A WASHINGTON SEA GRANT ADVISORY REPORT

POTFISHING AND ARTIFICIAL BAITS SYMPOSIUM

Proceedings

Sig Jaeger, Chairman

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Division of Marine Resources
University of Washington 98195

FOREWORD

This is a transcription from a taped recording of the Potfishing and Artificial Baits Symposium. The editing has been minimal, except to excise repetitious or obviously irrelevant material. It must be kept in mind that the participants have not edited their own remarks for grammar and punctuation, and that they were expressing opinions, ideas, speculations ad lib in a forum. The body of expression herein is therefore of a working session, and their ideas are not to be construed as final or sweeping conclusions, but as an exploration of possibly fruitful avenues for investigative pursuit.

Errors or deletions in transcribing this for reproduction are those of the Chairman, Sig Jaeger.

Regrettably, all those interested could not attend.

Other aspects of potfishing, such as handling and fishing techniques, were not explored.

The Chairman's special thanks goes to the participants, and particularly to those who put together the "machinery" for the symposium--the prime movers:

Dr. George Pigott, College of Fisheries, University of Washington
Dr. Brian Rothschild, National Marine Fisheries Service, Seattle
Mr. Terry Nosho, College of Fisheries, University of Washington
Mr. Buzz Johnson, Washington Sea Grant, Clover Park Education Center
Mr. Bob Palmateer, Washington Sea Grant, University of Washington
Ms. Pamela Egbert, Washington Sea Grant, University of Washington

Gratitude and apologies also go to the ladies who struggled with the dictaphone belts and rewrites to get this into print.

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POTFISHING AND ARTIFICIAL BAITS SYMPOSIUM

Sponsored by: University of Washington College of Fisheries
National Marine Fisheries Service
Washington Sea Grant Advisory Services

The symposium was held on March 13, 1972 in the College of Fisheries, Room 207. Participants were from the dungeness crab fishery; the king crab fishery; scientists from the National Marine Fisheries Service; a fishing captain from Vancouver, British Columbia, who is presently fishing blackcod with pots; three representatives from the Canadian Fishery Service, Department of the Environment; and representatives from the host, the College of Fisheries. A list of participants is appended.

We are grateful to all those who gave of their time and their knowledge to make this symposium possible.

Dr. George Pigott, of the Institute of Food Sciences and Technology, College of Fisheries, introduced the subject:

> The catching of finfish with pots or traps started some four years ago with Dr. Dayton Lee Alverson's initial investigation into the catching of blackcod in pots.
>
> Al Pruter and Dick McNeely and other members of the scientific and engineering staff of the National Marine Fisheries Service in Seattle have continued these investigations to the present time. We will in the future probably become more involved in these capture techniques as the fish stocks decrease and our knowledge of the fishing system increases.

Sig Jaeger of Washington Sea Grant, chairman of the panel, expressed the regrets of Dr. William Allen of Humboldt State College and Stan Ludwig of the Sea Grant activity of that institution, that they were unable to attend but were forwarding material on their experiments with artificial baits for dungeness crab. They had earlier stated that dungeness crab fishermen in the Humboldt Bay area were concerned about lost pots continuing to fish. They had to the present no sound experimental data as to the catch rate in such ghost pots. Some crab fishermen have been making small experiments with escape panels. Other fishermen in the area were using pots to catch blackcod and were actively trying to catch other species such as rockfish. The work of Dr. William Allen with artificial baits has met something of an impasse since the crab fishermen have currently moved out of the area and up the coast because of lack of crab locally, so there were none available to evaluate the artificial bait on the fishing grounds. The letter from Dr. Allen is as follows:

> My appreciation of the requirements of the crab fisherman for a bait is:
>
> 1. Low cost, avoid reliance on high priced baits such as razor clams.

2. Long-life underwater
3. No need for refrigeration

To this end I have been trying to use a gel as matrix which will hold a chemattractant and permit its diffusion at a controlled rate. A gel with admirable properties is polyacrylamide (widely used for the electrophoresis of nucleic acids and proteins). Polyacrylamide pore size can be varied over a wide range permitting the control of the diffusion rate of chemattractants. Residual monomers and catalysts in the polyacrylamide apparently prevent the growth of microorganisms thus eliminating the need for refrigeration. We have kept polyacrylamide gels containing crude squid extracts at room temperature for months with little apparent microbial growth. As a bait matrix polyacrylamide may have some problems. The low concentration of residual monomer (acrylamide may render the gel slightly toxic). Furthermore I have been informed that a former student at our school may have taken a patent on the use of polyacrylamide as a fish bait matrix.

The bulk of my work consists of a search for effective chemattractants. Chemo reception and pheromones of marine invertebrate seems currently to be a hot research topic. Several neurophysiological and behavioral studies have indicated that amino acids act as a feeding stimulant for crustaceans. In addition there have been recent reports on crustacean sex attractants (which would be the ideal chemattractant for a bait). In laboratory tests we have shown that glycine and glutamic acid elicit feeding responses. Preliminary field trials with a glycine bait were successful. During the current year we intend to test a wide variety of pure chemicals and extracts for chemattractant potency. Substances to be tested include: TMO, betaine, fish oils, essential oil extracts of plants and others.

Sincerely yours,

Bill Allen, Associate Professor
Zoology
Humboldt State College
Arcata, California

The first speaker on the panel was from the fishing industry, Captain Jack Torgerson, operator of the motor vessel M/V NEW ST. JOSEPH, of Aberdeen, Washington. Captain Torgerson fishes for dungeness crab and salmon in the coastal waters of Washington state. "Trends in Dungeness Crab Bait and Needs for New Bait Development" is his subject.

We use a standard dungeness crab pot about 40 x 20 inches with two entrances and one or two escape rings. We have tried many different sizes and configurations of crab pots but I will make no attempt to describe all these here now. I will concentrate on describing the various baits that we have used to date. We would like a bait that need not be frozen. A number of baits have been tried in the past 20 years, not all of which I have used. On artificial baits,

we have tried ordinary chimney bricks soaked in diesel oil or kerosene, and we did catch crab with it, not too well, but we did catch crab. Anise oil soaked into a sponge did not work at all. Another experiment current is the use of a thin sheet of stainless steel about 6 inches square fastened at several points in the pot so that they flicker as the tide passes through the pot. Some fishermen have all pots fitted with these stainless steel flashers, and claim they work well, while others disagree. One trip we accidentally spilled a good deal of diesel oil on the bait and rather than go back in for fresh bait we used it anyway, and despite this, we did not see any difference in the catch rates in the pots.

Among the regular or natural baits that we have used, razor clams, both fresh and frozen, have been standard up to the present. The frozen clams, broken, seem to work the best. The last couple years Japanese squid has been used more and more and seems very effective. The price for this bait has gone from 16 cents a pound to 48 cents a pound. The squid seem to fish only two or three days. We are trying American squid now because it is priced at 15 cents to 12 cents a pound. We tried this bait several years ago and it didn't seem to fish well at that time, but this seems to have changed now. But we're using it a little differently. We don't cut up the squid now, we are leaving it whole in the bait container. This is different from our past practices of cutting up the bait, chopping it fine.

We are using herring which is effective, cheap, and seems to work especially well offshore. The herring doesn't seem to work as well close to the beach, maybe because the crab's feeding habits are different there.

Herring costs about 8 cents a pound. It is easy to handle, and we chop it quite fine so that it will work best, but not so fine that it washes out of the bait box. The herring doesn't fish as long as razor clams, which will fish longer when we have to lay in port for bad weather.

Hanging bait, fish carcasses, work well also, as on the Columbia River we have tried silver salmon from the hatcheries.

It also seems that the bait containers do a better job if they are relatively low in the pot rather than too high up. If the bait containers are close to the bottom of the pot, then they get into the mud.

