80/15

FISHING INDUSTRY RESEARCH TRUST ACCOUNT

FINAL REPORT

1981

ITEM

1. Title of Proposal: Feasibility study of the application of satellite remote sensing to fisheries investigations.

2. Name of Applicant: Tasmanian Fisheries Development Authority.

3. Division, Department or Section: Research and Resource Section.

4. Proposal: Computer compatible tapes from Landsat, Tiros N and Nimbus 7 will be digitally enhanced and water masses around the Tasmanian coasts characterised using parameters including temperature, salinity, secchi disc, water colour, chlorophyll. Ground truth and catch data will be obtained from Japanese feasibility squid vessels, Polish midwater trawlers, T.F.D.A. research and patrol boats. Any association between water mass and fish catches will be determined.

5. Name of Person Responsible for Programme:

   J. D. Thomson, M.Sc. Agr., Marine Chemist.

6. Qualifications of Staff to be Employed on the Programme:

   Five years working on environmental and hydrological studies with the T.F.D.A. (refer also item 10b).

7. Location of Operations: Based at Fisheries Research Laboratories, Crayfish Point, Taroona, 7006. Computer facilities including digital manipulation of satellite data from computer tapes were used at the Department of Engineering Physics, Australian National University.

8. Date Project Commenced: July 1980

9. Completion Date: An extension of time was granted to the end of October 1981. The work is continuing using data obtained during the FIRTA funded period.

10. Funds Requested:

	1980/81	1981/82
Air Fares	$1,200.00)	$1,500.00
Travelling Allowance	$3,780.00)	
Computer compatible tapes		
Nimbus 7	$2,600.00)	
Tiros-N/NOAA	$3,120.00)	
Landsat	$2,000.00)	
Computer time	$2,000.00)	$6,500.00
Dipix image analysis system		$120,000.00
Oceanographic buoys		$8,000.00
	$14,700.00	$136,000.00
		(Not Granted)

11. Funds to be provided by the applicant or sought from other sources: Salary of J. D. Thomson paid by T.F.D.A. An acoustically coupled Decwriter connection to CSIRO-NET was effected in May 1981 upon completion of a new wing at the Taroona Laboratories.

12. Variations in expenditure: Imagery from Nimbus 7 coastal zone colour scanner was unobtainable during the study period. TIROS/NOAA data was difficult to obtain so the study concentrated on Landsat data. Geostationary satellite data was obtained from the Bureau of Meteorology.

13. Expenditure:

	1980/81
Air Fares	$1,557.90
Travelling Allowance	2,708.03
TIROS/NOAA tapes	626.38
Landsat tapes	3,960.00
Computer time	1,850.00
G.M.S. data	280.50
Misceallaneous	667.96
TOTAL:	$11,650.77

14. Report:

Preamble:

Remote sensing methods have been used for pelagic fishing for many years. First aerial spotting of fish schools was used and latterly the use of airbourne radiometers has enabled the detection of water mass boundaries where pelagic fish concentrate to feed. (Hynd and Robins 1967, Roberts 1971, Williams 1981). Traditional methods of collecting shipboard data for oceanographic surveys related to fisheries are expensive and can only survey point stations at any one time. Data collected from successive stations are then extrapolated over time and space to depict the oceanic conditions of the area under study. With satellites large chunks of ocean can be studied in seconds with the opportunity for multi-temporal coverage. 'Sea-truth' is required but one station can serve to calibrate a vast area.

Kemmerer *et al.* 1978, demonstrated that Landsat data could be used to direct a fishing fleet to menhaden schools in real time. This study was a one-off demonstration that using aircraft sensors, shipboard equipment and satellite data, a fishing fleet could be directed to the turbid waters which favoured the formation of dense schools of menhaden. In practise, Landsat data cannot be used in real time and repeat coverage is available only every 18 days.

Landsat data do lend themselves to other fisheries uses. Attempts have been made in various parts of the world to map seagrasses, mangroves and reefs. Olsen (1977) has used Landsat imagery to evaluate areas of mangroves, seagrasses, mud and sandbanks in inventories of the Queensland coast. These inventories have helped to select areas for "Fisheries Habitat Reserves".

