collaboration, science integration and appeal to local stakeholders, including polar indigenous people. Also, several among these lead authors have been heading individual IPY project teams and during the preparation of the SWIPA, major effort have been devoted to track down and ensure the inclusion of IPY projects relevant to the project.

The preliminary findings of the SWIPA Project, as well as of many IPY 2007–2008 teams, demonstrate that all of the components of the Arctic cryosphere have changed dramatically over the past decade (2000–2010). These changes have multiple (and yet poorly known) feedback and cascading effects. This rapidly changing polar environment affects people in the Arctic and beyond. Understanding the results of these interactions is a major scientific challenge and a key SWIPA activity. Some of the many topics and questions under study in the SWIPA are:

- What will be the effects of cryospheric change on individuals, communities and regions in the Arctic, and how will those effects vary by location and economic sector?
- What will be the effects for global society from rising sea level and increasing climate change resulting from a changing Arctic cryosphere?
- Given that many changes under way will not easily be halted or reversed, what adaptations are possible in the Arctic and beyond?
- How will the increased flow of freshwater from the melting of the Greenland Ice Sheet, mountain glaciers and small ice caps in the Arctic influence ocean circulation, marine food webs and the people who depend on them?
- What is the total effect of cryosphere changes on climate through changes in reflection of solar energy, release of greenhouse gases and other feedbacks?
- What additional monitoring and observations are needed around the Arctic to better track cryospheric change and its many implications?
- Given that many changes under way will not easily be halted or reversed, what adaptations are possible in the Arctic and beyond?

The findings of the SWIPA project will be disseminated via many scientific and public channels during 2010–2011 and will be available in full by the time of the next major (post) IPY 2007–2008 Conference in Montreal in April 2012. Information on SWIPA and its products may be found on www.AMAP.no/swipa .

Structure of the SWIPA science report

– as decided January 15 2010 at the Potsdam workshop

Convening Lead Author (CLA) listed in green

PREFACE [1-2 pages]	
EXECUTIVE SUMMARY [5 pages]	
INTRODUCTION [3 pages] [draft by MS Olsen + L-O Reiersen]	
PAST AND PRESENT CLIMATE [10 pages] [J Walsh]	
MODELLING [10 pages] [J Walsh]	
SNOW [50 pages] [T Callaghan]	ICE CAPS + GLACIERS [50 pages] [M Sharp]
PERMAFROST [50 pages] [T Callaghan]	GREENLAND ICE SHEET [80 pages] [D Dahl-Jensen]
RIVER + LAKE ICE [50 pages] [T Prowse]	SEA ICE [100 pages] [W Meier]
HUMAN DIMENSION [G Hovelsrud] [25 pages]	
SYNTHESIS / INTEGRATION [35 pages] • Feedbacks [10 pages] [T Callaghan + T Prowse] • Sea level change [5 pages] [D Dahl-Jensen + K Steffen + M Sharp] • Contaminants and UV [5 pages] [L-O Reiersen] • Ecological [5 pages] [W Vincent] • Socio-economic [5 pages] [G Hovelsrud] • Major knowledge gaps + obs needs [5 pages] [B Goodison + J Key]	
CONCLUSIONS + RECOMMENDATIONS [5-10 pages]	
ALL REFERENCES [30 pages in small print]	
ACRONYMS + DEFINITIONS [5 pages]	
ANNEXES	

Figure 1: Structure of the SWIPA Science Report.

Fig.5.2-4. Proposed structure of the main SWIPA science report (as of January 2010).

Sea Ice for Walrus Outloook (SIWO)

Hajo Eicken, Gary Hufford, Vera Metcalf, Sue Moore, James Overland and Helen Wiggins

Reviewers: Igor Krupnik and G. Carleton Ray

The 'Sea Ice for Walrus Outlook' (SIWO), an activity growing out of the SEARCH IPY *Sea Ice Outlook* project (*Chapter 3.6*), is a new web-based resource for Alaska Native subsistence hunters, coastal communities and other stakeholders interested in sea ice dynamics and walrus subsistence hunting and management in the Bering and Chukchi Seas. Though chronologically launched after the official completion of the IPY observational period in March 2009, the SIWO descends from two IPY projects, Sea Ice Knowledge and Use (*SIKU* no. 166 – *Chapter 3.10*) and *Seasonal Ice Zone Network (SIZONet)* sponsored by the U.S. National Science Foundation's IPY program. Most importantly, it builds upon many years of partnership among sea ice and walrus scientists, subsistence users, local indigenous communities, weather forecasting and game protection agencies, anthropologists and heritage documentation specialists (Eicken et al., 2009; Oozeva et al., 2004; Krupnik and Ray, 2007; Metcalf and Krupnik, 2003; Ray and Hufford, 1989).

