PGD, ESC, Red Spot and/or anemia, he must identify, characterize and record parameters such as certain husbandry practices that lead to these diseases. However, most producers do not keep accurate history or records on the fish or individual ponds. From 1990 to 1994 an experimental catfish health management program was initiated on a few channel catfish production farms in the Mississippi Delta. This program attempted to identify true production numbers, characterize losses, record husbandry practices, and correlate water quality parameters that may or may not be associated with disease outbreaks. This paper presents only some of the observations and changes in production practice that resulted from this program. This paper also presents the results of the alternate date feeding field trials to prevent ESC based on this program.

Risk factors for bacterial gill disease in young rainbow trout in North America

Julie Bebak, Mona Baumgarter, and Gary Smith

A retrospective whole-population survey was used to investigate putative risk factors for bacterial gill disease (BGD) in young hatchery-reared rainbow trout in North America. Three sets of analyses were done. The first analysis included as cases all of the hatcheries in which there was at least one outbreak of BGD during the two year study interval, regardless of location of the outbreak in the hatchery. The case group for the second analysis was limited to hatcheries for which the BGD outbreak occurred inside the hatch house. The case group for the third analysis was limited to hatcheries for which the BGD outbreak occurred outside of the hatch house. For the logistic regression analysis that combined all cases of BGD, regardless of location of the outbreak, there was a significant association between mortality from bacterial gill disease and previous experience with BGD outbreaks, being a commercial trout hatchery, and being a hatchery with an annual salmonid fish production of

>250,000 fish. For BGD outbreaks that occurred in the hatch house, the presence of fish in the hatch house water supply significantly increased the odds of an outbreak, as did the use of ultraviolet radiation to disinfect the hatch house water, previous experience with bacterial gill disease, and being a commercial hatchery. The odds of a BGD outbreak outside of the hatch house was significantly associated with previous experience with BGD and with being a hatchery with an annual salmonid fish production >50,000 pounds.

Use of the stress induced furunculosis test to detect *Aeromonas salmonicida* in asymptomatic rainbow trout cultured in a recycle system

G. L. Bullock, R.C. Cipriano, and R. Kretschmann

We previously reported that *Aeromonas salmonicida* was cultured more frequently from gills and mucus than from internal organs of rainbow trout (*Oncorhynchus mykiss*) six months after Romet treatment to control furunculosis. However, 21 months after treatment the bacterium could not be cultured from mucus or gills. Sixty trout (avg. wt. 300 gm) were then given a Stress Induced Furunculosis (SIF) test which involved an intramuscular injection of 20 mg/kg prednisolone acetate and raising tank water temperature from 13 to 20 C over six hours. During an 11 day observation period five trout died and *A. salmonicida* was isolated from the kidneys. Mucus, kidney, and intestine samples from the remaining 55 trout were cultured on Coomassie Brilliant blue (CBB) Agar plates but none yielded *A. salmonicida*. Three additional SIF trials were carried out in which trout were kept in either four 4.3M circular tanks (20/tank) or one 8.7 M circular tank (80/tank). Mucus, gill, heart, liver, spleen, kidney, and intestine from each of 20 noninjected control trout and 20 injected trout on day 3 post injection were cultured on CBB agar plats. The seven tissues from injected trout were also sampled on days 4, 5, or 6 post injection (20/day). *Aeromonas salmonicida* was detected in each trial but mortality varied. No trout died in the first trial, one in the second and seven in the third. The pathogen was detected as early as the third day after injection but most samples were positive on day 5 or 6. Maintenance of trout in a single tank did not affect prevalence of positive samples. External sources were more reliable in detecting the pathogen with 8.2% of mucus and 6.0% of gill samples positive but only 0.9-3.0% of all internal samples were positive. Additional SIF tests are presently being carried out in which we are comparing detection of *A. salmonicida* in mucus, gill, kidney and spleen by culture on CBB agar and by a commercially available ELISA procedure.

Efficacy and safety of cypermethrin for treatment of salmonid sea lice

H. Michael Opitz, B. Pahl, C. Bartlett, D. MacPhee, and J. Pitts

Sea lice (*Lepeophtheirus salmonis*) have seriously impacted salmonid aquaculture in the Bay of Fundy since 1994. In Maine, *L. salmonis* increased to problematic levels and treatments were needed to avert serious losses. Emergency INAD exemptions were obtained for hydrogen peroxide and GPRDOI cypermethrin. Extensive treatments were carried out with GPRDOI cypermethrin in 1995 and 1996 and efficacy and safety evaluations are still ongoing. Cypermethrin GPRDOI has been effective in removing 80% of larvae stages, 98% of preadult and 89% of gravid females. No adverse clinical reactions due to the treatment compound were observed.

Safety studies in non-targeted animals (no scallops, clams, mussels, and sea urchins) revealed no detectable effect when these animals were exposed directly in the treatment bath or placed outside treatment pens. Lobsters, placed directly into the treatment bath of 5 ppb cypermethrin CPRDOI, were killed at the rate of 80%. No treatment associated death was observed in lobsters placed outside treatment pens.

Pharmacokinetics of enrofloxacin in the red pacu (*Colossoma brachypomum*) after intramuscular, oral and bath administration

G. Lewbart, S. Vaden, J. Deen, C. Manaugh, D. Whitt, A. Doi, T. Smith, and K. Flammer.

The intramuscular (IM), oral (PO), and bath immersion disposition of enrofloxacin were evaluated following administration to a cultured population of red pacu. The half-life for enrofloxacin following IM administration was 28.9 hours, considerably longer than values calculated for other animals such as dogs, birds, rabbits, and tortoises. The 4 hour CMAX of 1.64 ug/ml following a single 5.0 mg/kg dosing easily exceeds the in-vitro MIC for 20 bacterial organisms known to infect fish. At 48 hours post IM administration, the mean plasma enrofloxacin concentration was well above the MIC for most Gram-negative fish pathogens. The gavage method of oral enrofloxacin administration produced a CMAX of 0.94 ug/ml at 6-8 hours. This CMAX was well above the reported in-vitro MIC. A bath immersion concentration of 2.5 mg/L for 5 hours was used in this study. The CMAX of 0.17 ug/ml was noted on the 2 hour post-treatment plasma sample. Plasma concentrations of

enrofloxacin exceeded published in-vitro MIC's for most fish bacterial pathogens 72 hours after treatment was concluded. Ciprofloxacin, an active metabolite of enrofloxacin, was detected and measured after all methods of drug administration. It is possible and practical to obtain therapeutic blood concentrations of enrofloxacin in the red pacu using PO, IM, and bath immersion administration. The IM route is the most predictable and results in the most predictable and results in the highest plasma concentrations of the drug.

