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# Occupying the High Ground: Technology and the War on IUU Fishing

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Throughout history, military strategists have subscribed to the dictum that control of the high ground gives ‘a decided advantage’ and is ‘almost equated with victory’.[1] This common-sense view of decisive conflict has its origins in two dictums of Sun Tzu: ‘all armies prefer high ground to low and sunny places to dark’;[2] and ‘the clever combatant imposes his will on the enemy, but does not allow the enemy's will to be imposed on him’.[3]

With this historical background, the current chapter advances the thesis that technology constitutes the ‘high ground’ and is a valuable asset in combating illegal, unreported and unregulated (IUU) fishing. Emphasis is given to global technologies that are, or may be, deployed to counter IUU activities on the water, as well as more widely in the monitoring of international trade in fish products and post-catch landings.

The first part of the chapter categorises and defines IUU fishing, then identifies where it occurs, why it occurs and what its effects are. The second part outlines how effective and cost-efficient monitoring, control and surveillance (MCS) provide the ‘high ground’ for countering IUU activities.[4]

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[*] The views expressed in this chapter do not reflect the official views or decisions of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

1 S.J.M. Flores, ‘The Millennial High Ground’, *OSS Digest*, Vol. 4, 1999; available at <www.paf.mil.ph/digest/d43/d43_6.htm>.

2 Sun Tzu, *The Art of War*, Translated from the Chinese by L. Giles in 1910, Ch. IX, para. 11; available at <www.chinapage.com/sunzi-e.html>.

3 Ibid., Ch. VI, para. 2.

4 For current purposes ‘IUU activities’ are considered to comprise the ‘chain’ of activities associated with IUU fishing and, more broadly, ‘IUU operation’, as identified by D. Vidas, ‘IUU Fishing or IUU Operations? Some Observations on Diagnosis and Current Treatment’, in D.D.

Emphasis is given to inherent time and space constraints, particularly how the technology deployed is affected.

Finally, in line with paragraph 7 of the 2005 Rome Declaration on Illegal, Unreported and Unregulated Fishing, attention is given to using technology in 'remote sensing and satellite surveillance of fishing vessels to prevent, deter and eliminate IUU fishing, particularly in remote areas with lack of deployment of MCS facilities'.[5] Potential future developments are highlighted and some likely challenges to technologically-based MCS are identified.

## THE WHAT, WHERE AND WHY OF IUU FISHING ACTIVITIES

### What is IUU Fishing?

IUU fishing has been formally defined in various forums[6] with first use of the term being attributed to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) in 1997.[7] The scope of IUU fishing is seen to encompass fishing and related activities which have best been summarised by the 'Ministerially-Led Task Force on Illegal, Unreported and Unregulated Fishing on the High Seas' (High Seas Task Force) as:

– fishing in areas under national jurisdiction without the authorisation of the coastal state;
– fishing which contravenes or undermines conservation and management;
– failure to effectively exercise the required jurisdiction or control over vessels and nationals;
– failure to fully and accurately meet fishery and fishing vessel data reporting requirements.[8]

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Caron and H.N. Scheiber (eds.), *Bringing New Law to Ocean Waters* (Leiden: Brill, 2004), pp. 125–144, at pp. 127–130.

[5] The 2005 Rome Declaration on Illegal, Unreported and Unregulated Fishing, adopted by the FAO Ministerial Meeting on Fisheries, Rome, 12 March 2005; available at: <ftp://ftp.fao.org/fi/DOCUMENT/ministerial/2005/iuu/declaration.pdf>.

[6] D. Agnew, 'The Illegal and Unregulated Fishery for Toothfish in the Southern Ocean, and the CCAMLR Catch Documentation Scheme', *Marine Policy*, Vol. 24, 2000, pp. 361–374; see especially the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU), adopted in 2001 by the FAO Committee on Fisheries, paras. 3(1)–3(3); available at <www.fao.org/fishery/ipoa-iuu/en>.

[7] See agenda item on 'Illegal, Unregulated and Unreported Fishing in the Convention Area', in CCAMLR, *Report of Sixteenth Meeting of the Commission, Hobart, Australia, 27 October – 7 November 1997* (Hobart: CCAMLR, 1997), paras. 8(7)–8(14), pp. 25–26; available at <www.ccamlr.org/pu/E/e_pubs/cr/97/all.pdf>.

[8] See *Closing the Net: Stopping Illegal Fishing on the High Seas*, Final Report of the Ministerially-led Task Force on IUU Fishing on the High Seas, 2006, p. 93; available at <www.

It should be noted that IUU fishing does not fit the legal definition of 'piracy' in Article 101 of the 1982 United Nations Convention on the Law of the Sea (LOS Convention). However, it may be viewed as an act of 'depredation, committed for private ends by the crew … of a private ship'. Also, IUU fishing may not always be 'illegal' if it occurs in areas where no national or international fisheries regulatory measures apply. In specific terms, therefore, IUU fishing is commonly:

- fishing ('poaching') in defiance of national measures within the exclusive economic zone (EEZ) under the jurisdiction of a coastal state – 'illegal fishing';
- fishing by a vessel under the flag of a member state of an regional fisheries management organisation (RFMO), in contravention of that organisation's measures – 'illegal fishing';
- fishing, in any area, which is not fully reported – 'unreported fishing';
- fishing on the high seas in a manner which is not fully regulated or reported – 'unreported and unregulated fishing'.

### Where does IUU Fishing Occur?

IUU fishing is a global phenomenon that occurs on the high seas as well as in areas under national jurisdiction (see Figure 4.1).[9] It targets discrete, straddling and migratory stocks, and is often perpetrated in sea areas under the jurisdiction of developing states.[10]