Landsat data have also been used for hydrographic mapping. Warne (1978) demonstrated that reef areas could be calculated from Landsat data and that hydrographic charts could be produced at less than half the cost of conventional methods. However, the reflectance characteristics of different bottom types means this method must be accompanied by reasonable ground truth. Small features beyond the spatial resolution of Landsat are a problem.

Monitoring of ocean dumping from Landsat is being attempted in the U.S.A. (Konop 1978). Such studies are hampered by the shallow depths from which the light has been reflected.

<u>This Project</u>

As coastal Zone Colour Scanner data was not available, data were obtained from the Japanese Geostationary satellite. Details of the satellites investigated by this study are:-

Landsat

From the 1963 Nimbus design. Sun synchronous with a southbound equatorial crossing. Angle between the sun, centre of the earth and the satellite is 37.5°. Altitude 880-940 km. Inclination 99.114°. Period 103.267 min. Equatorial crossing 9.42 a.m. Coverage cycle 18 days (251 revs). Distance between adjacent tracks at the equator, 159.38 km. Swath width, 185 km. Landsat 1, 1972-1978. Landsat 2, 1975 - still operational. Landsat 3, 1978, reserve, limited operation. Solar elevation and azimuth change seasonally. Sensors, Multispectral Scanner (MSS) and Return Beam Vidicon.

MSS	Band 4	Visible green	0.5 - 0.6 μm
	5	Visible red	0.6 - 0.7 μm
	6	Invisible reflected infra-red	0.7 - 0.8 μm
	7	Invisible infra-red	0.8 - 1.1 μm
	8	Thermal infra-red	10.2 - 12.6 μm

Band 8 was only on Landsat 3 and it did not work.

Seasat

Altitude, 800 km circular orbit. Inclination, 108°. Period, 100.75 min. Not sun-synchronous. Sensors: ALT, Pulse Radar Altimeter; SASS, Seasat Scatterometer System; SAR, Synthetic Aperture Radar; SMMR Scanning Multi-frequency Microwave Radiometer; VIRR, Visible and Infra-red Radiometer.

Nimbus 7

Sun-synchronous, near polar. Altitude, 955 km. Period, 104.16 min. Equatoria crossing, northerly at noon, southerly at midnight. Adjacent tracks, 26.1° longitude. Objectives: to observe gases in the atmosphere; to observe ocean colour, temperature, ice. Sensors, seven of which two are of interest: CZCS, Coastal Zone Colour Scanner; SMMR, Scanning Multi-frequency, Microwave Radiometer.

Geostationary Meteorological Satellite

'Parked' orbit above the equator at 36,000 km above Nuiguini at 140° East. Sensors: Visible and infra-red by a spin-scan radiometer. This satellite produces the weather image seen on Australian television.

TIROS/NOAA

Altitude, 870 km. Inclination 98.91°. Period, 102 min. Equatorial crossing, TIROS northerly at 1500, NOAA southerly at 0730. Transmissions from TIROS/NOAA are APT, Automatic Picture Transmission and H.R.P.T., High Resolution Picture Transmission which are VHF 137.5 MHz and S-band 1698 MHz respectively. Of prime interest is the sensor AVHRR, Advanced Very High Resolution Radiometer.

AVHRR

Channel	Resolution	Wavelengths	
1	1 km	0.55 - 0.90	0.58 - 0.68
2	1 km	0.72 - 1.10	
3	1 km	3.55 - 3.93	
4	1 km	10.5 - 11.5	10.3 - 11.3
5	1 km	11.5 - 12.5 μm	

Usefulness: Ch 1 Daytime cloud and surface mapping

2 Surface, water delineation

3 Sea surface temperature, night time cloud mapping

4 SST, day/night cloud mapping

5 SST (mainly in the tropics).

ARGOS data collection service of CNES operates through these satellites for a cost of $20/platform/day.

As CZCS data from Nimbus 7 were unobtainable contact was maintained with Dr. David Tranter, CSIRO Fisheries and Oceanography who had tapes on order. Some images became available in May 1981. CZCS data has proven to be better than the initial processing problems indicated. Satellite values compare well with shipboard data. CZCS will be a useful tool for primary productivity studies in coastal waters. (Mueller 1981). At present the spacecraft is experimental so data can only be obtained through the NASA project leader by arrangement. Archived data will be available. Real-time data will only be possible when a receiver is built in Australia (see also TIROS/NOAA).