Safer Seafood Through HACCP: An Overview of the Seafood Hazard Analysis and Critical Control Point (HACCP) Program

Janet E. Whaley

The Food and Drug Administration, under Title 21 of the CFR (Part 123), requires all food processors and importers to have an Hazard Analysis Critical Control Point (HACCP) Program in place by December 18, 1997. This program is based on a preventive system of hazard control rather than a reactive response, and will be used to ensure safer food products for consumers. To aid in this process, the HACCP system is designed to identify hazards and to establish and monitor controls. Identifiable hazards include harmful microorganisms as well as chemical and/or physical contaminants. To meet compliance, fish processors are required to prepare and implement a written HACCP plan whenever a hazard analysis reveals single or multiple food-safety hazards that are reasonably likely to occur. Not designed to be a stand-alone program, the HACCP must be built upon other current food safety programs such as Good Manufacturing Practices (i.e., sanitation and personal hygiene programs) to make it work. The purpose of this paper is to overview the seven principles on which the HACCP system is based, to review the required training to perform the HACCP and to discuss some potential roles for aquatic animal health professionals in the HACCP.

Natriuretic peptide production in the intestine of the Japanese eel

Christopher A. Loretz, Catherine Pollina, Hiroyuki Kaiya, and Yoshio Takei

Natriuretic peptides (NPs) are potent inhibitors of intestinal salt absorption in teleost fishes. In seawater fishes, intestinal salt absorption (essential for hydromineral regulation) and nutrient absorption (essential to meet caloric need NA+ ($A_{Na}s$) compete for the enterocyte apical membrane electrochemical gradient for . A novel hypothesis has been proposed in which local, paracrine secretion of NP (to inhibit salt absorption) reduces competition for NA+ (A_{Na} to promote nutrient uptake regionally during passage of the digesta while salt transport in other segments of the intestine continues unaffected (Loretz and Takei, 1996).

Enteric production of NP in the Japanese eel (*Anguilla rostrata*) was evaluated using gel permeation (GP-) and reverse-phase high-pressure liquid chromatography (RP-HPLC), and immunohistochemistry. GP- and RP-HPLC elution profiles of atrial (ANP) and ventricular natriuretic peptide (VNP-36), two major teleost NPs, in extracts of anterior, middle and posterior intestine were determined using homologous radioimmunoassay. Both NPs, as well as a smaller molecular form of VNP (VNP-25), were identified in extracts of all three intestinal segments. Tissue sections from anterior, middle and posterior intestinal segments were subjected to immunohistochemical staining using highly specific rabbit antisera directed against the eel NPs, and FITC-coupled goat anti-rabbit IgG for fluorescence visualization. In anti-ANP-serum-stained sections from all three intestinal segments, numerous cells of the intestinal epithelium, especially at the bases of villi, exhibited dense fluorescence. Staining with antisera to VNP yielded similar cell distributions, although the number and staining intensity were reduced. Subepithelial localizations of immunoreactivity (enteric neurons?) were also detected, especially for ANP.

There biochemical and immunohistochemical findings of enteric production support the competition hypothesis which depends on the potential for restricted delivery of NP. The distribution of immunoreactive ANP and VNP in diffusely-arranged cells of the epithelium in all intestinal segments suggests paracrine secretion in response to luminal stimuli (distention or nutrient presence) and cellular targets in the epithelium (ion transport regulation). Subepithelial localization in enteric neurons may indicate targets in the muscular layers (peristalsis and vascular flow regulation).

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The use of clove oil as an anesthetic in rainbow trout (*Oncorhynchus mykiss*)

Deborah M. Fine

The use of anesthetic agents in aquaculture significantly reduces the morbidity and mortality associated with stressful procedures such as spawning, weighing and measuring, vaccinating, and transportation. The factors that must be considered in choosing an appropriate anesthetic agent include: efficacy, particularly with regard to a rapid, smooth induction and recovery, cost, availability, ease of use, and potential side effects.

Clove oil has been used as a topical anesthetic in Indonesia for centuries. It is a dark brown to golden liquid that results from the distillation of flowers, buds, stalks, and leaves of clove trees (*Eugenia aromatica*). Clove oil consists primarily of the following compounds: the phenols eugenol (70-90%) and eugenol acetate (>17%), and kariofilen 5 (12%).

The use of clove oil as an alternative anesthetic agent to tricaine methane sulfonate (MS-222) for handling rainbow trout brood stock was studied at a commercial aquaculture facility. The time for loss of consciousness was slightly longer for clove oil than MS-222: three minutes for clove oil versus two minutes for MS-222. However, water in the clove oil treatment tank did not need to be changed as frequently as in the MS-222 tank. Therefore, although it took longer for fish to become anesthetized with clove oil, there was less overall waiting time because fewer tanks needed to be filled. There were no mortalities associated with the use of clove oil as an anesthetic in spawning. The cost of clove oil was $11.19/kg. Approximately 20 ml of oil were needed to treat a 325 liter dope tank (0.067 ml/l) for a total cost of $0.22/treatment. In comparison, MS-222 costs $265.00/kg. Twenty five grams were required to treat a dope tank for a cost of $6.62/treatment.