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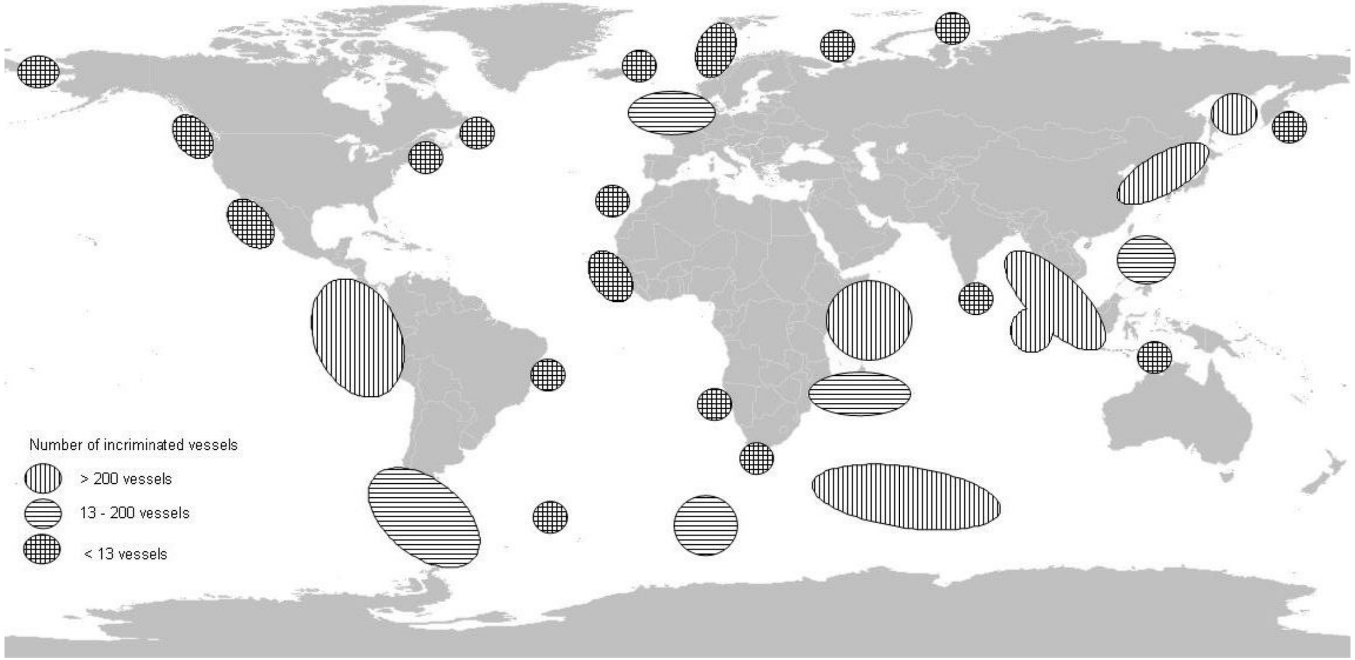
high-seas.org>. On High Seas Task Force see further Lodge, chapter 8 in this book.

[9] U.R. Sumaila, J. Alder and H. Keith, 'Global Scope and Economics of Illegal Fishing', *Marine Policy*, Vol. 30, 2006, pp. 696–703.

[10] Marine Resources Assessment Group (MRAG), *Review of Impacts of Illegal, Unreported and Unregulated Fishing on Developing Countries, Final Report* (London: MRAG, 2005), p. 14; available at <www.dfid.gov.uk/pubs/files/illegal-fishing-mrag-report.pdf>.

**Figure 1: Location of vessels implicated in IUU fishing**




Source: Sumaila et al., 'Global Scope and Economics of Illegal Fishing', p. 698.

## Why does IUU Fishing Occur?

In the simplest analysis, IUU fishing takes place because the expected economic profits outweigh the negative consequences attached to the probability of detection and the subsequent level of penalty likely to be incurred as a result.[11] In economic terms, the associated ‘drivers’ are realised catches (size and catch-per-unit-effort), price (value of catch) and cost of fishing (labour and operating costs). As emphasised by Sumaila, Alder and Keith,[12] greed may also play a role: an operator may engage in IUU fishing solely for the profits to be had.

It follows that target IUU stocks are usually of high value and there is often an element of corporate criminality involved in IUU activities.[13] Equally, ineffective enforcement systems, a perceived disregard for (or lack of legitimacy of) fisheries regulations, a general lack of governance, and social acceptance of ‘law breakers’ – all contribute to motivate IUU fishing. The opportunity to make money quickly, unhindered by legal constraints or social transparency, thus allows IUU fishing to flourish.[14]

An exception arises when IUU fishing is undertaken from sheer necessity. Insufficient food and a general lack of food security may drive impoverished coastal communities to violate fisheries regulatory measures, in order to secure edible protein. However, the introduction of modern fishing technologies and the greater globalisation of trade have tended to increase the industrialisation and urbanisation of such fisheries.[15] The outcome has generally been a shift in power and influence away from fishers to traders,[16] with impoverished fishers themselves soon becoming the victims of IUU fishing activities rather than the beneficiaries.[17]

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[11] Sumaila et al., ‘Global Scope and Economics of Illegal Fishing’, pp. 697–698.

[12] Ibid., p. 697.

[13] R. Baird, ‘Corporate Criminals and Their Involvement in IUU Fishing: An Australian Perspective’, *Fisheries Law and Policy Review*, Vol. 1, 2005, pp. 170–187; R. Baird, ‘Aspects of Illegal, Unreported and Unregulated Fishing in the Southern Ocean’, Vol. 5 in *Reviews: Methods and Technologies in Fish Biology and Fisheries*, J.L. Nielsen (ed.) (Dordrecht: Springer, 2006), pp. 76–78.

[14] Sumaila et al., ‘Global Scope and Economics of Illegal Fishing’, pp. 697–698.

[15] K.L. Cochrane, ‘Reconciling Sustainability, Economic Efficiency and Equity in Fisheries: The One That Got Away?’, *Fish and Fisheries,* Vol. 1, 2000, pp. 3–21, at p. 5.

[16] P. Friis, ‘The European Fishing Industry: Deregulation and the Market’, in K. Crean and D. Symes (eds.), *Fisheries Management in Crisis* (Oxford: Fishing News Books, 1996), pp. 175–186.

[17] MRAG, *Review of Impacts of Illegal, Unreported and Unregulated Fishing*, pp. 57–59.

## What are the Effects of IUU Fishing?

Broadly, IUU fishing not only compromises stock sustainability through its tendency to overfish target stocks: it also leads to the loss of economic opportunities and to negative effects on food security and environmental protection.[18] Furthermore, negative impacts arise when fishing operations are conducted with little regard for potential effects on non-target species like seabirds.[19] Consequently, IUU fishing can be said to be *insidious*, *unfair* and *unsustainable*. It tends to compound uncertainty in estimation of stock status, since essential data on catch levels and target species demographics are not provided. This effectively undermines approximation of 'total removals' – a situation which CCAMLR has countered, with some success.[20]

# IUU FISHING AND MONITORING, CONTROL AND SURVEILLANCE

## Background

As IUU fishing poses a serious challenge to effective ocean governance, it rightfully preoccupies the international community. As a problem affecting many RFMOs and national authorities, it requires a substantive commitment of valuable, and often limited, resources to counter its effects. The attached compounding of uncertainty about target-stock status complicates these effects and, as emphasised elsewhere, hinders sustainable stock management.[21]

Davor Vidas has made the point that the act of fishing is only a part of the IUU problem.[22] As he notes, IUU fishing comprises an interlinked chain of 'events' (Figure 4.2) – the 'IUU chain' – of which 'at sea' operations are only a part.[23] This would make port and trade activities two other important components of the IUU chain. Together all three factors scope the activities which an effective and holistic MCS system should address.