There was a difference in the stomach contents of the Japanese squid and the American squid. When we tried the Japanese squid I noticed they have a very full red stomach. The American squid has a yellowish sort of color.

We have not tried soaking bricks in salmon or herring oil.

With razor clams it seems through some trials we made that fresh clams do not fish quite as well as frozen clams.

We have not tried or tested the difference between thawing the bait before we put it in the containers or putting it in while frozen. We keep the bait as cold as possible until ready to use it.

Sometimes when bait is thawed before we put it into these bait containers it makes sort of a mess because some soft baits, like herring or anchovies, fall apart. Frozen bait is much easier to handle.

Yes, there is an end-pot effect. Generally about 33 to 50% better than the rest of the pots in the string, that is, if no one else is too close with their gear. The end-pot effect continues as we set-back because we are also moving the string as much as a quarter of a mile.

When the fishing is poor, I set the pots a little farther apart in the string, and move them closer together when the fishing is good. But we cannot move them too close together because they then drift crosswise.

Konrad Uri, king crab fisherman.

Yes, in the king crab fishing in Alaska we also have this end-pot effect. But after two or three lifts in the same place, this disappears. Quite a bit of what Jack says is also true of the king crab fishing. Different areas sometimes require different baits. We've tried halibut bait at Adak and it works fine, but it doesn't seem to work in the Bering Sea. Reindeer meat also works well at Adak, but not in the Bering Sea. Salmon works beautifully in the Bering Sea, but it is difficult to get hold of. Oil from fresh herring may work, I don't know, it sounds very interesting. Fresh herring works very well, throw a whole block into the pot and we know it is going to be full. At Adak we did have some unbaited pots, and the baited pots were nearly full in four or five hours, and the unbaited pot alongside was empty. I have heard that some people think that a lost unbaited pot fished continually, but I don't really think so. We have picked up pots that have been lost for years and found no crab in them, and we also note from fishing in the area that fishing was good there. Ghost pots don't do as much damage as lost gill nets which we have sometimes found drifting about in our gear. These nets were full of skeletons and skins of king crab, sometimes with two, three, or even four legs gone. These are the results I think of lost gill nets on the bottom.

To get back to bait, clams don't seem to work at all until we get farther west from some reason or another; the squid we tried was probably processed, and blackcod was indifferent.

Jack Torgerson:

Recently some crab fishermen have tried these white plastic jars that they get from pharmaceutical houses, and they seem to fish as well as the glass jars. That sort of ruins the theory about the crab seeing through the clear glass jars.

George Pigott:

Several years ago, in cooperation with Captain Ed Grabowski, we looked at the possibility that spoilage may have been a factor in bait effectiveness through a period of time. We irradiated some bait, and from Ed's notes there seemed little difference on the pot soaks, but it appeared that if several days lapsed between hauls there was a definite increase. We were not able to complete the experiment because Ed was lost when NORTH SEA was sunk. The bait we used was herring.

Konrad Uri:

I don't know about spoilage, the Bering Sea is quite cold, but we did try some IQF frozen herring which did not fish at all, it was dry as a bone. In the same area we had good fishing with the regular block frozen herring. Maybe the dry type of bait like they use for lobster on the East Coast will work. We need a pretty big freezer when we are turning over 70 or 80 pots a day. If we happen to get a box of bait that has been thawed, possibly spoiled a little, then refrozen, this does not fish at all. The king crab will not go for it.

We have not tried the pelletized bait. Some king crab boats have tried the powder bait, and it was reasonable when we first tried it several years ago, but now it's too expensive. You simply tore one side from the package and there were the perforations, and then hung it in the pot.

Fred Hipkins:

Three years ago NMFS ran a bait experiment on dungeness crab pots up at Lopez Island. We used regular fresh or frozen herring as a control. We experimented with the lobster bait imported from the east coast and the pelletized herring bait from Moore's plant in La Connor. With one package in each pot, the regular herring outfished these by 3 to 1. When we doubled or tripled the lobster bait or the pelletized bait, we did as well as the regular herring. On the last lift, at the end of the experiment, we had remarkable results with the pelletized bait when we tripled it. These processed baits are more expensive than herring but being very oily, they last longer. We have not continued these bait experiments. This bait was very easy to handle, but when filling the bait containers it certainly went fast.

Jack Torgerson:

I forgot to mention that a while back we tried something called Porpoise food; dark brown, it looked like cooked oatmeal, a mixture of fish and kelp I understand. When the fishing was good it worked as well as any of the other bait, but when the fishing was poor it quit fishing altogether.

Terry Thompson:

Wilburn Hall says that he fished with every other pot unbaited and that many times these unbaited pots fished as well as the baited pots. I wonder if the conditions off the Oregon Coast are the same here. Wilburn says further that this is particularly true at some times of the year, he did not say at which times of the year.

General Comments:

There is some difference in the bottom between the Washington Coast and the Oregon Coast, the latter being steeper and more irregular compared to the flatter areas off the Washington Coast. At certain times of the year it appears there is more life on the bottom than at other times of the year, particularly in shrimp. Also, as in the Bering Sea, there are barren areas which seldom, if ever, have life on the bottom. The same statement, about baited and unbaited pot productivity, seems about the same. Everyone still baits their pots, however.

Doug Magoon, Washington State Department of Fisheries:

Jack has a point in that baiting experiments and the time of the year makes a significant difference. Prior to the season's opening, we had some charter vessels test fishing the bait. We mixed with the herring bait some of the creations of Max Patashnik. This processed bait fished as well as the natural bait, but after the season opened, and fishing pressure increased, the productivity of the processed bait dropped rapidly. Quite a few various baits were tried in the Westport-Aberdeen area, particularly in the 1940's, and I have summaries of these experiments. Most of the tests were with fresh clams as the control bait. Slow frozen clams, against the control bait: 250% on a one day soak; 108% on a two day soak; and 95% on a five day soak.

Clam gurry: One day soak was 115% of fresh clam, but by the fifth day it was down to 61%. This dropped in a hurry.

Frozen squid, probably from California: 231% on a one day soak, dropped to 92% on a two day soak. These tests were made in 1942.

Cockles were also tried: Here is one at 118%. This seems unusual to me since they were generally running about 50 or 60%. Fresh herring: 115% one day soak, 70% on a two day soak.

Salmon: 48% one day soak. Seal Meat: 68% one day soak. No bait was 0. Soft shell clams ran around 50% on a one day soak. Horse clams ran 105% on a one day soak. Flounder heads were at 61% on a one day soak. Obviously many of these did not work.

Jack Torgerson:

Other baits that have been tried are anchovy and smelt, these worked with fair success. Deer meat was tried and this worked quite well; hair seals and sea lion meat didn't either work at all or with indifferent success. Octopus may be good halibut bait but it didn't work at all well for crab; however, oysters worked rather well. At one time we had some canned clam viscera, and this worked fairly well. When we ran out of bait, we punched some holes in the can and threw them into the pot. Canned tunafish also worked, we think possibly this may have been due to the oil in the canning. We also ground up some clams, minced it very fine and formed it into a ball and then dipped in paraffin thinking that by this method the paraffin wrapped baits would finally dissolve and the bait would work effectively longer. However, this was kind of a mess, with no particular success. Horse meat also caught a few crabs, but not as well as the clam bait.

To summarize, razor clams are probably best all round. However, in Alaska, especially at that time of the year when there is a good deal of herring spawn around most of the beaches, herring seems to work the best. Dead and/or spent salmon from around the creek mouths also works quite well at the right time of the year. Whatever is the natural feed for the clams at that particular time and place, does a good job if you know what they are feeding on.

Artificial bait should be cheap, easy to handle. When we have high water in the rivers, and with heavy clouds of mud coming out from the shore, the crabs generally move out. With strong southwest winds, and stronger currents therefore, the bait tends to mud up. Bait that would be sort of self-cleaning, perhaps disintegrate a little bit, would help us.