There are variations in the efficacy of clove oil as an anesthetic that appear, at least in part, dependent upon water temperature and mineral content. The initial studies were conducted at the main research facility with water temperature at 15° C. When similar concentrations were used at a satellite hatchery with water temperature of 9°C, and significantly higher mineral content, the same strength was not as effective. Although fish lost consciousness, they remained at a much lighter plane of anesthesia, and would flinch considerably when touched. If the concentration of clove oil was increased then the fish became extremely agitated when placed in the dope tank. This problem was solved by using a combination of clove oil and MS-222. For this particular hatchery, MS-222 was normally used at a

concentration of 238 mg/l when doping a tank with this compound along. When employed with 0.067 m./. of clove oil, the amount of MS-222 required could be reduced to 119 mg/l.

The withdrawal time for MS-222 is 21 days. There are currently no published regulations regarding withdrawal times for clove oil in food fish. Therefore, if anesthesia is required for a procedure involving food fish, then using MS-222 is the appropriate anesthetic choice. for brood stock and other fish not intended for consumption, clove oil is an apparently safe and extremely economical alternative to MS-222.

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Special imaging and preservation techniques in marine animal medicine

Ilze K. Berzins, Brent Whitaker, Gary March, Ron S. Wade and Grover Hutchins

Radio-opaque gel was used to delineate the dorsal fin vasculature, a useful blood collection site, of the dogfish shark. The technique was also used to outline the cardiac vasculature of several species of marine mammals and sea turtles. The hearts were then prepared for educational and display purposes using a preservation technique known as plastination.

Pathology, immune reactivity and zoonotic potential of cultured hybrid striped bass infected with mycobacteriosis

Stephen A. Smith, Steven D. Holladay and John L. Robertson

Mycobacteriosis ("piscine tuberculosis" or granuloma disease) is an important chronic, systemic acid-fast bacterial infection of fish. Infections have been reported worldwide from over 150 different species of marine, brackish and freshwater fishes representing more than 40 piscine families. Normal host defense mechanisms against this bacterial pathogen includes a variety of inflammatory, hematologic and immunologic processes. Thus, an outbreak of mycobacteriosis in a commercial hybrid striped bass culture facility allowed the correlation of disease stage with splenic immunologic parameters, including histopathology, hematopoietic cell counts and macrophage activation. Cellular counts of splenic tissue were evaluated by a Coulter electronic cell counter, and splenic macrophage chemiluminescent response and phagocytosis were determined by flow cytometry. The cellularity of the spleen was found to be markedly reduced in mycobacterium-infected fish relative to uninfected control, while splenic macrophages from infected fish displayed an increased chemiluminescent response.

Infections are generally thought to be primarily disseminated through the aquatic environment and to other fish by the death of infected individuals resulting in the release of the infectious organism into the water. However, infections may also result from fish feeding on contaminated fecal material, by transovarial transmission, or spread through the release of reproductive material during spawning. In addition to causing pathology in fish, these organisms have a documented zoonotic potential for humans, especially immunosuppressed individuals. Therefore, an outbreak of mycobacteriosis in an aquaculture system or facility presents a serious problem for both the persons feeding and maintaining the fish and persons handling and processing the infected fish.

Zebrafish and Medaka embryo monitoring of the aquatic environment: chemical pollutant--inducted cardiovascular defects

Merle Mizell, Roxanna Smolowitz, John Stegeman, Eric Romig, and Rajesh Katayani

Extraembryonic membranes, such as the fish chorion, provide a protective barrier between the embryo and the environment. Although the fish chorion excludes many chemical pollutants, some noxious agents can still gain access to the aquatic embryo. Therefore a monitoring system that test the effect of chemical directly upon the embryo must be established. Although exposure to a single toxin in the laboratory can determine the concentration at which a pollutant become a health or environmental hazard, embryos and adults in nature are not merely affected by a single chemical, but are exposed to mixtures of different pollutants. Our purpose in this study was to test whether the zebrafish or medaka embryo could provide an efficient model for the rapid observation of the effects of chemical mixtures on development.

Aquatic Wildlife Medicine

Rosemarie Borkowski

The clinical study of ill and injured aquatic wild animals broadens our understanding of disease entities among entire populations of these species. Aquatic animals presenting to wildlife veterinarians provide insights on topics such as heavy metal contamination of waterways and the altered prevalence of infectious disease due to changes in water quality. The medical treatment of aquatic animals contributes to the body of veterinary knowledge from which we may draw to address problems of wild and captive aquatic species, including those which are threatened or endangered. This presentation includes case highlights from diverse aquatic species which contributed to our understanding of squatic animal health.

Clinical veterinary medicine of aquatic species at the Wildlife Conservation Society

Paul P. Calle, Mark D. Stetter, William B. Karesh, and Robert A. Cook

Clinical veterinary medical care for aquatic species at the Wildlife Conservation Society involves both the Wildlife Health Sciences' Clinical Studies Department and the International Field Veterinary Studies Unit. The clinical medical practice encompasses the animal collections of the Society's five New York based institutions (Bronx Zoo Wildlife Conservation Park; Central Park, Queens, and Prospect Park Wildlife Centers; and the Aquarium for Wildlife Conservation). The clinical case load includes the medical and surgical care of both freshwater and marine fish; a wide range of freshwater amphibians and reptiles as well as sea turtles; marine and freshwater avifauna; and marine mammals (five pinniped species, California sea otter, polar bear, and two species of cetaceans). In addition to the collection specimens, participation in the Northeast Regional Stranding Network for marine mammals and reptiles provides additional clinical cases. These have included stranded sea turtles, pinnipeds, and cetaceans. In 1994 a pilot whale was successfully rehabilitated and released.

Field work involving marine pinnipeds (southern sea lion, southern elephant seal, South American fur seal) and birds (Magellanic, humboldt, and rockhopper penguins, imperial cormorant, kelp gulls), aquatic reptiles (anaconda, black and spectacled caiman), and fresh water dolphins have been conducted in South America by the International Field Veterinary Studies Unit. These studies have focused on health assessment, development of anesthetic protocols, and immobilization for satellite radio transmitter attachment in conjunction with the Society's ongoing field conservation efforts.

How wet is the World Wide Web?