In this feasibility study, geostationary satellite data were used. Visual imagery is obtained by the Bureau of Meteorology at least once a day and infra-red imagery every three hours though the Bureau can obtain data more frequently if necessary. Obtaining the data from the Bureau is more difficult. The easiest method is to receive the digital data by landline. I obtained digital printouts from the Melbourne Bureau of Meteorology. One printout was obtained each week from the 7.1.81 to the 27.5.81 at a total cost of $280.50. These GMS data, were used to direct the vessel "Challenger" on an albacore survey when cloud free imagery was obtained within a reasonable time lapse. The printouts took from

1-5 days to get to Hobart. More frequent data could not be provided by the Meteorological Bureau as they assert they have insufficient programming staff to cater for outside users. GMS data were up to 10°C different from sea truth and demonstrated the problems of a measurement of only the top few millimetres of the water column. Location can be a problem when using photographic images from the GMS satellite as is distortion in southern latitudes. Toward the end of the life of the first GMS, the satellite image was cut off around Bass Strait. This has been rectified by the launching of a replacement satellite. TIROS/NOAA data were obtained from NOAA in December 1980 but the wrong spatial resolution had been sent and the data were not promising. Later AVHRR Global Area Coverage data obtained in the form of Computer Compatible Tapes and read at ANU, Engineering Physics. Some images had large patches of cloud making geographic orientation difficult. The possibility that these data could be obtained four times a day if a receiving station were established in Australia could mean a boost to pelagic fisheries in Australia or at least a more fuel efficient industry. NOAA-6 data are being used off the west coast of the U.S.A. to direct vessels to the places where albacore and striped tuna are likely to be feeding. (Laurs *et al.* 1981). The tapes took 6-8 weeks to arrive.

NOAA-6 tapes were compared with Landsat tapes from the same day. Good correlation was obtained though one was measuring infra-red radiation and the other visible.

Landsat scenes in three series were obtained from the Australian Landsat Station. These scenes ranged from 36° - 46°S, and follow the N.S.W. coast from Bateman's Bay to Cape Howe, across Bass Strait to Flinders Island, Banks Strait then down the east coast of Tasmania. Sea truth included ship-board data from the Tasmanian joint venture squid fleet in January 1980 and airbourne radiometer data in October 1980. As well as mesoscale studies Landsat data lends itself to estuarine studies because of the pixel size (spatial resolution) of 80 m x 80 m. However, in the very non-uniform estuarine environment a great deal of ground truth is required for interpretation of images. Swanport on the Tasmanian east coast was used as an example as well as Franklin Sound in the Furneaux Group. The latter area exemplifies the bathymetric uses of Landsat data in areas with shifting sandbanks.

Appended is a paper presented to the Landsat '81 Conference. (Thomson and Carpenter 1981).

(a) Utility of satellite - remotely-sensed data in fisheries investigations.

Satellite data can be used on studies concerning: water temperatures, reefs, pollutants, oil slicks, suspended particulates, wave heights, direction, spacing, meteorological conditions, coastal wetlands, breeding grounds.

Some of these do not require real-time data and can be studied using archived data. Others require real-time data particularly studies concerned with pelagic fish. Until more digital interactive image-analysis systems are available the use of satellite data will not be widespread. Packaged systems including software are available off-the-shelf at a cost of $100,000 - $150,000.

(b) Characterization by use of satellite data, water masses associated with pelagic fish.

Satellite data is able to delineate water masses as shown by Thomson and Carpenter (1981) and Legeckis and Cresswell (1981). It was intended to use the Tasmanian Joint Venture fleets to provide fish catch data and compare them with the position of the water masses. Unfortunately no joint venture squid vessels operated off the Tasmanian coast during the 1980/81 season. The Polish midwater trawler the 'Denebola' did not stay long in Tasmania and due to the restriction placed on it catches were small. Their cruises did not coincide with available 'cloud-free' satellite imagery. The T.F.D.A. will be continuing to seek associations of pelagic fish with water masses this summer. The known movement of albacore and striped tuna is associated with the intrusion of the East-Australian Current in Tasman waters. This can be detected using Landsat or NOAA-6 imagery, and the approximate position of warm water can be found using the G.M.S.