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[18] See IPOA-IUU, para. 1.

[19] D.G.M. Miller, E. Sabourenkov and D. Ramm, 'Managing Antarctic Marine Living Resources: The CCAMLR Approach', IJMCL, Vol. 19, 2004, pp. 317–363.

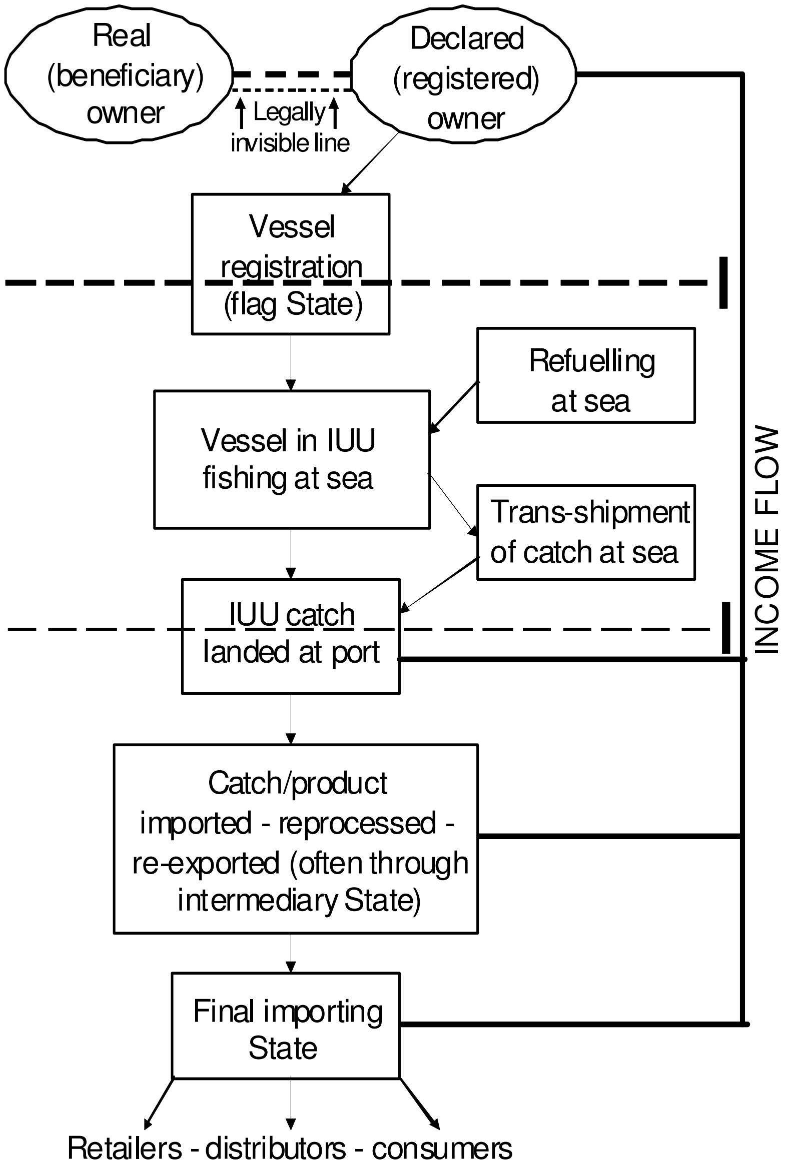
[20] E. Sabourenkov and D.G.M. Miller, 'The Management of Transboundary Stocks of Toothfish, *Dissostichus* spp., under the Convention on the Conservation of Antarctic Marine Living Resources', in A.I.L. Payne, C.M. O'Brien and S.I. Rogers (eds.), *Management of Shared Fish Stocks* (Oxford: Blackwell Publishing, 2004), p. 71.

[21] D.G.M. Miller, 'Managing Fishing in the Sub-Antarctic', *Papers and Proceedings of the Royal Society of Tasmania*, Vol. 14, 2007, pp. 121–140, at p. 138.

[22] Vidas, 'IUU Fishing or IUU Operations?', pp. 127–130.

[23] In accordance with Vidas, 'at sea' is used in the sense of the Law of the Sea coverage, i.e., 'from vessel registration to the landing of catch in a port'; Vidas, 'IUU Fishing or IUU Operations?', p. 128.

**Figure 4.2: The IUU fishing 'chain' of activities, according to Vidas**




Source: Vidas, 'IUU Fishing or IUU Operations?', p. 129

In particular, there is a serious need to penetrate the ‘legally invisible line’ between the declared or registered owner of an IUU vessel and the actual (‘beneficial’ or ‘real’) owner, to identify the latter (see Figure 4.2).[24]

The nature of IUU fishing activity, along with its beneficial (real) ownership, is often transnational and lacks accountability and transparency. The entire IUU chain is ‘typified by loosely organized networks of individuals with specialist knowledge of the area in which they work’.[25] Because of the ‘veil of secrecy’, MCS have to address the entire length of the IUU chain to be effective.[26] The length of the chain, in turn, is crucial in determining the MCS actions to be taken along its entire length – from the beneficial owner to the final sale of catch.

## MCS *versus* IUU Fishing Activities

Based on definitions from an FAO Expert Consultation in 1981, MCS consists of:

– ‘Monitoring’: continuous requirement for measurement of fishing characteristics and resource yields, which implies supervising and observing relevant activities with appropriate reporting;
– ‘Control’: regulatory conditions under which the exploitation of resources may be conducted;
– ‘Surveillance’: degree and types of observations required to maintain compliance with the regulatory controls imposed on fishing activities.[27]

The implicit consequence is that any regulatory action and sanction arising from MSC requires *detection* of non-compliance through the detection of a ‘relevant object, error or crime’. *Interception* is usually necessary to seize or apprehend the perpetrators of non-compliant activities. *Interdiction* then follows interception in the form of arrest of the persons or vessel(s) involved, with restraint being applied to prohibit further non-compliant activity.