Sand fleas on the bottom are also a problem, especially if the holes in the bait boxes are a little too large. The sand fleas come in through the holes and eat up the bait before the crab has a chance.

Some fishermen have been approached by people who claim to have a super bait. They ask only that the fishermen give him 10 or 15% of his gross in return for the use of the bait. No chance! If they have a new bait, put a price on it, and we'll buy it. We need the clams for food anyway.

Sometimes we miss baiting a pot. When we are on fair fishing, even the unbaited pots have three or four crabs in them.

Discussion:

Well, one of the reasons that the first American squid we tried, a few years back, did not work so well may have been because it was bleached. I understand the present American squid is being frozen directly.

Yes, it is true that river-run smelt and river-run salmon may have used up most of their body oils in reproduction, and its possible that such bait isn't as effective as ocean-run.

While shrimp fishing I thought about saving smelt that we caught incidentally, and I knew that I could use it in the crab fishing, but it appeared to be too much trouble since we were so busy anyway.

In testing various kinds of bait, we get a ball park figure on bait effectiveness. Since the end pots fish best, we ignore them. We try the test baits in the middle of the string, every other bait. Fifty or 100 pots hauled gives us a pretty good figure.

Yes, any source of organized testing, would help us. We run 35 pots an hour, top speed, so we don't take notes. But we do compare our bait experiments with other fishermen.

No, I don't know that we can see a 10 or 15% increase, but we can eyeball a 40 or 50% increase.

I remember one time the hanging bait really looked good, we thought this was it. But the crew shoveled most of the crab overboard because they were females. But this was only one instance. (Note: Hanging bait was not identified. Possibility of selectivity towards sex not discussed.)

Jack Torgerson:

Yes, we have tried up to four bait containers per pot. We also tried glass jars, but I was prejudiced at first because we had an accident, one of the crew cut his wrists very badly. However, we did finally try using half pint jars because other fishermen claimed it worked so well. We just punched holes in the lid. We hang the glass jars with the lid down, it doesn't seem to work so well with the lid up. The glass jars worked very well, it seemed that we caught just about a third more.

I use mostly now only two bait containers. It doesn't seem to work so well, if I get too many bait containers in the middle of the pot.

Pete Schalestock, Moore-Clarke Co.:

We make the pelletized bait at Moore-Clarke and it runs about 50 cents per pound, but the price can vary with the formulation and the volume of production. I do not know what the formulation was in 1942, but this has been changed since. Essentially the present mix is known as the Oregon moist pellet, and is an open formula. Composition is about 28% herring meal, 5% crab, 2% kelp, 15% cotton seed meal, some corn solubles, 30% fish divided about equally between tuna viscera, salmon viscera, and herring. This was frozen fish, thawed and pasteurized and added as a slurry. And about 6% of fish oil. We are making this all day every day. The price, 15 cents per pound, is f.o.b. the plant. If this appears to have promise, the formula can be adjusted, and some of the meaningless stuff deleted. We could substitute some kind of filler and remove the expensive cotton seed meal for example. There is a vitamin pack which obviously is not needed and can be deleted.

Buzz Johnson, Washington Sea Grant:

Late last winter, and in the summer, we tried some Moore-Clarke bait as an experiment, but it did not seem to quite make it. It seemed to finish at about one-third of Japanese squid. Last summer we tried again with some additives. Whole herring and hydrogenated oil; whole herring and geoduck stomachs; whole herring and salmon heads; and using frozen razor clams as the control, these baits varied from one-third to one-half of that control. Additional problems were that last summer the fishery was still limited, catch was low, and the estimate of effectiveness is a ball park figure. There are possibly other complications. One, when used in glass jars the formula turns sour within one or two days. However, last winter when used in wood bait boxes, the baits were out for 10 days at times, and came back in the same size chunks. The bait looks like brown oatmeal, and did not wash out of the bait boxes, contrary to our expectations. Perhaps the formula could be made soupier to fish faster. This bait seems to have a potential.

Wayne Patterson, CHIMO I, Canada:

In the greater depths of fishing for blackcod we have tried salmon bait. This was no good. Seemed to turn sour almost immediately, despite its being in an open bait container with probably a good flushing action through it. I wonder if at the greater depths, 200 to 400 fathoms, if the increased pressure doesn't remove the oils more quickly? It seems that if the bait were frozen when used that it might fish longer, especially in the cold waters we operate in.

Chairman:

One way of testing bait, of course, is to see how well it fishes. Perhaps other approaches can be explored. One such approach may be that of testing in the laboratory, an animal's olfactory response

to essences of various bait. Doug Weber of the physiological laboratory, of the National Marine Fisheries Service here in Seattle has been trying this latter approach.

Doug Weber, NMFS, Seattle:

We haven't yet used blackcod, but these experiments may apply equally well. We have tried 20 or 30 other species. I should state here that similar work has been done at the stations on crabs. Basically, we are looking at a neurophysiological response. A technique for screening baits and odors. The olfactory bowl is exposed and electrodes are inserted to the olfactory epithelium, between the nose and the brain. The fish are anaesthetized to reduce physical activity. The tape records both response and simultaneously tapes an electrocardiogram. The anaesthetic is a chloride type compound, similar to the material used by the South American Indians. It inhibits muscular movement. The middle tracing is the olfactory response intercepted by the electrodes.

There is always some neural activity, so the line fluctuates, but at a steady rate. If we give a fish an odor and he detects it, he lets us know through increased neural activity. The response shown on this tape is from a coho reacting to a hand wash. For example, if you wash your hands in the water of a fish ladder, the salmon below will immediately leave. This hand wash is a known reaction and as a test is a control which confirms that the fish under test is still with us. The next fluctuation of greater amplitude is a reaction to L-methionine, and amino-acid. The next reaction is to another amino-acid, which is a compound of the hand wash business, but the increased fluctuations indicate something else is going on here. The last response is to the odor of another salmon, of its own species. A good deal of this work has also been done with catfish and with goldfish This seems to be a basic problem, that in order to screen attractants we have had to resort to field testing, and this is slow, expensive, and inferential at best. Another amino-acid form is D-methionine, which these salmon do not respond to, but we do get a response from catfish. This could be a clue for a species-specific attractant.

Being immobilized, the fish cannot give us a behavioral response as an indication of whether the increased neural activity recorded is a positive or negative reaction. In come cases there is a simultaneous cardiac response which may be of value in this respect. Many salmon give a sound, and this may be recorded as a cardiac response. Perhaps behavioral response can be correlated with the cardiac reaction. The skipping of a heartbeat indicated here is essentially a startle response. Right now, essentially, we can only determine that the fish does or does not detect the introduced elements. Interestingly enough, although the hand wash experiment at a fish ladder will drive the salmon away for a short time, they do not react visibly to the introduction of L-methionine, and we know by laboratory work that they can detect it.

Investigating the use of pheromones is another activity in fish response. These hormones are often used as a sexual attractant, exuded by fish ready to spawn. Experiments by Bartok with catfish also seem to indicate that a dominant fish in a school exudes an individualistic smell for identity. Speculatively, attractants may possibly be not only species specific, but sexual specific.

We cannot yet tell by the amplitude of response how strongly the fish is attracted to a particular bait. Presently, people looking at this same thing in salmon are closely examining the frequency of recorded response as a clue. Also, isolates compounded may reinforce each chemical to heighten the fish response. The hand wash response probably will not have a great effect on salmon reacting to a gill net which has been handled by the fishermen, since the contact has been rather superficial and will no doubt rapidly wash away.

Discussion:

Suggested that possibly hormones introduced into crab bait may serve to attract the large males predominantly; that since the crab industry is a million dollar industry, this would be well worth looking into in an organized way. Since females are not taken for market, such a method may reduce mortality in females injured during the capture process. Present experiments on attractants and response are of a low priority in most cases. We wonder if this can be adjusted upward.