The SIWO project was formally discussed with representatives from Bering Straits communities for the first time in January 2010 at a meeting supported by the Eskimo Walrus Commission in Nome, Alaska (www.kawerak.org/servicedivisions/nrd/ewc/index.html) and the National Science Foundation. The template and the plan of work were quickly developed and the first weekly sea ice and walrus distribution assessment went online on the newly launched SIWO website on 2 April 2010.

The SIWO is a pilot initiative (2010–2011) aiming to develop consumer-focused ice- and weather-forecasting capabilities that address practical needs of hunters in Alaskan indigenous communities as well as game managers and marine biologists. For the first time, it created a formal alliance among the U.S. National Oceanic and Atmospheric Administration; the National Weather Service, the University of Alaska Fairbanks; the National Science Foundation and its SEARCH program, which generated the *Sea Ice Outlook* initiative (*Chapter 3.6*); the Arctic Research Consortium of the United States, which administers the SIWO website; and the Eskimo Walrus Commission, an organization of 19 indigenous communities in Western and Northern Alaska.

The SIWO produces improved local weather forecasts and detailed assessments of local sea ice conditions relevant to walrus distribution and migration in the Northern Bering Sea and southern Chukchi Sea region adjacent to northwestern Alaska and northeastern Russia (Chukchi Peninsula). SIWO updates have been released weekly for the period

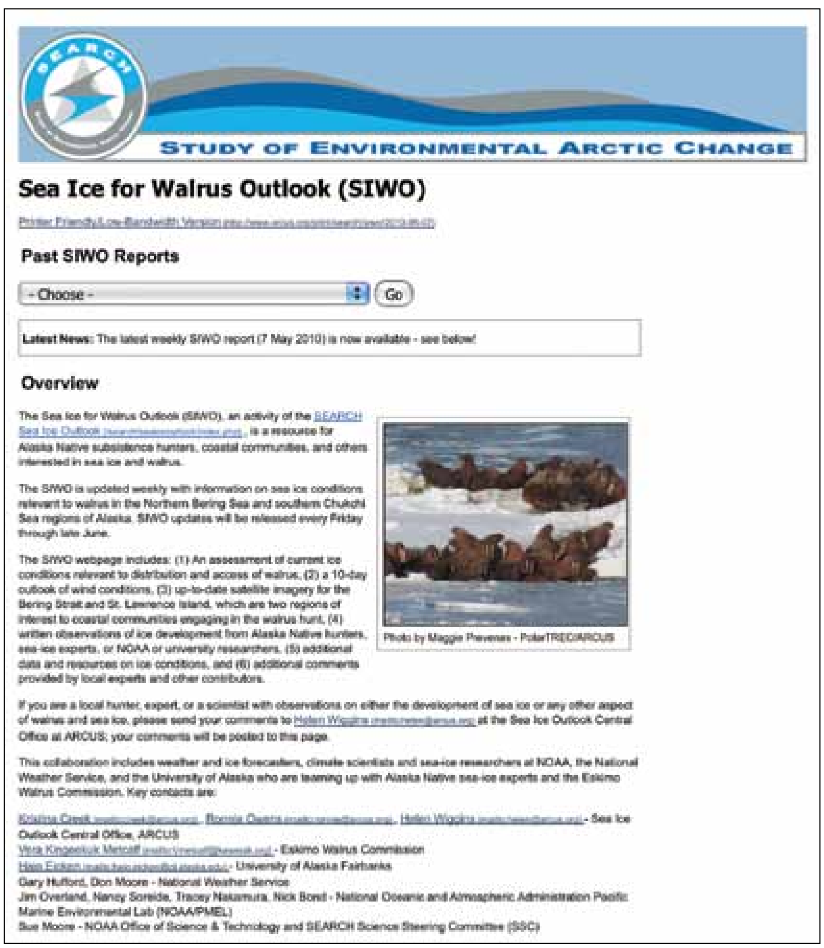

Fig.5.2-5. Opening page of SIWO service website www.arcus.org/search/siwo/.

from April 2010 through mid-June 2010. This period was selected to match the interest of local Alaskan stakeholders who hunt walrus primarily during the peak of the spring migration during break-up and northward retreat of ice in the Bering and Chukchi Seas (Metcalf and Robards, 2008).