Duane Steward

The World Wide Web is an exponentially growing source of information and attracts an exponentially growing population of browsing patrons. Author David Siegel recently published a book in which he suggests the categorization of first, second and now third generation websites. He describes the evolution of websites beyond mere information repositories to "environments" where the design of the site compels a person to linger, interact and even build a sense of community. It is reasonable to expect the development of aquatic veterinary medical interest in such a circumstance. The dispersed nature of the interest in aquatic veterinary medicine makes the WWW particularly appropriate for exchanging information. The question remains, "How well is this opportunity being utilized?"

This presentation will grant a brief tour of the currently available sites of interest to the aquatic veterinary medical community. In the process strategies for discovering sites will be discussed and demonstrated.

A summary of the 1995-96 Live Sea Turtle Stranding on Cape Cod, MA, USA; Associated Critical Care Techniques

Howard N. Krum and Connie Merigo

The 1995 stranding season on Cape Cod, MA produced record numbers of live stranded sea turtles. The New England Aquarium admitted 17 live loggerhead (*Caretta caretta*) and 28 live Kemp's ridley (*Lepidochelys kempii*) turtles. Animals live stranded for approximately a one month period beginning in mid November. All animals were cold-stunned but also presented with a number of other pre-existing health problems such as boat strike wounds, fish hook foreign bodies, ruptured eyes and frost bite. The most common problem aside from hypothermia was dehydration. Local therapy for wounds included debridement of necrotic tissue followed by topical and systemic antimicrobial therapy.

Nearly all animals were obtained from water in the 30's-40's ^{o}F and were admitted with body temperatures from ~50-65 ^{o}F . Turtles were warmed in water baths from their starting temperatures to the upper 70's ^{o}F and ultimately to 80-82 ^{o}F as rapidly as possible (~2-3 weeks). The rate at which an animal was warmed was determined by gross physical signs such as activity level, appetite, skin turgor, degree of enophthalmos,

and laboratory values of serum [Na^+], [Cl^-], [K^+] and osmolality. Rate of fluid therapy was determined similarly. Animals received 1.0-1.5% body weight of sterile fluids intraperitoneally (IP) as frequently as every other day. The fluid preparation consisted of a mixture of 2.5% dextrose/0.45% NaCl and standard lactated ringers solution in a 2:1 ratio respectively.

Two severely debilitated Kemp's ridleys received fluids via an interosseous (IO) route established in the distal humerus. IO fluids consisted of the standard soln. described above but was modified with NaCl to more closely match the individual's's serum osmolality.

Animals that were persistently anorexic despite other therapies were tube fed a shrimp or squid mash in combination with IP fluid administration. Animal survival rates will be compared with previous stranding seasons.

Wildlife rehabilitation during an oil spill in the Arabian Gulf

Virginia Pierce

A team of people knowledgable in oiled wildlife rehabilitation was sent by the United Nationsl to the Arabian Gulf during the war between Iran and Iraq. We trained 50 people from six different countries around the Gulf.

Pathophysiology of a failed pet shop

Alex E. Land and Rona P. Shapiro

The authors had a growing practice, capable support staff, no nearby petstore competition and most importantly merchandising was the hot practice growth concept of the 1980's. so we decided to incorporate a pet store into our hospital expansion. A year and a half later we closed the Obetz Petz Pet Store.

Detection of illegal egg removal in the American lobster, *Homarus americanus*

Robert A. Bullis

Illegal removal of eggs in an attempt to obtain seemingly legal female lobsters can have dramatic effects on populations and if gone unchecked can rapidly result in sustained damage to the lobster fishery. Tests for the detection of illegally altered lobsters are, by necessity, extremely important tools for maintaining a viable reproducing population. Traditional techniques rely on a set of general criteria as warning signs that lobsters may have been illegally harvested. Lobsters that have eggs in the gill chamber, limp abdomens, and/or swollen swimmerettes show evidence of mishandling. The swimmerette stain test is used to confirm wrongdoing. Briefly, a swimmerette is removed from a suspect lobster; the non-plumose hairs (setae) are closely examined for the presence of cement and/or egg casings; and the swimmerette (pleopod) is stained, fixed and preserved as evidence. The cement, which stains purple, provides visible proof by which the court can judge guilt or innocence. Until recently, the techniques described above were successful in exposing and limiting the illegal harvest of berried females. Unfortunately, a new method for the illegal removal of eggs has been discovered recently by lobstermen which avoids detection by the swimmerette stain test. This extremely effective technique involves dipping the berried females into solutions of chlorine bleach and seawater for a short amount of time. Following a soak, the lobster is gently shaken which removes all cement and egg remnants from the hairs. Loss of cement residue results in a loss of stainable material and, hence, a negative swimmerette stain test. Rapid spread of this technique through the lobster fishery could be enormously damaging. A new field-test capable of detecting dipped animals was developed to compliment the swimmerette stain test currently used for detecting scrubbed animals. Based on the detection of residual chlorine on swimmerettes, this test is simple in concept, easy to use, and cost effective. A pleopod is clipped from a suspect lobster and placed in a plastic or glass vial containing 20 ml of deionized water and 1.0 gram of potassium iodide. When a non-dipped swimmerette is placed in this solution, it remains clear. If a swimmerette has been dipped in chlorine, however, the solution instantly changes to a bright yellow. Animals most recently dipped have the most intense color change. The intensity of this temperature dependant color change falls off over time but is able to detect chlorine under standard field conditions for up to 12 days post-dipping. Off shore fishing trips for lobster are usually from 1-10 days in duration. Color change can be documented with a spectrophotometer (350 nm) that can measure and record test results for use as evidence of wrongdoing. Together, the swimmerette stain test (SST) and the chlorine residual test (CRT) provide wildlife managers and law enforcement officials with an extremely important tool kit with which to protect the lobster fishery from those who would choose to exploit it.