(c) Determining if real time data could be obtained in the future for dissemination to the catching sector if associations in objective (b) are significant.

The catching sector in the tuna industry currently use airbourne radiometry which gives an indication of fronts along the aircraft's track. Satellites can provide extensive isotherm charts for fishermen. (Laurs *et al.* 1981). The Meteorological Bureau could transmit isotherm charts as well as isobar charts on facsimile machines. However, the Meteorological Bureau does not have the capability to receive HRPT or CZCS data so until a reception facility is established there is no possibility of real-time data for the catching sector. If a public reception facility recoded the high resolution temperature data and broad cast it in the form of an isotherm chart, then fishing vessels could receive the charts through facsimile machines costing between $3,500 and $5,000, depending on whether the radio is built-in. It should be a reality in 3-4 years time.

At its 19th meeting on 24.3.80, FIRC "agreed to recommend a grant of $14,700 as a feasibility study for one year and noted that if successful a much more ambitious project would be required to achieve optimum results."

Disappointingly, the application for the project to continue was refused by the committee despite being ambitious. Had the project been approved a marine remote-sensing facility would now be set-up and would have become a national facility on C.S.I.R.O. Divisions of Fisheries and Oceanography moving to Hobart. Now there is no national marine remote-sensing facility and no reception facility for satellites of interest to marine scientists and fishermen alike. The cost-effectiveness of satellite imagery is demonstrated by oceanographic studies off the Western Australian coast and off south-east Australia. The images in Legeckis and Cresswell (1981) confirm 30 years of oceanographic work in the Indian Ocean and provide perspective to the earlier satellite-tracked buoy experiments of Cresswell *et al.* (1978). Similarly, the observation of Newell (1961) of a northward flow of cool saline Bass Strait water aginst the New South Wales coast north of Cape Howe was supported by the ship track and X-BT data of Godfrey *et al.* (1980) but confirmed by satellite imagery (Nilsson *et al.* 1980).

Summary

Satellite data of use in fisheries investigations are from Landsat, TIROS/NOAA and Nimbus 7 CZCS.

Water masses associated with pelagic fish can be characterised by temperature (NOAA-6) or colour (Landsat and Nimbus 7 CZCS). Colour is a better indicator of water mass.

Real time data will only be available when a satellite receiving station with High Density Tape Recorders is set-up to receive NOAA-6 and Nimbus 7 and this complete data set is converted to a simple isotherm or isochroma chart and transmitted for facsimile reception. This is all feasible technically and would improve the economics of pelagic fishing and probably catches as well.

Acknowledgements

I would like to thank John I. Wright, Production Manager, Greenseas Division of Heinz from Eden, N.S.W. for providing airbourne radio metric data. I would also like to thank Dr. Frank Honey in advance for NOAA-6 CCT's. Special appreciation must go to Dr. David Carpenter, ANU Engineering Physics for his close co-operation on this project. Without his software expertise this work would not have been possible.

References

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DISCRIMINATION OF OCEAN WATER MASSES FROM LANDSAT

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ABSTRACT

Landsat data have been used to discriminate the oceanic water masses off the south-east coast of Australia. The digital data were examined using an interactive computer system with the images displayed on a video monitor for interpretation. Good agreement was found between the patterns seen and data obtained from other sources. These patterns were also consistent with the known behaviour of the East Australian Current system and could be used to locate ocean fronts.

INTRODUCTION

Landsat Multispectral Scanning Radiometer (MSS) data from two passes over the south-east coast of Australia were examined to investigate the potential of these data for locating fish populations associated with water masses. Pelagic fish in particular feed along the boundaries of juxtaposed cold and warm water masses and the prediction of probable fish concentrations from satellite data is potentially valuable in the efficient management of pelagic fisheries. Landsat data are inherently better suited to estuarine and coastal marine applications because of the small pixel size and relatively poor radiometric resolution, but they were used in this investigation since the imagery is now readily available for the bulk of the Australian Fishing Zone from the Australian Landsat Station. The scenes involved were Path 95, Rows 85-90, from the 16th January 1980 and the 21st October 1980.