Each weekly analysis on the SIWO webpage (www.arcus.org/search/siwo - see Fig. 5.2-5) included: (1) an assessment of the current ice conditions relevant to distribution and access to walrus, (2) a 10-day outlook of wind conditions (speed and direction), (3) up-to-date satellite imagery for the Bering Strait and St. Lawrence Island, which are two regions of the most interest to coastal indigenous communities engaging in the walrus hunt (Fig. 5.2-6), (4) written observations of ice development from Alaska Native hunters, sea-ice experts, NOAA/NWS and university researchers, (5) additional data and resources on ice conditions, and (6) additional comments provided by local experts and other contributors, local hunters and academic specialists alike. Indigenous observers from four Alaskan communities, Wales, Shishmaref, Gambell and Nome are contributing to the assessments, together with scientists and observers on ships at sea, at the Alaska NWS headquarters in Anchorage and at the University of Alaska Fairbanks, who are using satellite imagery, coastal radars and airborne observations.

A key aim of the SIWO activities is to improve research and operational products for assessment and forecasting of weather and ice conditions in Arctic coastal environments. Thus the NWS, in collaboration with the National Center for Environmental Prediction (NCEP), is generating high-resolution long-term weather forecasts (requiring dedicated model runs) for the region. Feedback from local experts on the accuracy and relevance of this product in turn can help improve model performance. Here, input by local partners, like Winton Weyapuk Jr. in Wales, Paul Apangalook and Merle Apassingok in Gambell, who provided updates on ice conditions and deployed supplemental drift sensors proved of critical importance. Similarly, remote sensing products, such as high-resolution visible-range imagery and synthetic aperture radar (SAR) scenes, are interpreted and discussed by both sea-ice geophysicists and local hunters. Both the type of imagery provided and the mode of delivery have been modified from original plans based on comments and input from coastal communities. For example, the Alaska Satellite Facility (ASF) was able to provide short-term access to high-resolution, weather-independent

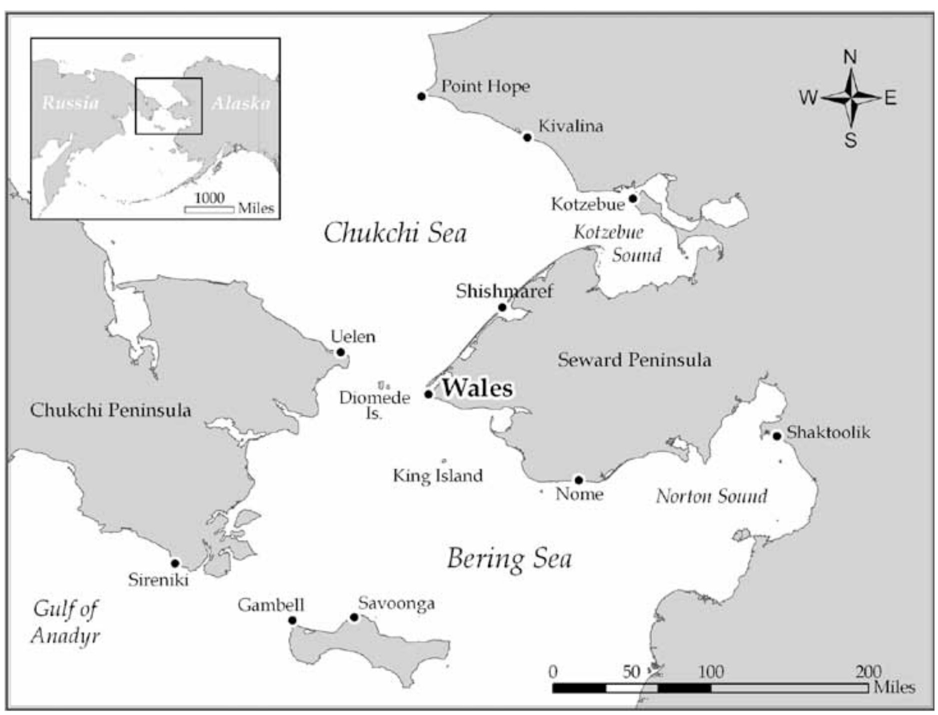

Fig.5.2-6. Area covered by the SIWO pilot initiative in the northern Bering Sea and southern Chukchi Sea (from SIWO website www.arcus.org/search/siwo/).