MCS is a key element in the ‘enforcement triangle’ (Figure 4.3), which consists of a range of actions, legal steps and processes to be implemented in countering IUU fishing activities, and in which effective information ex-

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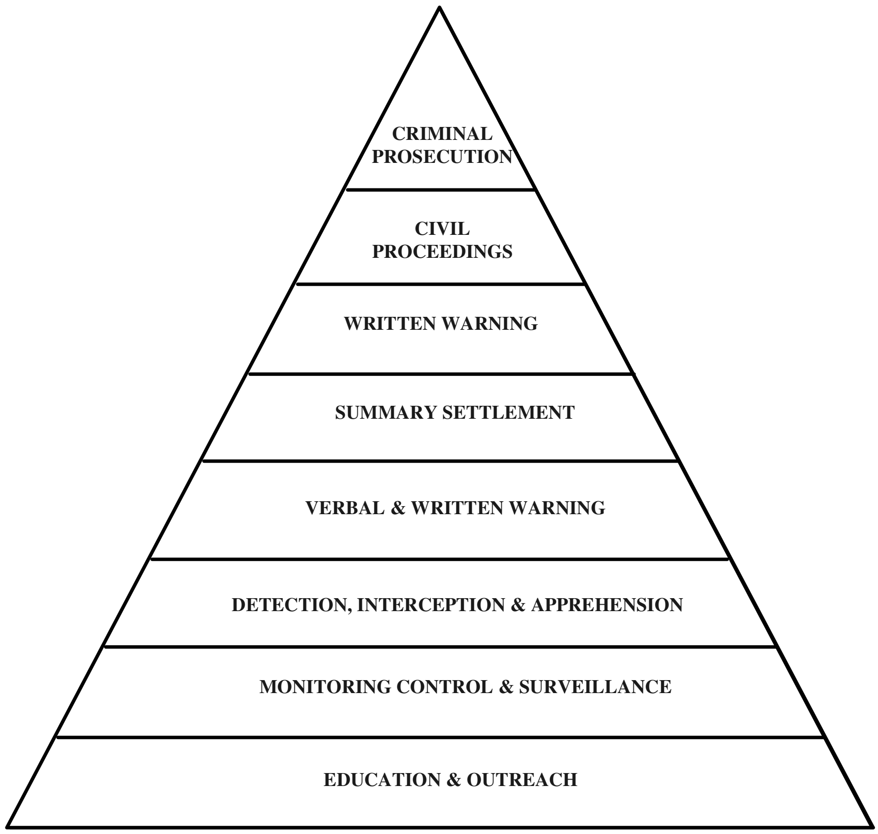
[24] See also L.D. Griggs and G.L. Lugten, ‘Veil Over the Nets (Unraveling Corporate Liability for IUU Fishing Offences)’, *Marine Policy*, Vol. 31, 2007, pp. 159–168.
[25] *Closing the Net*, p. 22.
[26] Griggs and Lugten, ‘Veil Over the Nets’, p. 160.
[27] P. Flewwelling, *An Introduction to Monitoring, Control and Surveillance Systems for Capture Fisheries*, FAO Fisheries Technical Paper No. 338 (Rome: FAO, 1995), p. 10. See also *Report on an Expert Consultation on MCS for Fisheries Management* (Rome: FAO, 1981).

change and education to promote regulatory compliance form the basis. Education makes for improved appreciation of, and insight into, the need for regulatory measures. It also serves to legitimise the measures themselves. Therefore, education and knowledge are put into effect when MCS initiates regulatory action, which may range from verbal warnings to criminal prosecutions and convictions.

**Figure 4.3: The fisheries enforcement triangle and legal process**




In short, MCS combats IUU fishing activities by:

- monitoring fishing activity;
- facilitating information gathering;
- reducing uncertainty attached to both the above;
- monitoring compliance with regulatory measures;
- providing a basis for sanction;
- improving fisheries management.

## The Problem of Scale

As MCS counters the entire IUU chain, it is essential to account for the spatial and temporal constraints of any MCS system that is used. The information so gathered is then used to: (a) determine the type of MCS to be deployed, (b) further inform compliance enforcement action, and (c) collect evidentiary material for later legal action in application of sanctions. The type of information gathered is itself a function of the MCS undertaken.

Flewwelling has stressed that MCS is actually the execution of a plan, or strategy, for the oceans. It entails operations aimed at underpinning an agreed fisheries management policy.[28] Therefore, re-examination of Figures 4.2 and 4.3 leads to the conclusion that for MCS to be fully effective it should be flexible, as well as able to account for the whole range of time and space scales characteristic of any particular IUU activity. Variations in scale themselves are contingent on the spatial and temporal resolution of the target stocks, as well as on the scales over which fishing vessels operate and fish trade occurs (Figure 4.4). For example, a migratory fish such as tuna may be fished individually, or as shoals of fish. To catch tuna, a single IUU vessel applies its fishing strategies for anything from several hours to weeks over an area of tens of kilometres. The same vessel then tranships its catch some hours after fishing, or lands it in a port some days/weeks after it was caught. The export, import and ultimate sale of landed fish take place over a period of days to years and at a scale of a few to ten thousands of kilometres. A comprehensive MCS approach will need to be able to account for all these possibilities, in order to detect non-compliance at any stage. Obviously, the transnational nature of IUU activities also affects the MCS being implemented as a function of the IUU chain's time and space constraints.

## MCS and the High Ground

According to Sun Tzu, successful armies should 'occupy the high ground and await the enemy'.[29] The previous section showed that the 'high ground' for combating IUU activities relies on effective MCS. To fully address the time and space scales illustrated in Figures 4.2 and 4.4, institutional cooperation and cost-effective information sharing become key considerations – especially in the case of high-seas fisheries under the regional

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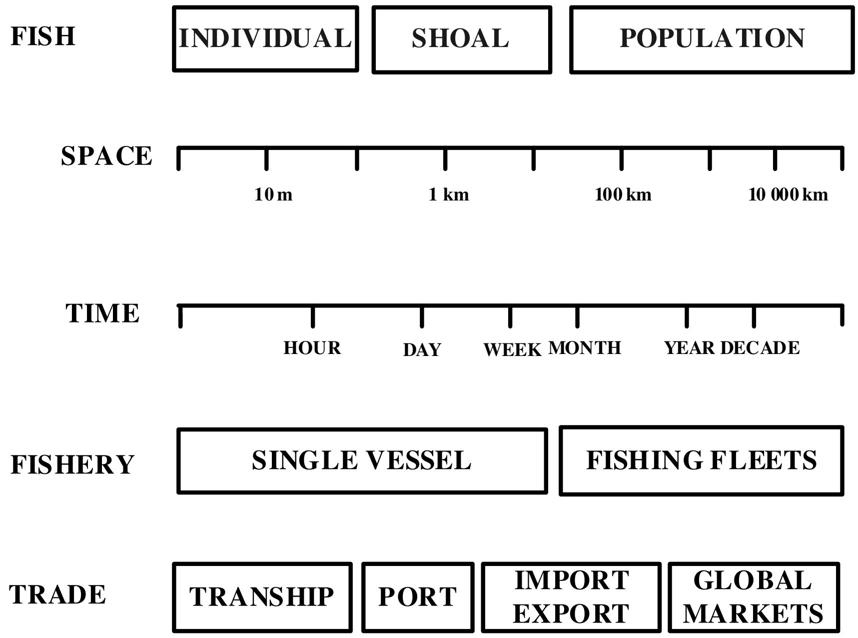
[28] Ibid., p.10.