METHODS

Computer Compatible Tapes of the MSS data were purchased from the ALS following assessment of cloud cover using the micro-image catalogue. These data were examined on the image analysis system of the Department of Engineering Physics, A N U; this is an interactive system based on a PDP 11/45 mini computer. The data were used in the form of the digital spectral radiance values (grey levels) from the CCT's, but for this application the original 60m x 80m pixels were aggregated to form larger pixels of 480m x 480m. This not only allowed the examination of whole 185km x 185km scenes within the 512 x 512 pixel display, but also retained the correct aspect ratio of the data and avoided any 6-band striping.

Since clear ocean water absorbs light so strongly in the spectral regions corresponding to band 6 (700-800nm) and band 7 (800-1100nm), only the data from band 4 (500-600nm) and band 5 (600-700nm) were used to search for patterns in the ocean. Bands 6 and 7 were used to discriminate between land and water.

Initially, the grey level ranges in the individual bands were examined using single band pseudo-colour displays and then two methods were used to produce enhanced displays for interpretation. The data ranges for the bands over the ocean obtained from the single band displays were used in a parallelepiped (box) classification of the data. This combined the data from the bands to produce enhanced displays in which adjacent water masses differentiated by the classification were assigned contrasting colours. Alternative displays were created by combining the data from bands 4, 5 and 6 into false-colour composites optimised for the water data ranges.

The display parameters and classification specifications were kept constant throughout the examination of each data set. Thus photographs taken of the images displayed on the video monitor could be used to make up a consistent set for interpretation of the whole area covered.

RESULTS

The displays of the individual bands 4 and 5 contained obvious patterns even though the total range of radiance values was invariably small. For example, over the ocean, band 4 was found to have a typical range of 22-27, out of a possible range of 0-255. Band 4 and band 5 were always highly correlated and showed similar patterns, although these were seldom identical. The false colour composites of bands 4, 5 and 6, a conventional means of displaying multispectral data, combined the patterns of bands 4 and 5 with the ability of band 6 to discriminate between land and water. However, the colours were dull, of low contrast, and the patterns were indistinct. The classification, based largely on bands 4 and 7, discriminated well between water and both land and clouds as well as producing high contrast colour displays which facilitated interpretation.

The patterns brought out in these displays were interpreted as variations in ocean colour associated with differing water masses and so it was possible to describe the features seen in terms of the known characteristics of the water masses likely to be present in the area. These were essentially the water associated with the East Australian Current system, which brings warm water down the east coast of Australia from the north, and the water associated with the west wind drift which brings cooler water from the Great Australian Bight into the southern Tasman Sea.

DISCUSSION

In the imagery from the January pass, the East Australian Current water was seen to extend down the New South Wales coast to meet the clearer west wind drift water around Cape Howe. It then appeared to move east to circumvent the clearer water occupying Bass Strait before turning back to meet the Tasmanian coast near Flinders Island and extending as far south as Hobart, leaving some pockets of the clearer water along the east coast of Tasmania. The clearer water was seen again to the south of Tasmania.

The extent of the cloud cover in the more southerly scenes made the interpretation rather difficult since it was not always possible to positively identify the water type. The classification procedure gave good discrimination against cloud since all pixels not conforming to the spectral requirements of any of the classes were displayed as black. The cloud cover assessments were made using the band 6 images in the micro-image catalogue and it is important to note that the cloud cover affecting band 4 was always more extensive than seen in those images.

The October data showed a rather different situation with the East Australian Current water intruding into Bass Strait along the Victorian coast and reaching Flinders Island. The clearer water associated with the west wind drift occupied the area off the east coast of Tasmania and extended into eastern Bass Strait, to about halfway between Flinders Island and the Victorian coast to the north. The boundary between the two types of water was well defined. The clearer water displayed some internal structure but this was less spectacular than that in the more opaque water which showed meanders typical of the East Australian Current.

These interpretations were consistent with those based upon available ship data and with the known behavior of the water masses in this region. The clearer water observed in this study was the colder of the two water types and the boundaries between such water masses are the thermal fronts where the planktonic food of pelagic fish concentrate. Although Landsat data may be more suited to estuarine and coastal marine applications, this study has demonstrated the usefulness of Landsat in describing meso-scale oceanic structure, even when there is a small range of radiance levels. The patterns visible in the displays allow the correct extrapolation of point or transect data, from ships or aircraft, so that the shape and position of the ocean fronts can be properly mapped over large regions.