Jack Torgerson:

The equipment for performing olfactory response experiments with crab is here, it is more a matter of devising and perfecting the technique. Who do we go to and apply the pressure to get something done along these lines? I'll furnish the crabs. Our present method of experimenting with bait is very expensive to us in lost time. And even then it is difficult for us to detect improvements in the order of 10 or 20%. With such a wide variety of baits presently used, does this effect the estimates of the stocks of crab? Perhaps, but we don't know how much. It seems that experiments should be oriented toward eventual practical economic values also, besides basic experimental work.

Max Patashnik NMFS, Seattle:

Our experiments with processed bait started initially with a Navy contract to develop an appropriate food for captive marine mammals. Essentially it is a protein carrier in which to inject essences as attractants. We can control the texture, and its rate of solubility. As bait we can eliminate unnecessary nutritive ingredients to reduce cost. Besides this sample handout, we have a great amount of untapped material in our archives in our laboratory.

Pete Schalestock:

We worked with Max in developing a method to manufacture in volume. The food is of a dry type mixture for easy storage. We tried experimental batches with a variety of added fish ingredients. Right now we are sitting on an established producing capability but we need the most effective additive for bait, and then I'm certain there will be a market. One unknown, is the effect of cooking on fishing effectiveness. Another problem is how many effective bait variations can we come up with and still produce in quantity to keep the price down? From what I have heard today, apparently no one bait is going to satisfy fishermen in various areas. This may be solved by using two or more components in the system to increase its scope of effectiveness under a variety of conditions and places.

Discussion:

Some sound experimental data is needed from various areas to establish the definite and best array of attracting properties needed. Examination of stomach contents of dungeness crab for preferred foods shows razor clams and small crab. In Newport, crab waste from the canneries has not attracted crab, but rather seems to keep them away. This may be for other reasons such as low salinity at the river mouth, or a high BOD, reducing oxygen supply.

Chairman:

The real value of a bait is best demonstrated when the stocks of fish or crab are scarce; there is an old saw in the trawling industry which says that "when there is a lot of fish around, you can almost catch them with a sack". Doug's method has its promise, but the realization may yet be a long way off, therefore it appears that the only certain route today is a controlled experiment on the fishing ground. To do this we need a central coordinating operation, to set standards and store and evaluate the data. We need to know who is doing what, and the knowledge accumulated. What is the total volume of bait by weight used in the various fishing industries today? The ultimate most effective and economical attractant will probably be a synthetic. The demand for a recognized effective natural bait will probably drive the price up and may further be restricted on a seasonal basis of availability.

Discussion:

Ten years ago bait in the shape of a wiener enclosed in cheese cloth was used as halibut bait; it worked well enough but we had trouble shaking the cheesecloth off the hook, the remnants got in the crewman's eyes in the process, but there was no real need for it then because there was a fair variety of economical bait available through established channels. Last year we paid 43¢ a pound for octopus bait, and the price on herring, grey cod, and salmon that we use for bait is going up steadily. A typical trip will use up

8,000 to 10,000 pounds of bait; maybe 3,000 pounds of octopus, 3,000 pounds of salmon possibly, and the rest in herring or frozen grey cod; and make five or six trips a year. A hopeful note may be that if the right attractant is found we may not need a great quantity; the human being detects smells on the order of parts per billion and fish have even greater olfactory sensitivities. Initially the promise of an artificial bait will probably be realized in a pot-type of fishery rather than in a hook and line fishery such as in halibut where 5,000 to 7,000 hooks a day are baited; a dungeness crab pot averages about 10¢ per pot to bait and 70 or 80 pots a day doesn't require a very large volume necessarily, but they have more flexibility in absorbing additional costs if this can be offset by increased effectiveness.

Alan Beardsley, NMFS, Seattle:

We observed 40 dungeness crab around pots in a tank. The crab were tagged and numbered for identification. We had a three-fold purpose:

1. Behavior experiments on dungeness crab in captivity.
2. Observe crab reaction to two different types of pot: a stainless steel pot and a pot covered with Poly Vinyl Chloride (PVC).
3. To test three different artificial baits using squid as a control.

Initially the PVC pot caught twice as many crab as the control pot; the same was true of the squid bait compared to the artificial baits. The final determination was to determine through behavior whether this was a realistic situation.

Were the crabs being conditioned? If a crab entered the pot one day, would he be more or less likely to enter again another day? Since there was a random distribution, I concluded there was no conditioning, and this held true through the two week period of the experiment. The validity of the experiment still remains a question since experiments on a fishing vessel with PVC pots and regular pots had opposite results. It should be kept in mind that a number of animals in confinement are under stress and that they have only two alternatives in the tank, whereas at sea they have many alternatives.

I cannot say that the captured crabs guarded the tunnel, but in a short time they went to the exit port, then eventually moved up on top of the tunnel near the narrow end and remained there. They did not seem to set up territories, in fact sometimes they balled together. Tank observation has its values, but it is limited and there should be a constant awareness in this respect so that no sweeping conclusions are drawn. Tanks may serve as a backup for inferred evidence gathered at sea. Over a lengthly period of captivity, the crab, through feeding routines and behavioral restrictions, become increasingly conditioned.

William High, NMFS, Seattle:

We observed pots while on the Tektite project in the Virgin Islands, living for two weeks in an undersea habitat. We were not looking for specific behavioral patterns of fish relative to pots, but rather to generate ideas and observe general fish activity around pots, mindful that any specific behavioral patterns of one species doesn't necessarily apply to other species. By observing general behavior we hoped to expand the scope of our idea when assessing inferred fish behavior up here. Reef fish do seem to have different behavior patterns than the fish we have observed up here, their activities for one, are less far ranging. Squirrel fish had aggregating areas in the coral, and the pots caught nothing until they were moved to within 6 feet of the aggregating area, and within a few hours had a substantial number of squirrel plus other species confined in the pot. It seemed that location was the prime factor and that bait played little or no role.

On a recent dive in Florida with small fish in the pot, their increased escape activity seemed within a short time to attract larger fish, which readily entered the pot, ate the small fish, and that seemed to end the attraction. Live bait in the pot may well have a greater attraction for such elusive species as the lingcod. One method may be to trap bait fish and enclose them in a small cage within the pot, but in substantial depths these bait fish may not survive the pressure change. During the course of our dive we inserted small bait fish within the pot on the bottom and almost invariably within a day or two we had a large lingcod or other cabezons in the fish traps.

On the Tektite project we observed that some species, the grouper in this case, seemed to know precisely where to enter the pot without seeking about. One specimen remained some distance from the pot and when he finally decided to enter, swam directly to the pot and through the entrance without hesitating or seeking any alternatives. Visibility in the shallow water of the Caribbean is quite good, but it appeared that in this particular case some rationalization took place.

The gated entrance seemed to be the most effective on Tektite project, the fish entering readily. In the case of the ungated tunnels, larger fish would push their way through the narrow entrance of the tunnel, but smaller fish meeting this resistance were easily discouraged and turned away. Our observations affirm that a sound and detailed study of tunnel entrances is essential to determine the most effective configurations.

Port Townsend Bay on Puget Sound is to my knowledge well populated with lingcod, and at diver depth we closely observed the pot and the lingcod reaction and we have concluded that this species is difficult to entice into the pot. As for mortality of confined fish, lingcod survived within the pot seven to nine days, whereas rockfish survive at the most two to three days. The rockfish is an active swimmer and this may be a criteria of his survival, whereas lingcod habitually

lay quietly on the bottom for long periods. We can only assume from this that various species also have various physiological requirements not yet positively identified.