[29] Sun Tzu , *The Art of War*, from the bamboo text, c.a., 180 B.C.E., in The Denma Translation Group (ed.), *The Art of War, The Denma Translation* (Boston, MA: Shambhala, 2002), quote 44; available at <http://thid.thesa.com/thid-0698-8201-th-1509-8857#th-0310-5919>.

**Figure 4.4: Time and space scales for various components of the IUU fisheries activities chain**




competence of an RFMO.[30]

In an ideal world, contemporary MCS is based on an integrated suite of procedures, processes and activities. Triggered by a regulatory authority, these usually involve:

- licensing vessels to fish legitimately, with various conditions attached;
- reporting vessel movements;
- reporting fisheries catch and effort;
- detailed recoding of information in fisheries logbooks;
- reporting vessel sightings;
- reporting vessel inspections (at sea and in port).[31]

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[30] M.W. Lodge, D. Anderson, T. Løbach, G. Munro, K. Sainsbury and A. Willock, *Recommended Best Practices for Regional Fisheries Management Organizations. Report of an Independent Panel to Develop a Model for Improved Governance by Regional Fisheries Management Organizations* (London: Royal Institute of International Affairs, 2007), pp. 110–114.

[31] Flewwelling, 'An Introduction to Monitoring, Control and Surveillance', Annex F.

The manipulation and archiving of data so collected benefits significantly from the widespread use of computer-based technologies.

Provided such procedures, processes and activities are efficiently implemented and administered, they are essentially 'low-tech' in terms of technological sophistication. They do not usually require highly specialised knowledge or expensive technology to support their application. However, they require periodic validation or 'ground truthing' to address the time and space limitations attached to a particular form of MCS, or its coverage.

'Ground truthing' may be addressed by scientific observation programmes. However, it is facilitated by surveillance from the air or space (by aircraft or satellite), especially when combined with on-water monitoring. Following detection, specialised and expensive assets (like patrol boats) are deployed to intercept non-compliant behaviour efficiently. Aircraft patrols are often used to update and direct on-water activities.

Both vessel patrols and aircraft surveillance serve a 'policing' role as well. This involves intelligence gathering as well as detection, interception and interdiction. Nevertheless, the High-Seas Task Force has highlighted the point that deployment of expensive surveillance assets like aircraft and patrol boats may still be limited in terms of spatial and temporal opportunities for successful detection of IUU activities, most noticeably by not providing the necessary proximity for interception, interdiction and ultimate prosecution. Further:

> there is a real question as to whether the resources will ever be enough given the increasing volumes of trade, the increasing complexity of operations and the sheer size of the maritime areas to be covered.[32]

It is here that the advanced technologies of the early 21st century have an important role to play.[33]

## How Technology Helps

As tools to detect IUU fishing activities globally,[34] modern – and emerging – technologies go a long way to addressing the fears expressed by the High Seas Task Force. They markedly broaden the potential MCS resource base by:

- improving spatial and temporal cover;
- improving timeliness of MCS action and information gathering;

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[32] *Closing the Net*, pp. 25–26.
[33] See Ansell, chapter 10 in this book.
[34] See further Kuruc, chapter 5 in this book.

– widening information-gathering capabilities;
– improving information accuracy and objectivity;
– facilitating data archiving, particularly in electronic form.

Given the strategic advantages of the 'high ground', modern technologies serve to enhance policing, detection and monitoring of non-compliance through broadening information- and intelligence-gathering capabilities. Table 4.1 illustrates some contemporary MCS-based technologies. Each technology is ranked from low to high (1 to 5) in terms of its perceived suitability of application. Rankings are in turn a function of: (a) expense (including latent infrastructure needs); (b) time and space coverage; (c) timeliness of response; (d) technological complexity; and (e) cost-efficiency, determined from service cost in relation to potential detection of non-compliance.[35] Examples of estimated costs for some of the technologies illustrated in Table 4.1 are provided in Table 4.2 and have been used to determine the rankings in the former.

The technologies outlined in Tables 4.1 and 4.2 range from those widely used today (like VMS) through those improving, or modifying, currently available systems (such as coastal radar or sigint[36] interception or laser illumination to improve infra-red photography) to cutting-edge technology under development or being planned (like VDS and over-the-horizon radar). Such modern developments as vessel management systems integrate several available technologies (like VMS and satellite phone technology) to improve real-time reporting of vessel position as well as catch.

Significantly, many of the technologies in Table 4.1 (such as VDS) have evolved for civilian use from previously classified military projects. As a future MCS technology to be pursued, the monitoring of surface vessels or submarines using bioluminescence is an obvious military technology for future civilian development to augment IUU fisheries surveillance.[37]

It should be stressed that development of modern MCS has depended largely on improved information technology, data manipulation and comput-

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[35] Estimation of costs and MCS type were determined taking into account information provided in Appendices I – IV of A.R. Smith, 'Monitoring, Control and Surveillance in Developing Countries and the Role of the FAO', in C.P. Nolan (ed.), *Proceedings of the International Conference on Integrated Fisheries Monitoring* (Rome: FAO, 1999); available at <www.fao.org/docrep/x3900e/x3900e00.HTM>.

[36] 'Sigint' stands for 'signals intelligence', usually derived from interception of radio or telephone traffic.

[37] 'Enlightened by the Light: Using the Ocean's Living Light Shows to Fight Terrorism or Track the Planet's Most Massive Migration', *Press Release*, Biloxi, 29 October 2002; available at <www.hboi.edu/news/press/oct2402.html>.

ing power over the past few decades. Bergh and Davies note that 'large amounts of varied information are generated by MCS activities'.[38] Whilst information often needs to be available almost immediately for MCS purposes, other information is required over longer time periods, for monitoring the fish stocks themselves. Such varied requirements mean that information management has to ensure accurate, timely and consistent information without overburdening information compilation, checking, and storage. Modern memory-intensive computers are crucial for this, as are integrated computer networks to optimise data storage and computing capacity.