SAR imagery provided by a Japanese satellite downlinked at ASF in Fairbanks.

A project such as SIWO also requires retrospective analysis to ensure that both scientific findings, e.g. with respect to downscaling of model output and remote sensing data to the local scale and assessment of operational products, lead to significant progress. Such activities benefit greatly from having the SIWO partnership embedded in a larger, U.S. interagency program (SEARCH), which can draw on broader expertise and resources from the scientific community, government agencies and local organizations. Support from outside experts, such as Carleton Ray and Igor Krupnik, who have provided critical input and support to this effort, also help ensure that such local or regional activities can be translated to a larger pan-Arctic scale.

Though designed as a small pilot project, SIWO carries on the legacy of IPY 2007–2008 in terms of making polar research relevant and valuable to the growing number of local stakeholders. It solidifies partnerships across science disciplines (ocean and ice studies, atmospheric science, marine biology, anthropology and subsistence research) and between scientists and indigenous organizations that were forged during the IPY era. SIWO may eventually become a prototype of a much broader observational service network that would incorporate indigenous ice and weather observations into the existing agency-supported weather and ice monitoring and forecasting. Such integration could significantly augment and improve the design and implementation of an Arctic observing system from broad to local spatial and temporal scales (Eicken et al., in press). If such incorporation occurs, what started as pilot efforts by a few IPY 2007–2008 projects may eventually become a permanent fixture of the agency-run polar 'services' for years and decades ahead.

Conclusion

The impact of IPY in polar science was several-fold. It encouraged the submission of new research programs from the wider community and the merger of many smaller projects with larger ones, so as to make them more interdisciplinary and increase their potential impact. It triggered new and growing efforts within SCAR and IASC to submit aspects of their work as IPY projects and the speeding up of programs in the works, like ACCE and SWIPA. It led to the development of programs that had been called for in the IPY planning documents, but not submitted by the research community (e.g. SCAR developed the SOOS proposal outside the formal IPY structure when it was clear that no research proposal had addressed this need). Lastly, it encouraged the re-labeling of some planned work by the national operational agencies as IPY. All of these efforts contributed to the mass of outputs begun or delivered during the IPY years. In that respect, IPY was a great catalyst for action, adding urgency and impetus to activities that might otherwise never have begun or would have been much delayed in execution.

There was also a definite impact of the IPY process, in terms of planning, language and ideology on many other initiatives of the 'IPY era.' Firstly, IPY 2007–2008 solidified the transition to more *societal-relevant* science and pushed polar research to be more attuned to the needs and interests of multiple stakeholders, such as polar residents, policy-makers, environmental groups, science educators and the like. Secondly, IPY embedded a new format of polar research with a much broader ('across-the-range') spectrum of disciplines than had been common for earlier multidisciplinary studies and infused more input from social sciences and local knowledge of polar residents, at least in the Arctic. That transition is obvious for ISAC, SAON, DAMOCLES and other primarily physical research and observational initiatives in IPY, but it generated similar transitions in many other IPY-era programs. Several teams are known to have altered their work plans to make them adhere more overtly to the IPY goals in order to contribute to the IPY outcomes, or even to be seen to be doing so.

These activities, like ACCE, SWIPA, SIWO (reviewed here) and others of their ilk can all be viewed as IPY-adopted or IPY-inspired. The contribution of such 'IPY-inspired' projects to achieving the goals of IPY has been considerable. They all advance the same interdisciplinary approach that addresses status and change in the polar regions and that explores societal and ecosystem impacts of the geophysical processes, so fitted very well with the ethos of IPY.

References

ACIA, 2005. *Arctic Climate Impact Assessment.* Cambridge: Cambridge University Press, 1042p.

AHDR *(Arctic Human Development Report),* 2004. Níels Einarsson, Joan Nymand Larsen, Annika Nilsson, and Oran R. Young, general editors. Akureyri: Stefansson Arctic Institute.

Allison, I., (ed). 1983. Antarctic Climate Research: Proposals for the Implementation of a Programme of Antarctic Research contributing to the World Climate Research Programme. Cambridge, SCAR, 65 pp.