Data from pot fishing for blackcod on the Washington coast indicates that blackcod begin to die in the pots after four days. (Note: Charles Hitz of the Fisheries Research Center, constructed a histogram of blackcod mortality in the pots from records gathered in the last two years, which confirm that mortality starts within the four day period but that the percentages are quite low until the eighth or ninth day when mortality sharply increases.)

We also tried mirrors hanging in the pots like flashers thinking they would be an additional attractant for the lingcod, but nothing conclusive was determined because the experiment terminated shortly, so this still remains a speculation. We did not observe that there was a substantial difference in catch between gated entrances and those with wire fingers, known as fikes, nor that fish damaged themselves particularly on the latter. However the wire in the fikes on those pots which Sig experimented with were bent on every haul.

The best generalization is probably that species will vary in the violence of their reaction to confinement. It was noted with some species that a fish within the pot would display aggressive behavior toward a fish outside the pot and that when the other fish entered the pot this aggressive behavior ceased. Again this reaction may be due to some sort of territorial behavior, and this will vary with species. It appears that blackcod is more gregarious and docile either in captivity or in relation to others of his species. In contrast the very small damsel fish of the Caribbean is very aggressive in defending his territory; we have seen him drive away 10 and 15 lb. fish, and though harmless, even biting at us if we trespass. In watching fish behavior, it is difficult to be completely objective because in observing fish behavior and trying to devine the reasons for particular patterns, we interpret this in the light of our own limited knowledge and motivations.

Discussion:

Wayne Patterson notes that in the blackcod pots there are few fish with damaged noses generally as an indicator of seeking escape, but adds that with pots which have a great number of fish in them that the proportion of such damage is proportionately greater. He adds that few if any blackcod were damaged so severely as to make them unmarketable. The condition of trapped blackcod is generally good, in fact Vancouver buyers feel that the flesh of trapped fish is superior to long-line blackcod because the oil content seems lower.

(Note: Some biologists have speculated that blackcod confined for a number of days without food may well internally consume a portion of the oily fat for which the blackcod are noted.)

Terry Thompson, Fisherman, Newport, Oregon.

In Newport this past winter I experimented with several pot variations in a 30,000 gallon aquarium located there. I first duplicated the Virgin Island pot in configuration. This pot has been in use for a couple months. The pots, being wood framed, may not stand up to the rough handling on shipboard, but could probably be built in the same shape from steel rods.

The pot is S shaped, so that the periphery is a series of continuous curves. Fish observed reacting to standard pots seem to dislike or are unable to understand sharp corners; the effectiveness of the round dungeness crab pot may possibly be a valuable modification to fish pots. This pot has been effective for sea bass and perch, and I have been unable to capture sea perch in any other pot but this one. The only type of fish that has escaped from the pot that I have observed has been wolf-eels.

The rockfish after entry rise to the top of the pot and circle about above the tunnel, and this behavior pattern prevents their finding the exit. When the outside of the pot has been flattened, fish which had previously continued around the pot following the curved surface now tended to turn at the corners and seek back and forth along the flat surface to enter the pot. Apparently this is because in part at least, he is trying to remain close to the bait and at the corner is getting farther away from the bait and if he continues would lose contact with the pot. This is one interpretation.

One bait experiment with a salmon head was ineffective, in fact I caught more fish in an empty pot. I have also tried squid, herring, anchovies, octopus, fish carensses, clams, geoducks, and live shrimp enclosed in a jar. The live bait was very definitely effective and may reinforce the food seeking of the fish visually, and by the turmoil in the water in addition to an olfactory appeal. Skates seem to have very short range eyesight, sometimes being well into the tunnel before they become aware of the pot. It seems that there is a range of intelligence in various fish species. Sea perch appear to very quickly understand how to escape from the pot. Few bottom fish escape. Lights and glittering objects in the pot so far have not been effective. Activity in the pot does seem to attract other fish. The idea of live bait sounds most interesting. I once used a baited hook inside the pot, the first fish in took the bait and vigorously tried to free himself, very quickly attracting other fish, the thrashing is communicated by low frequency vibrations which most fish can easily detect through the lateral line. I had about 300 lbs. inside a five-foot pot in about 20 minutes, mostly sea bass and cabezones.

(Alan confirms that in the Virgin Islands there may be a considerable lapse of time before the first fish enter, and that if his escape activity is quite vigorous, other fish subsequently enter in rapid succession, until it appears that something of a critical mass is reached and entry activity diminishes and then ceases. It may be possible that this critical mass could be related to their collective escape activity, so that prospective entrants shy away.)

Terry Thompson:

If the pot is tilted too much, I note that flatfish touch the inclined plane of the tunnel mesh and turn around and leave. When the pot is level I notice that flatfish would enter the tunnel and lie in the entrance for a short period, then enter. Snappers also seem to back away from a mesh. They won't touch it nor will they generally force their way through a closely constricted tunnel entrance. A tunnel entrance that seems effective for both flatfish and round fish is a triangular opening with rounded corners, the peak of the triangle being up. I have had as many as 30 sole in one pot in one night, plus a few other fish. I too favor the tandem tunnels, because the escape rate seems to be much lower. If the fish does escape through the inner tunnel, he generally goes to a corner or lies close under the tunnel against the end of the pot. The snappers seem to escape more easily because they remain swimming about in the middle of the pot, but the lingcod, flatfish, and rockcod do not. I'm not sure this is relavent, but they seem to return to the corner of the pot end from which they entered.

Bait location inside the pot seems to be very important for fish. A hanging bait from the top of the pot seems more effective than bait in a container. Sometimes for reasons I could not determine, with the same bait and the same pot, but at different times, fish entered the pot almost instantly and in considerable number. I've seen 200 lbs. of fish inside the pot in less than 15 minutes. Why, I don't know. Herring and squid are the two best baits, the squid possibly having a slight edge on the herring. In the shallow waters of the bay we also caught quite a few cormorants, but when left in there they were not particularly good bait. Loose web in the sides of the pot seemed to discourage fish from entering, also black web seems some what better than others.

Chairman:

Effectiveness of a round fish pot may well be because a fish sees a curved surface as a continuous surface, eliminating the complications of negotiating sharp corners which lead him away from the bait, and as Terry mentioned may lose interest and continue away from the pot. To pose a question, how much can the radius of a curve be reduced so that the fish may still perceive this as a continuous surface? This may possibly vary with species and with fish size.

William High:

The Fisheries Research Center made a cruise project to attempt a determination of the relative merit of tandem tunnels versus single tunnels in the pot, since opinion was, and still is, divided on their relative merit. Unfortunately, we could not haul more than 18 pots because of bad weather, but our tentative conclusions are that there is no difference. The relative merit may well be dependent on a time factor. That is, although single tunnels and tandem tunnel

pots may fish equally well when hauled on a daily basis or short soaks, their relative efficiency may differ on longer soaks of several days, for example. Observed behavior of other species during the Tektite dive was that some would swim about the pot and miss the entrances because they circled the pot in an oval pattern. Tunnels on two or more sides of the pot might increase the likelihood of their entry.

Discussion:

Terry's observation is that more fish escape from a double tunnel setup than from a tandem setup. The project cruise under discussion does not support this, although it is recognized the data is severely limited. The CHIMO gear has been altered a little because we found that the strings holding the tunnels in position parted, because of the abrasion of the fish in the pot. We have now installed rubber cords to hold these in place. We have observed on some project cruises that some data is only tentative, not because our methods were incomplete or invalid, but because undetected environmental changes may vary conditions so that the early data will not agree with the later data, and we have sometimes found that we have directly contradictory evidence. It must also be taken into account that many times the observation points are limited in number. There is contradictory evidence, for example, about the end-pot effect in blackcod fishing. This can well be an expression of where the string of pots is located in relation to possibly a rather small body of fish. Also the lack of end-pot effect may be due to tidal movement of the end-pot which is generally conceded to be detrimental to fishing. Terry confirms this with his tank observations. King crab fishermen use pots weighing 750-800 lbs. to avert the problem of pot movement on the bottom.