Many of the technologies indicated in Tables 4.1 and 4.2, are expensive and technically advanced. Consequently, their routine use tends to be limited to prosperous industrialised states, as such technologies are beyond the reach of many developing nations – although that is often where they are most needed.[39]

Despite such obvious shortcomings, the ability of 'high tech' to vastly improve the scope, scale, precision, detail and timeliness of MCS remains a major advantage. Satellite and aerial photogrammetric information in particular is easily shared, relatively detailed, almost instantaneous and collectable over a wide area. The cost of accessing such information has been estimated as comparable to that of deploying a patrol vessel over a similar area, which makes the sharing of this type of technology attractive and relatively cost-effective also for developing states.[40]

Examples of likely tradeoffs in costs and benefits are shown for some MCS systems in Table 4.2. While these vary with the services concerned, vessel and aerial patrols are essentially the most expensive components in terms of MCS per unit effort (the product of service cost and scale of cover). Although initial asset costs are lower than those of, for example, sending a satellite into orbit, they are still high, as are daily operating costs.

Fortunately, many expensive MCS platforms (such as satellites, patrol aircraft and vessels) can be shared. The Southern African Development Community (SADC) MCS Programme[41] has achieved this through regional

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[38] P.E. Bergh and S. Davies, 'An Overview of Namibian Fisheries, Focusing on Monitoring, Control and Surveillance', in *FAO/Norway Government Cooperative Programme – GCP/INT/648/NOR, Report of a Regional Workshop on Fisheries Monitoring, Control and Surveillance* (Rome: FAO, 2000), p. 152; available at <ftp://ftp.fao.org/docrep/fao/field/006/X1352E/x1352e15.pdf>.

[39] Here it should be noted that an estimated USD 937 million of a global total of USD 2.4 billion is lost to IUU fishing in the EEZs of Sub-Saharan African states alone; see MRAG, *Review of Impacts of Illegal, Unreported and Unregulated Fishing*, p. 100.

[40] Lodge et al., *Recommended Best Practices*, pp. 110–114.

[41] *SADC Regional Monitoring, Control and Surveillance (MCS) of Fishing Activities – Informa-*

cooperation in sharing, and hiring, expensive vessel and aircraft assets. With the reduced operating costs from region-wide VMS monitoring and improved MCS focus, the SADC Programme has increased its overall effectiveness in countering IUU fishing activities in the region. This has been achieved through shortened prosecution times and penalty-based cost recovery, as well as an increase in successful prosecutions. In effect, expensive MCS technologies are made to pay for themselves by using the increased revenues from successful prosecutions to the benefit of overall compliance enforcement in a developing-state context.[42]

Together with sharing expensive assets, regional and wide-area networking of data gathering systems can offer additional advantages for regionally coordinated MCS. Here, technical cooperation optimises information technology needs in terms of individual functional and technical specifications. The Forum Fisheries Agency (FFA) in the South Pacific is a classical example of effective networking for a regional VMS and MCS system.[43] Equally, the global MCS Network offers similar advantages, its major focus being intelligence gathering and information exchange.[44]

The MCS Network was established to improve the efficiency and effectiveness of fisheries-related MCS activities through enhanced cooperation, coordination, information collection and exchange between national institutions responsible for fisheries-related MCS. The Network makes use of all available MCS assets at the global level.

## CONCLUDING REMARKS

IUU fishing activities have serious negative implications for global economic equity, food security, social upliftment and biological sustainability.[45] The various technologies outlined here offer highly promising solutions to eliminating IUU fishing activity: they enhance detection and monitoring capabilities, facilitate information gathering, and

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*tion Leaflet* (Gaborone: SADC, 2006), pp. 1–4; available at <www.mcs-sadc.org/Publications/LeafletFeb06.pdf>.

42 J.D.K. Wilson, 'Cost Effective and Sustainable MCS Operations in LDCS', in *Presentations from the International MCS Symposium* (Cape Town: SADC, 2005), Table 3; available at <www.mcs-sadc.org>.

43 NAVIGS s.a.r.l., *Fishing Vessel Monitoring Systems: Past, Present and Future*, Report prepared for the High Seas Task Force (Appelle, France: NAVIGS, 2005), pp. 36–39; available at <www.high-seas.org/docs/hstf_vms_final1.pdf>.

44 Information on the MCS Network may be found at <www.imcsnet.org/imcs/index.shtml>. On MCS Network see also Kuruc, chapter 5 in this book.

45 *Closing the Net*, pp. 19–20.

promote flexibility to address the entire IUU chain. However, they cannot provide a complete solution.

To date, it has been emphasised that converging on a lasting 'cure' for IUU fishing requires considerable political will and international cooperation.[46] It also requires well-planned coordination in the transference of essential expertise and technology from those who possess it (industrialised states) to those who do not (predominantly developing states). Clear-sighted, realistic and operationally effective implementation of Articles 24 to 26 of the Fish Stocks Agreement is vital.[47] The MCS Network, FFA and the High Seas Task Force offer encouraging examples of how progress may be made.

A warning to ponder is the very real danger that MCS may become over-reliant on technology. The High Seas Task Force does not see VMS as a panacea to providing vessel position, speed and course.[48] In effect, VMS is not an end in itself but rather a tool to enhance MCS in the broadest sense. The dangers of technological over-reliance stem from a common shortcoming of many MCS systems: they tend to concentrate on surveillance, at the expense of monitoring or control.[49] Surveillance is effectively the most expensive MCS component, but it is monitoring and control that provide the information and legal framework necessary for MCS to be truly effective.

The MCS legal framework still faces many challenges, especially in relation to using aerial technology (aircraft and satellites) over the high seas. Molenaar and Tsamenyi conclude that 'international law does not substantially restrain states wishing to engage in satellite remote sensing'.[50] However, how such information can be better used to prosecute IUU vessels remains unclear. In practice, there is a lack of both international and national legal precedents for dealing with evidential information collected from technologies such as VMS.[51] Nonetheless, it seems likely that the negotiating positions of IUU operators will eventually be eroded as more legal prece-

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[46] Vidas, 'IUU Fishing or IUU Operations?', pp. 143–144.

[47] Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, UN doc. A/CONF.164/37; text in UNTS, Vol. 2167, pp. 3ff.; available at <www.un.org/Depts/los>. The Agreement was opened for signature on 4 December 1995; entered in force on 11 December 2001. As of 8 June 2009, there were 75 parties.

[48] *Closing the Net*, p. 27.

[49] Flewwelling, 'An Introduction to Monitoring, Control and Surveillance', p. 11.