Allison, I., M. Béland, K. Alverson, R. Bell, D. Carlson, P. Cutler, K. Danell, C. Ellis-Evans, E. Fahrbach, G. Hovelsrud, J. Huber, V. Kotlyakov, I. Krupnik, J. López-Martínez, T. Mohr, H. Ödmark, D. Qin, V. Rachold, C. Rapley, O. Rogne, E. Sarukhanian, C. Summerhayes and T. Yamanouchi, 2009. The State of Polar Research: a statement from the International Council for Science/World Meteorological Organization Joint Committee for the International Polar Year 2007–2008.World Meteorological Organization, Geneva, 16pp.

Dahl-Jensen, D., J. Bamber, C.E. Bøggild, E. Buch, J.H. Christensen, K. Dethloff, M. Fahnestock, S. Marshall, M. Rosing, K. Steffen, R. Thomas, M. Truffer, M. van den Broeke and C.J. van der Veen, 2009. Summary – The Greenland Ice Sheet in a Changing Climate Snow, Water, Ice and Permafrost in the Arctic (SWIPA). AMAP: Oslo, 22 pp.

Eicken, H., Lovecraft, A.L. and M. Druckenmiller, 2009. Sea-ice system services: A framework to help identify and meet information needs relevant for Arctic observing networks. Arctic, 62:119–136.

Eicken, H., L.A. Ritchie, and A. Barlau, in press. The potential role of local, indigenous knowledge in Arctic offshore oil and gas development, environmental hazard mitigation, and emergency response. In *North by 2020: Perspectives on a Changing Arctic,* A.L. Lovecraft, and H. Eicken, (eds).

Krupnik, I. and G.C. Ray, 2007. Pacific walruses, indigenous hunters, and climate change: Bridging scientific and indigenous knowledge. Deep-Sea Research Part II, 54:2946–2957.

Mayewski, P.A., M. P. Meredith, C. P. Summerhayes, J. Turner, A. Worby, P. J. Barrett, G. Casassa, N. A. N. Bertler, T. Bracegirdle, A. C. Naveira Garabato, D. Bromwich, H. Campbell, G. S. Hamilton, W. B. Lyons, K. A. Maasch, S. Aoki, C. Xiao, Tas van Ommen, 2009. State of the Antarctic and Southern Ocean climate system. Reviews of Geophysics 47 RG1003, 38 PP., doi:10.1029/2007RG000231

Metcalf, V. and I. Krupnik, (eds), 2003. Pacific walrus. Conserving our culture through traditional management. Report of the Oral History Project under Cooperative Agreement #701813J506, Section 119. Eskimo Walrus Commission, Kawerak, Inc., Nome, Alaska.

Metcalf, V. and M. Robards, 2008. Sustaining a healthy human-walrus relationship in a dynamic environment: challenges for comanagement. Ecological Applications, 18(2):148-156.

Oozeva, C., C. Noongwook, G. Noongwook, C. Alowa, and I. Krupnik, 2004. Watching Ice and Weather Our Way/Sikumengllu Eslamengllu Esghapalleghput. I. Krupnik, H. Huntington and C. Koonooka (eds). Arctic Studies Center, Smithsonian Institution: Washington, DC.

Ray, C.G. and G.L. Hufford, 1989. Relationships among Beringian marine mammals and sea ice. Rapports et Procès-Verbaux des Réunion Conseil International pour L'Exploration de la Mer, 188:22-39.

SCAR, 1989. The Role of Antarctica in Global Change. Prepared by the SCAR Steering Committee for the IGBP:28 p.

SCAR, 1992. The Role of the Antarctic in Global Change: An International Plan for a Regional Research Programme, Prepared by the SCAR Steering Committee for the IGBP: 54 p.

SWIPA, 2009. Climate Change and the Cryosphere: Snow, Water, Ice, and Permafrost in the Arctic (SWIPA) An Arctic Council 'Cryosphere Project' in Cooperation with IASC, CliC and IPY. Project summary, 60p www.amap.no/swipa/#Products.

Turner, J., Bindschadler, R.A., Convey, P., Di Prisco, G., Fahrbach, E., Gutt, J., Hodgson, D.A., Mayewski, P.A., and Summerhayes, C.P., 2009. Antarctic Climate Change and the Environment. SCAR, Cambridge, 560pp.