Anesthetic agents for use in the invertebrate sea snail, *Aplysia californica*

Terri R. Clark, Patricia C. Nossov, James P. Apland, and Margaret G. Filbert

The sea snail, *Aplysia californica*, is a widely used invertebrate animal model for cellular neurophysiology studies. A neuromuscular blocking agent, magnesium chloride, is commonly used for chemical restraint in *A. californica*, but may be considered inappropriate due to its paralytic rather than anesthetic effects. The study reported here was initiated to search for appropriate anesthetic agents to use in these animals. Tricaine methane sulfonate (MS-222) and halothane, two commonly used anesthetic agents for fish and amphibians, were tested by immersive, gaseous, and intracoelomic routes of exposure. Intracoelomic administration of MS-222 and vapor exposure of halothane induced partial relaxation in a small number of animals, but neither agent resulted in complete loss of reflexes at the dosages used in this study. Use of immersive solutions for concentrations of MS-222 at 1:10,000 and 1:1,000 were ineffective. Use of immersive solutions of MS-222 at 1:100 and halothane at 3 ml/L concentrations proved to be noxious and distressful. Although the study was not conclusive for appropriate dosages of halothane and MS-222 to use in *A. californica*, it does substantiate anatomic and physiologic differences seen in these animals, compared with vertebrates, which influences their response to anesthetic agents.

Public policy and the Gulf of Maine Ecosystem: Update

Gary Tabor

I will discuss relevant issues relating to the fisheries crisis in the Gulf of Maine and efforts to manage this marine area as an ecosystem. Some of the topics to be discussed: fishery involvement in stewardship and ecosystem scientific efforts; potential for marine protected areas and impact of Amendment F of New England multi-species plan.

Surgical biopsies from rainbow trout for fish health inspection purposes

G.A. Wooster, H.-M. Hsu, and P. R. Bowser

Non-lethal surgical procedures for obtaining liver and kidney tissues for use in fish health inspections were evaluated. Four groups of 25 mature rainbow trout (*Oncorhynchus mykiss*) (mean weight + 1193 gm, mean total length + 44 cm) were treated as follows: Group 1 -- anesthesia only (control); Group 2 -- sham operation (incision made with no biopsy taken, 13 liver biopsy, 12 kidney biopsy site); Group 3 -- liver biopsy; and Group 4 -- kidney biopsy. Surgical procedures averaged 15 minutes for sham-operated fish and liver-biopsy fish, and 25 minutes for kidney-biopsy fish. Mean weight of liver and kidney biopsies were 0.195 and 0.210 gm, respectively. Fish were held in concrete raceways with flowing water at 9.5C for 180 days, at which time reproductive function was evaluated. Survival at 180 days was 100% for control and sham-operation fish, 96% for liver-biopsy fish and 92% for kidney-biopsy fish. Mortalities were note directly associated with the surgical procedures. All fish were reproductively functional at 180 days, which corresponded with spring spawning. After the 180 day holding period mean weight of the fish was 1882 gm and mean length was 50 cm. At termination of the study a significantly ($P<0.05$) higher percentage of fish in the liver-biopsy (75%) and kidney, biopsy (61%) groups had adhesions when compared to fish from the control (0%) or sham-operations (32%) groups. Nephrocalcinosis was observed in significantly ($P<0.05$) high percentage of fish in the kidney- biopsy (47%) group than fish from the control (0%), sham-operation (8%) or liver-biopsy (8.3% groups. Results suggest that non-lethal liver and kidney biopsies for fish health inspection purposes can be performed on salmonid broodfish with no apparent deleterious effects on spawning. Economic feasibility of such procedures needs critical evaluation.

Hawaiian monk seal recovery efforts - disease investigation

Cindy P. Driscoll and Robert Braun

The Hawaiian monk seal is one of the most critically endangered pinniped species second only to the Mediterranean monk seal. In 1984 the National Marine Fisheries Service began collecting undersized pups from the wild for captive rehabilitation and release back to the wild to bolster populations. The program centered the recovery effort around population dynamics, and recently has included a focus on disease investigations. A current problem facing captive rehab pups involves corneal opacities. The etiology of this disease process is under investigation by NMFS and many other collaborative experts.

1996 Right Whale Mortalities Investigation

Cindy P. Driscoll

The North Atlantic Right Whale is the most critically endangered large whale species in the world. Currently only approximately 325 individuals are known to exist in North Atlantic waters. Commonly only 1-2 dead stranded individuals are found along the northwestern Atlantic coast each year. These deaths have been attributed to various causes often including evidence of human interaction as a contributory factor. During the 1995-1996 Fall/Winter field season six confirmed Right Whale deaths alarmed the marine mammal community. Additional carcasses were reported floating off-shore, but could not be retrieved. Marine mammal veterinarians, pathologists, biologists, along with federal/state/local management personnel investigated the deaths. While conclusive determinations remain under review, large whale examination protocols are being developed to address future investigations.

Reflections on 20 Years of *AQUAVET*®
1977-1996

Donald A. Abt, V.M.D.
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In early 1976, a few faculty members at the University of Pennsylvania's School of Veterinary Medicine developed a concern for the general lack of involvement with aquatic animal health by the veterinary profession in the United States. This concern resulted in preliminary discussions with members of the scientific community in Woods Hole, Massachusetts during the early summer of that year. Being the home of numerous institutions involved in marine science education and research, Woods Hole was a natural site for the development of a program in aquatic veterinary medicine. In addition to the extensive biological and biomedical research carried out in this small Cape Cod village by such institutions as the Marine Biological Laboratory (MBL) and the Woods Hole Oceanographic Institution (WHOI), the National Marine Fisheries Service (NMFS) also maintained their Northeast Fisheries Science Center there. Each of these institutions use aquatic animals in carrying out their respective missions. From a veterinary perspective, Woods Hole appeared to be the ideal spot for developing essential knowledge and expertise in the normative biology and diseases of the more than 200 species of marine vertebrates and invertebrates used as laboratory animals, food animals, and companion animals in the region. In addition, a budding marine aquaculture industry was being established within this same area.