[50] E.J. Molenaar and M. Tsamenyi, 'Satellite-Based Vessel Monitoring Systems for Fisheries Management: International Legal Aspects and Developments in State Practice', *FAO Legal Papers Online,* No. 7, 2000, pp. 30–32; available at <www.fao.org/Legal/prs-ol/lpo7.pdf>.

[51] See chapter 5 by Kuruc, in this book.

dents are set, and successful prosecutions for non-compliant behaviour increase.

A major sub-theme of this chapter is that technologically-based MCS allows the regulator to 'act locally and think globally'. This suggests that promising new developments like statistical predictive analyses[52] could be applied to detect IUU fishing activity trends or patterns. These analyses, often termed 'data mining', pro-actively model historical data, broadly-based data correlations and assumed future conditions. MCS data accrued using the systems outlined here could then be integrated with more routine data (like reported catch and global trade figures) for better prediction of IUU fishing patterns, outcomes and events.

To conclude, it appears justified to assume that 'while fisheries management will always contain an element of uncertainty, the increasing availability of electronic technology will play an ever important role in reducing the guesswork when accurate conclusion and predictions need to be made'.[53] To return to our point of departure, Sun Tzu might have written of IUU fishing as follows: 'by using the high ground, MCS technology allows the regulatory authority to better detect, intercept and punish non-compliant behaviour'.

Of course, technology alone cannot achieve this – what matters is how it is used. 'Collaborative' and best use of available MCS technology globally should avoid over-reliance, but should also serve to provide for more accurate prediction of, and better outcomes from, MCS aimed at both legitimate fishing and IUU fishing. As with many other complex human endeavours, a balance will always be required between affordable technologies and those that are desirable simply for their technological standing alone. All the technologies outlined here are seen as being relevant to the former.

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[52] 'Using Predictive Analysis with Crime Data', *Oakland County Data Warehouse White Paper*, 2006; available at <www.oakgov.com/dataware/assets/doc/Predictive%20Analysis-Crime.pdf>.

[53] 'Policy Background of Monitoring and Control of Fisheries Activity', *Profet Policy*, 2003; available at <www.profetpolicy.info/index.php?option=com_content&task=view&id=67&Itemid=142>.

## Table 4.1A Fishing Vessels

| Technology – Nature and Purpose | Platform or Location | Rating | | | | |
|---|---|---|---|---|---|---|
| | | **a** | **b** | **c** | **d** | **e** |
| *Sound Surveillance*[a] *(SOSUS):*<br>Underwater acoustic detection; detect vessel movement; vessel identification; intelligence gathering | Patrol vessel; sonar buoy; sea floor; harbor mouth | 2 | 2 | 4 | 2 | 2 |
| *Photography*:<br>Digital photography and video; laser illuminated nighttime low-light (infra-red) imagery; remote and direct<br>Vessel identification, monitoring and surveillance; non-compliance detection; intelligence gathering; evidentiary information collection | Land (in port); patrrol vessel; aerial patrol satellite | 3–4 | 4–5 | 5 | 3–4 | 4 |
| *Vessel Monitoring Systems (VMS)*[b]:<br>Shipboard vessel location devices; monitor vessel location; real time tracking identified vessels | Fishing vessel; satellite relay | 4–5 | 3–4 | 5 | 4 | 5 |
| *Vessel Detection Systems (VDS)*:<br>Synthetic aperture radar; all weather imagery; monitor vessel location | Satellite;[c] aerial patrols | 2[d] | 5 | 4–5 | 2 | 3 |
| *Airborne Surveillance*:<br>Remote pilotless vehicles (RPV); surveillance; vessel identification | RPV aerial patrol | 2–3 | 4 | 4 | 3 | 3 |
| *Coastal Surveillance*:<br>Long range HF radar; vessel surveillance; vessel location | Land based;[e] satellite based[f] | 2 | 3 | 3 | 3 | 3 |
| *Direct Observation Systems*:<br>Surface and underwater observation; vessel identification; vessel surveillance | Autonomous vehicles (AVs);[g] acoustic based visual systems;[h] submarines | 1–2 | 2–3 | 3–4 | 2 | 1–2 |

| **Technology –**<br>**Nature and Purpose** | **Platform or Location** | **Rating** | | | | |
|---|---|---|---|---|---|---|
| | | **a** | **b** | **c** | **d** | **e** |
| *Satellite Phone Technology*:<br>Global sea-shore communication; voice and image based; on-board surveillance; scientific observation; vessel location | Fishing vessels [i] | 2–3 | 2–3 | 2–3 | 3 | 3–4 |
| *Vessel Management Systems*:<br>Integrated fisheries reporting; position and catch data reporting; management of vessel activities | Fishing vessel[j k] | 2–3 | 4 | 4 | 2–3 | 4 |

a. *Monitoring the Global Ocean Through Underwater Acoustics*, NOAA website, 2008, at <www.pmel.noaa.gov/vents/acoustics/sosus.html>.
b. ‘Fishing Operations: Vessel Monitoring Systems’, *FAO Technical Guidelines for Responsible Fisheries*, Vol. 1 (Suppl. 1), 1998.
c. J. Delineé, ‘The Vessel Detection System (VDS)’, 2007; available at <http://nec.europa.eu/research/press/2007/maritime-briefing/pdf/11-presentation-jacques-delince-vds_en.pdf>.
d. Reasonable costs once satellites launched – *Closing the Net*, p. 26.
e. R.H.Kahn, E.W. Gill, S.A. Saoudy, K. Hickey, B.J. Dawe and J. Walsh, ‘Experimental Results from a Long-range HF Ground Wave Coastal Surveillance Radar’, *Record of IEEE National*, 1993, pp. 107–112.
f. G.A. Allen, ‘Australian Coastal Surveillance Radar Through Low Altitude Satellites [online]’, in *Fourth National Space Engineering Symposium Reprints of Papers*, No. 88/10, 1988, pp. 94–97.
g. H. Gilbert and P. Kenul, ‘Homeland Security and the Global Ocean’, *Proceedings of MTS/IEE – Oceans*, Vol. 3, 2005, pp. 2362–2367.
h. ‘Underwater Surveillance’, *High Definition Sonar and High Resolution Underwater Surveillance* (Soundmetrics Corporation, 2008); available at <www.soundmetrics.com/SV/surveillance.html>.
i. R.T. Ames, G.H. Williams and S.M. Fitzgerald, ‘Using Digital Video Monitoring Systems in Fisheries: Application for Monitoring Compliance of Seabird Avoidance Devices and Seabird Mortality in Pacific Halibut Longline Fisheries’, *NOAA Technical Memorandum*, NMFS-AFCG-152, 2005, pp. 1–93; available at <www.afsc.noaa.gov>; and ‘EFCL Trials Successfully Completed’, in *Northwest Fisheries Science Center Fish Matters*, 2000, Vol. 2, p. 2; available at <www.nwfsc.noaa.gov>.
j. R. González, C. Gaspar, L. Curtolo, I. Sanguiliano, P. Osovnikar and M. Borsetta, ‘Fishery and Oceanographic Monitoring System (FOMS): A New Technological Tool Based on Remote Sensing, with Application in Ecosystem Management of Coastal Fisheries in Patagonia’, *Gayana*, Vol. 68, 2004, pp. 234–238.

