THE FUTURE OF BIOCONTROL INDUSTRY
(WITNESSING THE LAST 25 YEARS)

BIOGARD®

VITTORIO VERONELLI

ABIM 2012

BIOCONTROL 4 GROUPS

SEMIOCHEMICALS PHEROMONES

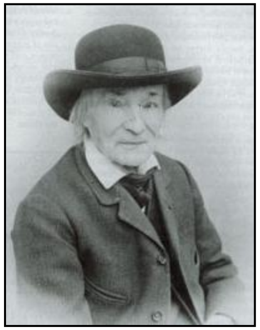
THE LAST 25 YEARS OF MY LIFE

Dr. Kinya Ogawa - Shin-Etsu

- 1988 - First approach (Oriental Fruit Moth)
- 1992 - IOBC Semiochemicals - S. Michele
- 1993 - South Tyrol (Codling moth)
- 1996 - Trentino - Mezzacorona (Grape moths)
- 1998 - IBMA
- 2001 - EU 91/414
- 2003 - 5 registrations in Italy
- 2012 - 70,000 ha MD in Italy

Shin-Etsu PHEROMONES

HOW IT STARTED



Fabre observes insect chemical communication

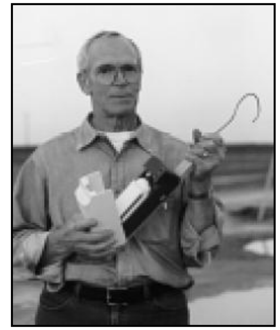
1879

Bruno Götz hypothesis on Grape moths

1940

Adolf Butenandt identifies *B. mori* Bombykol

1959



Harry Shorey conducts first field trial *(T. ni)*

1967

P. gossypiella first registered in USA

1978

Grape moths trials in Europe (DE, FR, CH, IT)

1983

1870s 1930 → 1990

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AND CONTINUED…

T. Wyatt 2009 - Fifty years of pheromones
Nature - Vol. 457 15 January 2009

ESSAY

Fifty years of pheromones

Powerful chemical signals have been identified in moths, elephants and fish, recounts **Tristram D. Wyatt**. But, contrary to stories in the popular press, the race is still on to capture human scents.

Fifty years ago this month, Peter Karlson and Martin Lüscher proposed a new word for the chemicals used to communicate between individuals of the same species: pheromones[1]. Since then, pheromones have been found across the animal kingdom, sending messages between courting lobsters, alarmed aphids, suckling rabbit pups, mound-building termites and trail-following ants. They are also used by algae, yeast, ciliates and bacteria.

The new word met a pressing need. Karlson had discussed it with his colleague Adolf Butenandt, who was about to publish the first chemical identification of a pheromone — bombykol, the sex pheromone of the silk moth *Bombyx mori*. The bombykol paper showed the equivalent of Koch's postulates for establishing causal relationships for pheromones: isolation, identification, synthesis and bioassay confirmation of activity[2]. Butenandt's work established that chemical signals between animals exist and can be identified, marking the start of modern pheromone research. Popular speculation about human pheromones, still going strong today, began too.

The idea of chemical communication was not new in 1959. The ancient Greeks knew that the secretions of a female dog in heat attracted males. Charles Butler had warned in *The Feminine Monarchie* (1609) that if you are stung by one honeybee, "other Bees smelling the ranke favour of the poison cast out with the sting will come about you as thick as haile". In *The Descent of Man, and Selection in Relation to Sex* (1871), Charles Darwin included chemical signals alongside visual and auditory ones as outcomes of sexual selection, describing the success of the smelliest among breeding male crocodiles, ducks, goats and elephants. Jean-Henri Fabre, also in the 1870s, described how male emperor moths flocked around a female moth hidden behind wire-gauze, but ignored visible females sealed under glass. Surely her smell was the attraction.