It became evident during the initial discussions with the MBL, WHOI, and NMFS leadership that an aquatic veterinary medicine program in Woods Hole would be most welcome. In addition, it was clear that the success of such an effort would be enhanced by broadening the effort within the veterinary educational community. Toward that end, the University of Pennsylvania invited their colleagues from the College of Veterinary Medicine at Cornell University to join with them in creating an educational program to provide students an opportunity to adapt their veterinary skills to aquatic animals. The exploratory activities of the summer came together during an August 16, 1976 meeting at which the two veterinary schools decided to submit a joint grant proposal to the New York Sea Grant Institute for support of the effort. The academic courses were defined by the two veterinary schools with advice from colleagues at the MBL, WHOI, and NMFS. The major players in this effort were: Drs. Robert R. Marshak, Donald A. Abt, and Leon P. Weiss, Penn's Dean, Associate Dean, and Chairman of the Department of Animal Biology; Edwin C. Melby, Jr. and Charles G. Rickard, the Dean and Associate Dean respectively at Cornell;

James D. Ebert, Director of the MBL; WHOI's Robert W. Morse; and Robert Edwards of NMFS. Additional useful advice was garnered from other scientists at the Woods Hole institutions. The appellation, *AQUAVET®*, was coined by Dr. Weiss. The MBL agreed to rent the necessary educational space to present the first course in the spring of 1977 and all three Woods Hole based institutions extended their good offices to encourage participation by their academic staff.

From this collaborative effort, *AQUAVET* has grown to become recognized as the bench mark veterinary academic program in aquatic animal medicine. A total of 602 students from around the world have participated in the introductory and advanced course offerings. To this day, the course continues to be presented at the MBL and representatives of the 5 founding institutions all continue to play major roles in the effort. Directorship of *AQUAVET* has been vested in Dr. Abt for the 20 years. Dr. Rickard served as Associate Director until his retirement following the 1985 course at which time Dr. Paul R. Bowser assumed that role on behalf of Cornell. Dr. Laurie J. Landeau, an alumnus of the 1981 *AQUAVET* I and 1983 *AQUAVET* II courses, joined Drs. Abt and Bowser in the administration of the courses in 1988 and continues at the present time as an Associate Director. Dr. Landeau concentrates on *AQUAVET* I while Dr. Bowser focuses on *AQUAVET* II.

Academic programs in Woods Hole have long followed the tradition of bringing together the best available students and faculty regardless of their affiliation with any particular academic institution. Locally, this is known as the "Parade of Stars" approach and is based on the concept that students obtain their greatest academic growth when afforded the opportunity to interact one on one with leading scholars in a given discipline. From its inception, *AQUAVET* has embraced this proven concept by selecting its faculty from a wide variety of academic, governmental and private sector institutions throughout North America.

AQUAVET faculty have served as a model for collaboration by scientists trained in a wide variety of biological and biomedical disciplines. They have admirably demonstrated the validity of the concept that veterinarians, clinical specialists, nutritionists, fisheries biologists, epidemiologists, population biologists, ecologists, and classically trained biologists in such critical fields as microbiology, immunology, genetics, neural science, and behavioral science collectively bring to the students an academic richness that enhances their educational experiences. Students and faculty remain in close contact through their time together as the classroom exchanges continue over meals and into the late evening at the Swope Center, MBL's dormitory/dining hall complex. Students treasure the interactive opportunities made available to them by these courses. That the faculty also derive great satisfaction from their participation

in *AQUAVET* is demonstrated by the fact that many of the original faculty from 1977 still actively participate in the course presentations, even after formal retirement from their home institutions. A number of *AQUAVET* students have followed the goals set down in 1977 and have themselves become leaders in the field. As such, several of these former students now serve as faculty in the *AQUAVET* courses. The passing of the torch to this next generation is a source of great pride and satisfaction and the list of former students well suited to carry on the program grows every year.

Sixteen students were selected from the student populations of the Cornell and Pennsylvania veterinary schools to attend the inaugural course in May of 1977. By the end of those four weeks, it had become obvious that the concepts behind the course were correct and that the program should be expanded to accommodate veterinary students from all schools. Announcements were made throughout the North American veterinary schools and colleges that *AQUAVET* would accept 32 students for the program in 1978. The earlier assumption that many veterinary students were anxious to combine their previously parallel but separate interests in veterinary medicine and marine sciences was proven correct by the more than 100 applications received for the 1978 class. Although the original concept was that only currently enrolled veterinary school students would make up the applicant pool for the course, it quickly became evident that a number of professionally active veterinarians also were anxious to avail themselves of the opportunities presented by *AQUAVET*. Practicing veterinarians with aquatic animal expertise were being sought out by home aquarists, aquaculturists, and research scientists who were turning more and more to the use of aquatic animals in private and governmental research laboratories. These veterinarians were anxious to increase existing skills while others, like current students, wanted to develop new expertise because of their parallel interests in aquatic animals and veterinary medicine. Consequently, throughout the past 19 years, each pool of applicants has included currently enrolled veterinary students as well as veterinarians from diverse corners of the profession.

With a firm belief that the generation of new knowledge through research not only benefits society at large but also affords students unique opportunities for personal growth and development, the architects of *AQUAVET* included a student research component in the design of the program. Eight of the 16 students in the 1977 class were placed in cooperating laboratories for 8 weeks of research experience following the course proper. In the fall, the students and many of the faculty convened at the National Marine Fisheries Service laboratory in Oxford, Maryland for a weekend of student seminars describing their research projects. The success of the research component assured the continuation of the *AQUAVET* Summer Research Fellowships. Funding constraints in subsequent years have

required that fewer students participate in the research phase but it has remained a prominent feature of the program. Once a student has been selected as a Research Fellow, their interests are matched with an appropriate laboratory either in Woods Hole or at some other site where they can conduct their research under the tutelage of an suitable mentor. While many opportunities exist right in Woods Hole, the best match is often found in some other location. Students are required to generate a proper scientific report summarizing their research. Often the effort results in the publication of a journal article.