The discussion emphasizes qualification is needed in several areas, but generally seems apparent that pots and their tunnel arrangement need to be altered for optimum results for the species sought; which in turn indicates that pots can be highly selective toward particular species on the basis of their behavioral responses. The slate and chicken wire trap commonly used by fishermen in the Virgin Islands has a different tunnel structure in that the inner entrance is round and is oriented downward; while diving we observed not one fish escaping from these pots. Bait used in these pots was a local cactus and was extremely effective. A king crab pot variation currently used has a webbed bag attached which increased its holding capacity, and with the pucker string, can be dumped faster than the usual pot. They do not appear to presently outfish the other pots, and the advantage of the quick dumping feature is offset in part because in bad weather the bag swings freely and frequently hits the vessel and damages a number of king crab.

Wayne Patterson:

Fishing blackcod in the inlets of British Columbia, even on heavy fishing, we get very little fish when we set back, this may indicate a stable population, and in the open sea, migratory patterns may change this. They have been effective enough so that the crew has dubbed them "vacuum cleaners".

Chairman:

A most important aspect of fishing pots with long-lines is that positions of the gear must be very precise, in case the end markers are lost, so that with accuracy, you can return and mark the location of the missing string, using the appropriate drag in recovering it. In addition to accurate location, in such great depths as over 300 fathoms, effective recovery gear and methods have to be devised. A string of blackcod pots lost means $2,500 or more, and recovery of lost gear is an essential competence.

Discussion:

A dungeness crab fisherman in Winchester Bay, Oregon, is working with parlor pots; early in the season he reported that he caught 25-30% more than in the other types. However, I have not talked to him recently.

John Heffernan, Northwest Wire Company, Seattle:

At the request of Barry Fisher, we have developed and manufactured two dozen folding, square, 4-tunnel, collapsing wire dungeness crab pots. Tentatively, he reports excellent results. These pots were designed to be manufactured in a wire plant using automated machinery, at minimal cost. We are working with entry mechanics, baiting, and juvenile exiting. Emphasis is placed on the collapsing function so that the vessels can carry many times as many pots as they presently carry of the non-collapsing type. You know better than I the economic value of this approach.

The experimental pots vary in size and in shape. We will be happy to furnish you with duplicates of these plans, but some features of the pots have patents applied for; we therefore suggest that you consult with us about these proprietary features. Crab pot manufacturing is not our basic function, but is incidental to our main manufacturing thrust of such items as wire displays, baskets and so forth. In the past 18 months we have been working with the National Marine Fisheries Service, OSU Fisheries Advisory, and individual fishermen. We now have the capability of manufacturing at low cost structurally sound wire pots up to 6 and 8 feet square, with no attrition due to mechanical failures. As some of you know, we have had the privilege of working with the group that developed the collapsing blackcod pot and have manufactured several hundred pots for Sig's boat.

Ed Lagerquist, Kona Crab Company, Hawaii

I will be returning to Hawaii Monday, to test John's new crab pots on the kona crab there. We are presently using a wire hoop around a tangle net, with shark meat for bait. The hoops are fished on long-lines, and have had good results, 20-30 crab, in one hour soaks in some places. The hooped tangle net is a local Hawaiian fishing device.

Terry Thompson:

We also have one of your fish pots in Newport, and even if they are made of raw steel, uncoated, there is little wasting, just a little rust that wipes on your hands. I wonder if part of their fishing effectiveness may be due to the fact that the wire mesh does not move in the tide in the manner of fiber web?

John Heffernan:

In manufacturing pots we have tried to keep them essentially simple mechanically, but we have used only the lowest alloy in carbon of steel in all parts of the pot. This essentially reduces the galvanic potential to 0, eliminating as far as possible the wasting of the pot through battery action, but also the deterrent which I understand affects fishing effectiveness. It is well to keep this in mind when adding gadgets to the pot made of other metals such as stainless steel or brass: the pitfall of dissimilar materials in pot fishing shouldbe kept well in mind. Even in the use of wooden traps, the use of chicken wire and galvanized nails may set up a battery potential that will affect their fishing ability.

Konrad Uri:

In the king crab fishing we had this problem because we used soft metal rods and stainless steel woven mesh, but we corrected this with nylon web. We also tried king crab pots with 4 tunnels but this did not seem to help.

John Heffernan:

In manufacturing the collapsible blackcod pots, we ship the panels in a compact package, and with the wire coils, can be easily assembled by the fishermen. This also permits the quick replacement of badly damaged panels in the pot.

Wayne Patterson:

On the boat serious damage was rare, but when it was necessary to mend a rupture, this was quickly done with nylon twine. Collapsing the pots involves about 40 seconds on the boat with two men, perhaps a little over a minute with only one man, and bent panels are easily straightened by hand. No great skill is involved in the work with

the pots except possibly with cutting the web on bars and meshes to get the correct taper for the tunnels. On the CHIMO I we have to collapse the pots on each haul and 30-40 seconds seems about usual.

Jack Torgerson:

For dungeness crab fishing one of the practical reasons we use round pots instead of square pots is that on a steep edge or a strong current if the pot starts to roll or tumble, the square pot readily winds up the buoy lines, eventually pulling the bag under the water surface and we lose it. At least this seems to happen once in a while in our area.

Chairman:

The next gentleman on the panel is from Arkansas. He has been experimenting with pots or traps as a harvesting and sampling device in catfish farming.

Donald Greenland, NMFS, Rohwer, Arkansas:

About 40,000 acres of pond in the southern United States produced an estimated 35 million pounds of catfish in 1971. Forty-four million pounds is the estimated production for 1972. Last year 6 million pounds went to the fish processors, the balance was sold live to holding facilities. The harvesting device must bring the fish out of the water in good condition. Present harvesting costs are 1¢ per lb., so pots must harvest in large quantities, in good condition, keeping the cost under 1¢. Present methods of harvesting are mostly through seining the pond. Forty acres of pond and 80,000 lbs. can be harvested in about four hours.

The fish farmer has about 29¢ a lb. invested, a marketing value of about 35¢ a lb. In the static water of the fish pond the traps we used caught averages of 1/2 to 9 fish per day. We then tried a trap 4' x 4' x 4' with a small demand-feeder mounted on top. We tried this in a white catfish pond. (Channel catfish is the basic species used in farming; blue catfish and white catfish are incidental varieties also raised.) The first night out this trap caught 2,500 fish, which was 25% of the fish in this 4.26 acre pond. We damaged some fish, and in turning them back into the pond we started an infection cycle.

We were encouraged by the catch and performed the same experiment in a channel catfish pond, and after 10 days we had caught nothing in the trap. This may be illustrative of what we were talking about here earlier on species selectivity.

Marketing sizes run from 3/4 lb. to 1 1/2 lb. Six pots were used in each of these experiments. When we introduced the device into another channel-cat farm pond we knocked the fish off their feed for 20 days, which was a loss to the cooperating farmer, but which we made up to him.

In a retention test we marked and entrapped 250 white catfish in the trap. In 24 hours we lost over half of the fish, but we picked up 615 fish from outside the trap. The funnel entrances are 3" in diameter at the inner end.

In a decoy fish experiment, we put five channel catfish in the trap and set the traps in a channel catfish pond. In seven days we averaged 100 fish per day. Without the decoy fish in the trap, we caught 25 fish per day. Commercial hoop-net fishermen in the river use some decoy fish in their hoop-nets.

Drop seining around a feeder to which the fish have been conditioned was tried. But the feeding school never really compressed enough. The ponds vary in temperature from a low in the winter of 32°F to a high in the summer of 94°F. Generally the catfish do not feed actively below 60°F. April to October is the general feeding time. In warm weather we have sometimes an oxygen depletion problem in the ponds; so that in entrapment we may well have a storage problem. I have seen a 40 acre pond with 80,000 lbs. of fish rolling at the surface from this oxygen depletion problem.