**Table 4.1B Fishing Grounds**

| Technology – Nature and Purpose | Platform or Location | Rating | | | | |
|---|---|---|---|---|---|---|
| | | a | b | c | d | e |
| *Light Emissions*: Nighttime light detection; monitor fishing fleet activity | Satellite[a] | 3–4 | 3–4 | 4 | 4 | 4–5 |
| *Over Horizon Radar*: Long range detection; monitor fishing fleet activity | Land[b] | 1–2 | 2–3 | 3 | 1–2 | 2 |
| *SIGINT Monitoring*: Signal interception; monitor fleet communications | Land[c] | 1–2 | 2–3 | 3 | 2–3 | 3–4 |
| *Satellite Remote Sensing*: Locate fishing grounds; indirect monitoring | Satellite[d] | 2–3 | 4–5 | 2 | 2–3 | 2–3 |

a. C.M. Waluda, P.N. Trathan, C.D. Elvidge, V.R. Hobson and P.G. Rodhouse, 'Throwing Light on Straddling Stocks of *Illex argentinus*: Assessing Fishing Intensity with Satellite Imagery', *Canadian Journal of Fisheries and Aquatic Sciences*, 2002, Vol. 59, pp. 592–596.

b. *Closing the Net*, p. 26.

c. US Coast Guard, 'Model Maritime Operations Guide – Maritime Security', (Washington DC: US Coast Guard, 2008), Ch. 2, para. E.22(d), p. 42.

d. M. Abrams, 'Thermal Infrared Remote Sensing Yields Unprecedented View of Earth from Space', 1996; available at <www.agu.org/sci_soc/eisabrams.html>.

## Table 4.1C Fisheries Trade

| Technology – Nature and Purpose | Platform or Location | Rating | | | | |
|---|---|---|---|---|---|---|
| | | **a** | **b** | **c** | **d** | **e** |
| *Electronic Catch Documentation* (e-CDS):<br>Determine total removals; monitor landings; monitor trade | Land[a] | 4–5 | 4–5 | 3–4 | 5 | 5 |
| *Chain of Custody Control*:<br>Maintain custody legal fish; monitor legal fish in market | Biochemical marking[b] | 2–3 | 4 | 3–4 | 2–3 | 3 |
| | Bar Codes[c] | 3–4 | 4 | 3–4 | 4 | 4 |

a. Agnew, 'The Illegal and Unregulated Fishery for Toothfish', pp. 367–368.

b. J.L. Ram, M.L. Ram and F.F. Baidoun, 'Authentication of Canned Tuna and Bonito by Sequence and Restriction Site Analysis of Polymerase Chain Reaction Products of Mitochondrial DNA', *Journal of Agricultural Food Chemistry*, Vol. 44, 1996, pp. 2460–2467; R.D. Ward, T.S. Zemlak, B.H. Innes, P.R. Last and P.D.N. Hebert, 'DNA barcoding Australia's Fish Species', *Philosophical Transactions of the Royal Society*, *Series B*, Vol. 360, 2005, pp. 1847–1857.

c. As, for instance, applied to rapidly process and monitor a wide variety of products; see information at <www.barcoding.com>.

**Table 4.2 Examples of a cost-benefit assessment of technologically**

| MCS Type | Type Monitoring | No. Vessels Monitored | Monitoring | |
|---|---|---|---|---|
| | | | Location | Fishing Gear |
| Vessel Patrol | On water interception vessel identification | 1–14/d | Good | Good |
| Aerial Patrol | Vessel identification | 60+/d | Good | Medium |
| Coastal Surveillance | Radar detection; visual observation | 100+/d | Good | Low[e] |
| Satellite Surveillance | Photographic detection; vessel identification? | 150+/d | Good | None |
| VMS | Vessel location | Fitted vessels only | Good | Some[l] |
| VDS | Detection; vessel identification? | 150+/d | Good | None |

Source: A. Smith, 'History and Future of Monitoring, Control and Surveillance', in *Report of* Fisheries Report No. 696 (Rome: FAO, 2002), p. 31.

**a**. Depends on locating vessel.

**b.** Approximate cost of patrol vessel.

**c.** Depends on observation.

**d.** Aircraft cost.

**e.** Only with visual observation.

**f**. If vessel identified.

**g.** Running costs only if radar available.

**h.** If coastal surveillance used to direct patrol. [where on table?]

**i.** Depends on frequency of satellite pass.

**based MCS to combat IUU fishing at sea** (modified after Smith)

| **Effectiveness** | | **Time Vessel Observed** | **Detection Effective-ness (IUU Vessels)** | **Areal Cover ($km^2$/hr)** | **Cost (USD)** | **Direct Arrest (Inter-ception)** |
|---|---|---|---|---|---|---|
| **Catch** | **Days at Sea** | | | | | |
| Good | Low | Low | High[a] | 750 | ~20 mil[b] 10–200k/d | Yes |
| None | None | Low | High[c] | ~ 7500 | ~10–100 mil[d] 0.5–5k/hr | No |
| None | High | Low[f] | Low[f] | ~10 000 | 0.2k+[g] | Possible[o] |
| None | Medium[i] | Medium[i] | High[j] | ~100 000 | Unknown[k] ±5k/image | No |
| None | High | High | Medium[m] | 100% | 50k/unit 8k/vessel 20/d[n] | Possible[o] |
| None | Med-ium[i] | Medium | Medium[j] | ~100 000 | Unknown | No |

*the Sub-Regional Fisheries Commission Workshop on Vessel Monitoring Systems*, FAO

**j.** If vessel positively identified.

**k.** Could be as high as $100 mil if designated satellite costed.

**l.**Possibly calculated from vessel movement & speed.

**m.** Knowledge licensed vessel location may inform IUU vessel location.

**n.** Costs low once unit installed.

**o**. Interception in port by coastal state or later by vessel flag state may be possible using evidence acquired by technology concerned.