Student admission to the *AQUAVET* courses is highly competitive with applications originating, on average, from more than 20 of the 31 North American schools plus several foreign countries each year, resulting in classes with a broad geographic mix. Consequently, the benefits of the program are disseminated throughout the veterinary profession at large as students and faculty return to their home institutions following participation in the courses. On their home campuses, the students share with their peers and resident faculty the experiences and lessons learned in Woods Hole. The effectiveness of this outreach activity is demonstrated by the fact that *AQUAVET* has never found it necessary to advertise the courses. Equally important is the extent to which *AQUAVET* graduates have become established over time in the many diverse niches populated by veterinarians. Applications for admission are regularly requested from individuals outside the academic institutions. Other requests come from foreign countries leading to exciting cross cultural exchanges during the weeks in Woods Hole. Clearly, the students learn as many important lessons from each other as they acquire from the faculty.

The introductory course is structured to give students a broad overview of aquatic animals and their complex environs. The course content is predicated on the assumption that students have completed the basic science portion of their professional education and are ready for entry into the realm of comparative biology and medicine. Aquatic animal medicine is truly *comparative medicine*. The enormous diversity of animal life, both vertebrate and invertebrate, taxes the abilities of the biomedical scientist. Appropriately, students are taught to transfer information learned about traditional terrestrial veterinary species to aquatic species. Comparing and contrasting the biological features of their subjects leads the students to an understanding of the veterinarian's role and contribution to the health of these animals. Students rapidly come to appreciate the need to define the normative biology of each animal before they can hope to deal with its medical problems. By the end of the intense four week course they have had an opportunity, not only to assimilate a great deal of new information, but more importantly, they have learned how the biomedical principles adopted in their traditional veterinary school courses are just

as applicable to these animals as they are to dogs, cats, horses, cows, sheep, and so on. In addition, they develop insights into those areas of scholarly deficit on which intensive research must focus. The primary goals of the introductory course are: to stimulate a desire in the students to apply their veterinary training to aquatic animals; to stimulate biomedical research applicable to the veterinary medical problems encountered by aquaculturists, aquarists, and research scientists; to stimulate the inclusion of aquatic animal medicine courses in the veterinary school curriculum; and to encourage students to continue essential training and intellectual development beyond the entry level of their professional veterinary degree.

The advanced course has been presented to date in two configurations. The first focused solely on health management concerns of aquatic populations maintained in closed life support systems. This *AQUAVET* II course was presented 4 times between 1983 and 1987. Approximately half of this four week course was devoted to the principles of mariculture. *AQUAVET* joined forces with the MBL in the presentation of the mariculture component after which the veterinary students examined disease concerns related to mariculture during the final two weeks. On the erroneous assumption that one of our primary goals in creating *AQUAVET* (i.e. to stimulate the incorporation of aquatic animal topics within the veterinary curriculum) had been met, action was taken in 1986 to retire the introductory course and concentrate our efforts on advanced topics. Consequently, only the mariculture/animal disease course was offered in 1987. However, it was quickly learned that this was not in keeping with the wishes and interests of the other veterinary schools and their students resulting in *AQUAVET* I being re-introduced in 1988.

In 1990, in response to numerous requests, *AQUAVET* II was redesigned to serve the needs of pathologists (and budding pathologists) seeking to develop expertise in the diseases of aquatic species commonly encountered as laboratory research animals or in the commercial aquaculture industry. While the new course contains some topics covered in the earlier *AQUAVET* II course, the major focus is on the histopathology of invertebrates and vertebrates (excluding marine mammals) of clinical and research importance. Alterations due to environmental toxicants, microbial diseases, parasitologic diseases, tumorigenesis, and nutritional aberrations are among the topics examined during this two week course. Pathologic alterations of commonly used laboratory animal model systems are explored as are diseases encountered in various aquaculture systems. Course participants have come from many professional sectors. State and federal agencies have sent research and regulatory personnel. Universities looking to expand their academic programs have sent junior and senior faculty. Veterinary students planning on careers in comparative pathology seek admission and several individuals have come from the pharmaceutical industry. This mix

of ages, backgrounds, and experiences adds significantly to the benefits of attending the course. Throughout the entire 20 years of *AQUAVET* it has been firmly believed that the personal and professional relationships cultivated between the participants, faculty and students alike, are of immense value as all strive to develop the field of aquatic veterinary medicine.

Not surprisingly, people often ask what it is like to attend AQUAVET - what are the days like? Before trying to address that question, let's examine the specific way in which the course is structured. Several basic philosophic principles are applied to all courses taught in Woods Hole, including AQUAVET. The first is that students should not be unnecessarily distracted from taking the fullest possible advantage of all the learning experiences available during the course. Students should be stimulated to learn as much as possible during the time spent in this unique scientific community. Thirdly, students should be encouraged to realize their fullest academic and personal potential which is assumed by the course organizers to be far greater than the students have ever believe it to be. Lastly, a fast pace with changing stimuli and expectations will help maintain essential levels of enthusiasm. Efforts to successfully implement these philosophic principles define the ultimate structure of the course and the work day of the student.

To facilitate taking full advantage of available learning opportunities, students live in a very comfortable housing/dining complex in double rooms with private baths. AND MAID SERVICE! Housing and meals are a fixed package. These meals are not a hardship. The quality, quantity and diversity of food available is as far removed from institutional food as can be obtained anywhere. If anything, the problem with the food is that students complain their willpower is shot, they are eating more than they should, and the prospect of having to cook for themselves again after the course is depressing. Despite these concerns, the effect is that students need not worry about meals save for the need to be at the dinning room at the proper times. By having the program responsible for addressing their basic needs of food and lodging, students need not divert energy away from opportunities to learn. The "Parade of Stars" approach assures there will be ample opportunities for learning. The relatively small class size, coupled with an admissions philosophy which seeks to accept only students deeply committed to this subject matter, sets the stage for students and faculty to establish relationships to be drawn upon in the future. It has often been said that the most important benefit of being at AQUAVET is the contacts a student makes with those who will later become their colleagues. An additional manifestation of this educational philosophy is noted in the number of faculty involved in the courses and the duration of their time in Woods Hole. The typical student/faculty ratio in AQUAVET I is 24/40. Naturally, all 40 faculty are not in residence at the same time but

constitute the participants in the parade. Knowing that access to a specific faculty person will be limited, students quickly learn to make optimal use of the finite time a teacher is in the village. Consequently, time spent in the interactive/learning mode is high.