Mr. Tarrant (NMFS) is developing a cage trap culture method. He starts the catfish fingerlings in the cage, starting the feeding cycle with a buzzer, With the sides of the trap open, he continues to feed the catfish on a buzzer signal. At harvesting he caught 40% of the fish. Later in the season, subsequent experiments raised this to 86% of the fish in the pond. This conditioning feature may have value in our entrapment experiment. Presently this involves considerable labor, but he is going to continue the experiments on a larger scale.

Harvesting catfish with pots is still too costly in labor and in fish damage. The pot's promise lies in that harvesting could be in small amounts, and selective for size also. Farmers look at seining as too expensive and antiquated. Catfish retreat from lights, and feeding activity may be greater at night. Mr. Tarrant feels that he may have done better if he had also tried his experiments at night. He has experimented a little with artificial scents but with no significant results yet.

The catfish farmer is interested in developing a mechanical device for harvesting; the seine is a device that is alien to him and requires skill and his direct supervision. Also the catfish farmer uses his marginal acreage for catfish and uses the greater portion of his acreage for raising beans and other agricultural products. Tests with the larger mesh seines as a selective device, creates a problem of gilling by marginal size fish. Selectivity to size is important, since in processing the larger fish have a smaller proportion of waste. Fish over 1 1/2 lbs. are regarded as the largest size the housewife wants; pan size is the controlling factor. Oversized fish are marketable, but are sold at a reduced price.

Instead of mesh size as a factor in controlling fish size, and to avoid the gilling problems, longitudinal wires appropriately spaced were used, and this substantially reduced the gilling problem

Catfish ponds generally at their deepest are about 8 feet. Soil with good water retention quality, geographically restricts the location of catfish ponds, and ready availability of good water. The delta areas have good and easily reached depths for well water. The catfish are stocked from fry and are a yearly crop. Other catfish harvesting methods such as draining the ponds, reef netting, and pumping have been tried but are relatively unsuccessful. Slat traps are used in the rivers in the south to capture crayfish, and is a generally acceptable method of capture. Concentrating the fish with an electrical field has been tried, and is being tried, but with varying success.

The catfish can sustain considerable abuse and survive, and can live in oxygen concentrations as low as two parts per million. The top productivity of 2,000 lbs. per acre of catfish is determined by waste disposal.

Scent may have some potential for capturing catfish, but in static water conditions I wonder if a scent trail to the trap would be well defined enough. Catfish traps have been used in the rivers since the early 1800's. A little has been done using a structure like the salmon trap with a lead; this may have some promise and probably more will be done like this. Stimulating fish activity with chemical additives in the pond may be a possibility; since the natural foraging pattern of the catfish has been lost during growth through artificial feeding. A stimulant such as copper sulphate in small quantities has been tried with perch. Catfish confined in a laboratory tank take a long time to calm down; they are easily disturbed by unusual noises, people passing by, even an airplane flying overhead.

Discussion:

Two unresolved questions regarding use of copper sulphate as a stimulant: First, the need for FDA approval of its use with food fish; second, neutralizing or disposing of the contaminated water, if it is not reusable for the next generation of fish.

Chairman:

Is it possible that some species of fish have another sensing mechanism, perhaps similar to but more rudimentary than the sonar capability of porpoise? Blackcod confined in pots in depths where there is little or no light, catch and eat small sand fleas; some comparative pot fishing by the Fisheries Center Vessel KELEZ, with limited hauling, infer that pots with fiber-webbed sides catch substantially more blackcod than the pots with wire mesh. The question may be relevant, but we do not have much information on this now, do we?

Herb Shippen, NMFS, Seattle:

Comparative fishing of blackcod pots and trawls was a cruise objective of the research vessel JOHN N. COBB. The blackcod pots used were 34" x 34" x 8' in length. A closing device on the tunnel was set for 24 nours. Another objective was to assess the fish density. The trawl used was a standard 400 mesh eastern with 4" mesh. Severe weather limited the time on the grounds. The pots and the trawl were fished at depths ranging from 100 to over 250 fathoms. The data showed that the pot caught four species in the 100-150 fathom depth and outside 250 fathoms caught only one species, namely the blackcod. The trawl, on the other hand, caught 15 species in the 100-150 fathom range, 14 species at 200 fathoms and 10 species at over 250 fathoms. Halibut and lingcod were caught in the pots at 100-150 fathoms, but not in the trawls at all. These species are caught in some areas by larger trawls, and faster towing vessels. The COBB trawls at 2 knots; most commercial vessels trawl faster. A larger proportion of rockfish was caught in trawls; only a few in the pots as is apparent from the data here.

Another interesting aspect is the comparative size composition of trawl-caught and pot-caught blackcod in 250 fathoms. Pot-caught blackcod were larger on the average then trawl caught, probably because the larger blackcod more easily escape from the trawl. Female blackcod in the same age group are generally larger than the male. This may account also, at least in part, for the differential sex ratio between pot-caught and trawl-caught blackcod. As seen in the table, blackcod from the pots averaged 78% female; trawl-caught blackcod average 39% female. For some unexplained reason, there seems to be more males in the trawl-caught than can be explained on numerical sex differential alone. There seem to be more males in the trawl-caught blackcod in the same size category as the females, compared to the pot-caught. Because of priorities we will not in the immediate future be resuming the comparative fishing.

Some blackcod tagged on Puget Sound, after several years, have been caught in the Bering Sea. This tagging by the Washington State Department of Fisheries of juveniles here, was duplicated by the Japanese in the Bering Sea, and subsequently captured off shoutheastern Alaska. Apparently juveniles frequent the inshore waters: random sampling along the coast also show that both spawning and larval forms of blackcod are well distributed. Therefore, no ready explanation is yet advanced for the distance travelled by the tagged blackcod. Larval blackcod has also been caught in sampling nets several hundred miles offshore. The Russians in the Bering Sea also report that blackcod migrate almost daily from the sea bottom to the surface. They report stomach contents of surface species, even of birds. It is difficult to be specific as to the spawning times; this appears to vary according to seasonal changes in water temperature: spawning taking place off the Washington coast in late winter (February or March), and later than this in Alaskan waters.

Wayne Patterson:

Buyers in Vancouver have cautioned us that spawning blackcod has a milky flesh; our last landing in March had females spawned-out, and during the course of the winter there has been no apparent difference in the flesh. Is there evidence indicating that maturity changes blackcod behavior toward a trap?

Discussion:

In some species (unnamed), there is a difference. It has been noted that juvenile blackcod are more attracted for example, to light than are adults, the only differential I know of now. In some species feeding activity is severely reduced during spawning. Of some species such as catfish, those caught in traps were mature. We do not presently have a backlog of information on catches by species composition related to sex, size, time of day. The Russian report that vertical migration of blackcod in the Bering Sea show that they approach the surface during the daytime and descend at night fall. We note in our tank in Newport that feeding activities seem to accelerate at dusk and at daylight in the morning. We do not have escapement data on the blackcod pots.

It has been noted in some fisheries that the larger fish take the bait first: is it possible that the closing of the tunnels after 24 hours may have restricted the size composition? In the deeper waters offshore, some pots were fished from dusk til daylight, others were fished from daylight through the daytime til dusk and we could not detect any substantial difference in the average catch of either period. This was off the coast of Oregon with the BARON in 1969. There seemed to be some tendency for the blackcod to move deeper in the late fall and early winter, and return shallower in the spring.

Chairman:

We should be mindful that the behaviors noted are on the order of tendency or indications, and that these inferences are drawn in some cases from limited observation both in number of pots hauled, and year round fishing activity. More systematic research with the main objectives needs to be done. Work done in tanks on blackcod behavior may not well reflect bottom behavior because the tank is well lighted, and bottom light in three or four hundred fathoms is virtually non-existent; in the first case fish is more dependent on eye sight; and perhaps solely dependent on smell when in the bottom depths.

Discussion:

Reaction to light by the blackcod was restricted to white light, we tried no other variations. Trawling for the blackcod in certain areas may have higher catch rate per hour of tow than pot fishing, but whether the size composition would be entirely marketable might be another question.

Chairman:

Size-selectivity by adjustment of mesh size, such as the four-inch which was used in the early blackcod pots, was effective for juvenile escapement, but we had a little problem when hauling in that we often had three to eight fish gilled in the mesh. Some were not marketable, this caused some delay in dumping the pot. The earlier suggestion today that the escapement mechanism may function better with appropriately spaced bars of some length rather than using mesh size only, is worth noting.

Discussion:

A trawler working outside Vancouver Island in the deeper areas notes that blackcod are in good quantity on the bottom but disappear without a trace in a short period of time, but he did not correlate this with daylight and dark, and I wonder if this may have something to do with the vertical migration we discussed? Some fish may even be sensitive to the signals from a depth sounder. For example, knowledgeable trawlers on known perch grounds simply trawl the area they frequent without preliminary sounding; if sounded first, the trace of the fish can be seen on the tape but the subsequent tow catches only remnants of the observed school. This has happened frequently enough that the fishermen prefer a calculated risk on the presence of fish rather than verifying it with the depth sounder.

Jack Torgerson:

Francis and I had what seems to be a similar problem when hake fishing last year; after we located the hake school we had difficulty in making any substantial catches, even though we had good and substantial indications on our sounding tape.

We know the trawl was at the proper depth through our telemetering equipment. The larger and more powerful trawlers did better than we, but they also had difficulties in this respect. Perhaps this problem could be verified by varying sounding frequencies: we do know that most fish can receive low frequency vibrations through the lateral line, which functions both for food detecting and also as a warning device of approaching predators. Has anything been done, or can anything be done, to determine their receptivity to a range of frequencies, and if this varies by species? As usual, we seem to expose more problems than answers; the basic question is, which ones are worth doing?

Fred Hipkins:

The CAPE FALCON is presently working with blackcod pots outside Morro Bay, California. We caught some lingcod, petrale sole, flounders, but we did not at that time try for blackcod. He mainly wants to see if he can catch good quantities of rockfish. He will keep one string of pots in the deep for blackcod, too. Last year in a survey down the coast we found that 21 boats had been fishing with pots for blackcod,

but were not actively catching this species at that time because the news about mercury in fish had severely depressed the market.

Some boats had been fishing with the lightly built cylindrical pots, and as these were made of light wire, they gave out readily. The repairs were made with nylon web and the fishermen reported that subsequent catches were much better in these repaired pots. With this clue we had some blackcod pots made by John with frames only, no wire in between. We webbed these pots with nylon, and sent them North on the KELEZ, along with the regular wire pots. In a string of five pots, we had the three nylon web pots. Because of bad weather and possibly strong tides, the three web pots were irreparably damaged. We hauled them once and their catch rate was about 5 to 1 over the regular wire pots. We are not building blackcod pots with tandem tunnels because if we are going to haul them every day, the extra tunnel would be wasted labor. Last winter we noted there was also a very small difference between the pots with a single entrance and those with entrances at both ends. A problem with the tunnels at both ends is that the dumping door had to be in the middle of the pot, and this caused considerable inconvenience when emptying the pot.

John Heffernan:

The pots built and finished with nylon webbing used on the KELEZ, were built for test with no emphasis on strength. We are building more now with a reinforced structure. Offsets in these pots at the ends enable them to fold flatter than the all-wire pots. Some of the new pots are six feet rather than eight feet in length, to test for optimum pot size and fishing effectiveness. Another factor in building these pots, has been in the design akin to an airplane wing, enabling the pots to flex under stress without permanent damage or distortion.

Chairman:

In some places we fished we had over a hundred fish in the pots, causing severe bending, and despite the small wire size, the pots returned to normal after dumping, nor have I seen a single weld give way. The wire web is spot welded under pressure and fuses the wires together, and even hammer blows to straighten bent wire causes no separation in the welds.

Fred Hipkins:

One thing has been well brought out here today, relative to gear selectivity, is that if you are going to fish redsnappers, you have to understand redsnappers, and develop the gear, the pot per se', the entrances and the tunnels, the bait, as well as knowing the areas and the time when and where they are found in the best quantities. There is a redsnapper pot fishery in Australia, with over 200 boats participating, getting at times from 200 to 400 pounds per pot on their gear.

Discussion:

On the question of catching greycod, we did in the last cruise catch some quantities in the shallow 40 to 50 fathoms range, using herring as bait. We did not catch them in great quantity, half a dozen to the pot or so, but we did not actively look for concentrations of greycod either.

It seems that fish which respond to bait could be a potential species in pot fishing. In the tank, large blackcod have not been seen to swallow small blackcod, what has been the experience at sea? Lingcod will enter a pot and attack smaller sablefish.

In the confined areas we have been fishing, the blackcod have swallowed the heads which we discard overboard. We have observed when dressing large blackcod that occasionally they have swallowed juvenile blackcod. The greatest number of lingocd caught in pots was four, but Bill High has made some interesting observations on lingcod behavior around pots in Port Townsend Bay. There may be a combination of bait and tunnel entry mechanisms that could improve the catching of this species.

Incidental catches of lingcod in dungeness crab pots is fairly common, especially when fishing close to rock piles. The entries are quite small and it appears that the lingcod must have driven himself through the entry with some force just to get in. Occasionally we have caught two in the pot, when dumped on deck they are still quite vigorous. Lingocd in pots rarely if ever have self-inflicted wounds, and I wonder if this may be due to the fact that they are not only above normal in fish intelligence, but physically they are quite lithe and this suppleness enables them to snake about in the pot without damage. This may be a factor in their ability to force entry through tunnels which seem to be too small for them, and a barometer of their determination to get in.

Robert McElwaine, Department of the Environment, Canada:

Some fishermen in our area are interested in trying these pots, and we have twelve pots made up, four with a 2" x 2" mesh, four with a 3" x 3" mesh, and the balance with 4" x 4" mesh. We may get more later. We are most interested in catching lingcod right now, and one of our fishermen is well acquainted with lingcod ground. The TANU took five pots out for experiments this winter, perhaps Mitch will describe this cruise.

Mitch Gay, Department of the Environment, Canada:

TANU has the capability as a research vessel but operates as a patrol vessel and is now on the way to the Bering Sea. In February we looked for lingcod on the West Coast of Vancouver Island, but trials were limited by severe weather. Herring was used for bait in all the pots, and set on rocky ledges in 15 to 20 fathoms. Some were

out for seven days before being hauled. One such pot had one octopus and a number of redsnapper skeletons. This was true of the pots that were out for a long period of time, and we conclude that fish cannot survive in shallow water while contained in the pots as long as in the deeper waters. A pot out for three days had 50 pounds of dead redsnappers and one live lingcod. A one-day soak with another pot caught a 50 pound halibut. One of the experimental pots had plastic bait jars with screw type lids. When we hauled this pot, we found one octopus inside, the bait jar lids were screwed off, and the bait was gone. In this instance it appears that the test was not basically one of fishing efficiency, but more like an intelligence test. We hope to have further pot trials when the TANU returns, possibly in Hecate Straits on the cod grounds.

Terry Butler of the biological station has done substantial comparative fishing for prawns with various trap configurations. This includes tunnel variations and burlap covered pots. Some prawn fishermen who fish the inlets in our area catch up to 38,000 pounds per year. Inquiries for literature on the subject should be addressed to the biological station.

APPENDIX

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