As is true for most of us, we are capable of accomplishing far more than we realize. Given an incentive to reach beyond our usual levels of expectation generally will lead to attainment of higher goals than those we might set for ourselves. Woods Hole courses generally apply this approach by placing demands on students which are attainable but only by personal stretching. The payoff comes when students realize that they actually were able to achieve the goals and that they have grown, both as a student and as a person, as a result of this process. Often this realization comes long after the person has left Woods Hole. Being in the company of others who deeply share your interests and eagerness to learn results in accomplishments beyond that which might have been attained working in isolation. Teamwork promotes success and with success comes confidence and the ability to move on to the next task.

An ample mixture of lectures, laboratory sessions and field trips, under the guidance of experienced, knowledgeable teachers, capable of leading students into the depths, wonders, and excitement of their subject, provides a sufficiently diverse set of stimuli to allow an intensity that would cause rebellion in a different setting. But again, the principles outlined above, when applied to a sufficiently diverse mix of educational modalities, serve to keep interest levels high and stamina levels above the norm. Eventually, tiredness wins out but by then the course is over and the recognition of one's accomplishments makes it all worth while.

So now we may return to the original question. A typical *AQUAVET* I day starts at 8:00 a.m. following breakfast together in the dinning hall (for those still able to make it to breakfast). The class may be a lecture, a field trip or a laboratory session. Everyone goes to lunch at 12 noon and classes resume at 1:00 p.m., continuing until the dinner hour which is from 5:00 to 6:00 p.m. We reconvene at 6:30 p.m. and make an honest effort to end the formal interchanges by 9:30 p.m. The informal sharing of knowledge continues until each is satisfied. Timing of several field trips is dependent upon the tidal cycle so variations in the timetable above are not unusual. If we have to leave at 6 a.m. on a field trip, the staff in the dinning facility provide a special breakfast before we leave or box lunches if we will not be able to return at noon time. As required, adjustments are willingly made to assure that the students gain the most they can from the scientific learning opportunities. Students are not expected to study in the traditional sense but rather ruminate on the material presented during the weeks and months which follow

their time in Woods Hole. This time is for gathering and interacting. Reviewing the information comes later. Students also conduct an experiment in setting up and maintaining a closed aquarium system to develop an understanding of such a micro-environment. This responsibility requires regular attention to the measurement of environmental parameters throughout the 4 weeks which must be squeezed in between class time, meals, sleep and social diversions. Each student is also required to prepare a seminar for presentation to the class and faculty during the course. The library is operational 24 hours a day, 365 days a year so the students are advised that there is "*plenty of time*" for the necessary library research associated with preparation of the seminar. The faculty often provide advice and information needed to complete this task. Interestingly enough, despite the demands placed upon the students, they still find time for socializing which is another important component of the unique educational experience known as AQUAVET.

The AQUAVET II schedule differs somewhat from that described for the introductory course. There are fewer field trips, fewer wet labs, more microscope time, no student seminars to prepare, and the lectures tend to be interspersed with scope time in a lecture/lab setting. Students are encouraged to bring slides of their difficult cases with them to the course so all may share in the interpretations. The nature of the subject matter requires proportionally fewer faculty than is the case with *AQUAVET* I. However, the guiding philosophy behind the course is comparable to that followed since 1977.

From the very beginning, it was felt that successful development of the field of aquatic veterinary medicine would require three components... education, research, and service. As the educational component became firmly established, adding the research and service elements assumed a higher priority. In October 1979 the two sponsoring veterinary schools and the MBL began exploring ways to expand their collaboration through provision of veterinary medical services to the experimental animals used at the MBL. A plan was designed through which the veterinary schools would assign a diagnostic veterinary pathologist to provide services, from an MBL provided laboratory, to the entire Woods Hole scientific community during the summer of 1980. The success of that trial demonstrated the need for the year-round presence of one or more veterinarians. Drs. Abt and Rickard, on behalf of *AQUAVET,* prepared a grant proposal to the Division of Research Resources at the N.I.H. for the creation of a year-round aquatic laboratory animal diagnostic/research laboratory. The proposal was funded to establish the laboratory effective August 1, 1981. Dr. Louis Leibovitz, a College of Veterinary Medicine faculty member at Cornell University, was chosen to be the first director of the resulting Laboratory for Marine Animal Health (LMAH). Dr. Leibovitz ably served as the Director of the LMAH until his retirement in January, 1989.

During these years, numerous previously unidentified diseases of marine laboratory animals were characterized. The LMAH generated a continuous supply of unique materials for use in the educational programs. In addition, the service and research efforts markedly improved the quality of the research subjects used throughout the Woods Hole scientific community. *AQUAVET* Summer Research Fellows availed themselves of numerous opportunities to work at the cutting edge of their chosen fields under the direction of a superb mentor. The laboratory continues to this day although it is now known as the Laboratory of Aquatic Animal Medicine and Pathology (LAAMP).

During the past 20 years many individuals have played a role in the success of *AQUAVET*. Those who recognized the need and proceeded to implement the plan in 1976-77 rightfully deserve much credit. The faculty who have generously given of their time and talent over these years also are worthy of special recognition. However, the accomplishments of the students who accepted our challenge to develop this field as a true specialty within the veterinary profession probably deserve as much, if not more, credit than any others. To date, 521 individuals have experienced *AQUAVET* I and enrollments in *AQUAVET* II have totaled 158. Many of the 602 who have come to Woods Hole to explore aquatic veterinary medicine have participated in both courses. From here they have gone on to attain advanced degrees, develop unique clinical or research skills, establish aquatic animal programs at a number of veterinary schools, become major figures in governmental agencies and private foundations, assume leadership roles in the aquaculture industry, and initiate training of the next generation of aquatic animal veterinarians. *AQUAVET* can not take full credit for their accomplishments as that belongs to the individuals themselves but it can take credit for urging them to follow their goals and helping them to believe they will succeed.