In 1932, the physiologist Albrecht Bethe had proposed the broad term 'ectohormone' to cover many kinds of chemical interaction, including communication or attraction of an animal to a food smell. Karlson and Lüscher wanted a term that more narrowly covered communication between members of the same species, but more broadly allowed for those chemicals to be created by a variety of organs ('hormones' by definition come from the endocrine glands). Their new term, from the Greek *pherein* for 'to transfer', and *hormōn* 'to excite', at a stroke replaced ectohormone. 'Pheromone' was sonorous, and close enough to 'hormone' to imply some similarities along with the differences: like hormones, pheromones could be expected to be specific, and active in minute amounts. They defined pheromones as: "substances which are secreted to the outside by an individual and received by a second individual of the same species, in which they release a specific reaction, for example, a definite behaviour or a developmental process." The new word and definition stuck.

Feast for the senses

Karlson and Lüscher were far-sighted, noting that pheromones were likely to be used by a wide range of animals, including fish and underwater crustaceans as well as land mammals and insects. They predicted that most pheromones would act via the conventional senses of smell or taste, but that some might be ingested and act directly on the brain or other organs — as happens in termites, whose pheromones affecting caste development are passed round by mouth through the colony.

"Controversy over mammalian pheromones has been almost as heated as the 'stink wars' between opposing troops of ring-tailed lemurs."

All these anticipations have been borne out, although Karlson and Lüscher might have been amazed at the range of molecules identified as pheromones since 1959, including everything from low-molecular-weight formic acid to polypeptides. We now know that many pheromones (including the sex pheromones of most moths) are not single compounds, but rather a species-specific combination of molecules in a precise ratio.

The ubiquity and variety of pheromones can be explained by natural selection. The evolutionary development of sex pheromones in a fish, for example, might have started with male fish detecting sex hormones leaking from a female about to spawn. The most sensitive males would get there first. Over generations, there would be selection for increased sensitivity of the receiver and increased production of the signal by the sender.

Chemical communication can also be exploited by other species. For example, some orchids, which benefit from attracting pollinators, produce a mixture of compounds that mimics female-wasp pheromones. The mimicry is so good that duped males will ejaculate on the flowers.

Karlson also catalysed a completely new field of study in biology, by asking a young biologist neighbour, Dietrich Schneider, if he could invent an electrophysiological way to assess Butenandt's silk-moth extracts for activity. Schneider's solution was the electroantennogram, still used today: wires inserted into both ends of a moth antenna are used to measure electrical signals as different extracts are presented. Recordings of activity in single antennal sensory cells followed in later years, as moths and their pheromones became a key model system in neurobiology.

The pursuit of pheromone science has not been entirely sweet and easy. The concept has faced key periods of controversy over mammalian pheromones, in battles almost as heated as the 'stink wars' between opposing troops of ring-tailed lemurs, which wave their pheromone-coated tails to assert their dominance.

In the 1970s, a group of researchers studying mammals argued that the term 'pheromones' should not be used for mammalian chemical signals, citing in particular the complex, highly variable odours that mammals use to distinguish littermate from stranger, for example for altruism or mate choice. These individual odours, including some related to the immune system, need to be learnt for recognition, and did not seem to fit Karlson and Lüscher's definition. Some researchers even doubted that complex mammals, including humans, could have their behaviour altered by something as simple as an instinctive reaction to a smell.

Debate continues among those in the field. I now agree that these variable odours are not pheromones, and instead are better termed 'signature odours' (the same holds for complex variable odours in social insects such as ants and bees, which also have to be learnt and are used for colony recognition). But species-specific small molecules that do fit the classic pheromone definition have now been identified for mammals. Most spectacular was the 1996 discovery that the female Asian elephant's sex pheromone is a small molecule — (*Z*)-7-dodecen-1-yl acetate — also used by some

WHY ?...DRIVEN BY CRISIS...?

"....We have evidence that grape moths can be controlled by the application of enough quantities of sex attractants."..

*"...**the problem of replacing arsenic** ...would be solved in an elegant way."*

Götz Bruno (1940). Sexualduftstoffe als Lockmittel in der Schädlingsbekämpfung. Umschau 44: 794-796

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BIOCONTROL AND PHEROMONES ADOPTION ONLY DRIVEN BY CRISIS…?

- Insecticide Resistance
- Concern about Insecticide Residues
- Outbreak of Invasive Species
- Outbreak of Secondary Insects

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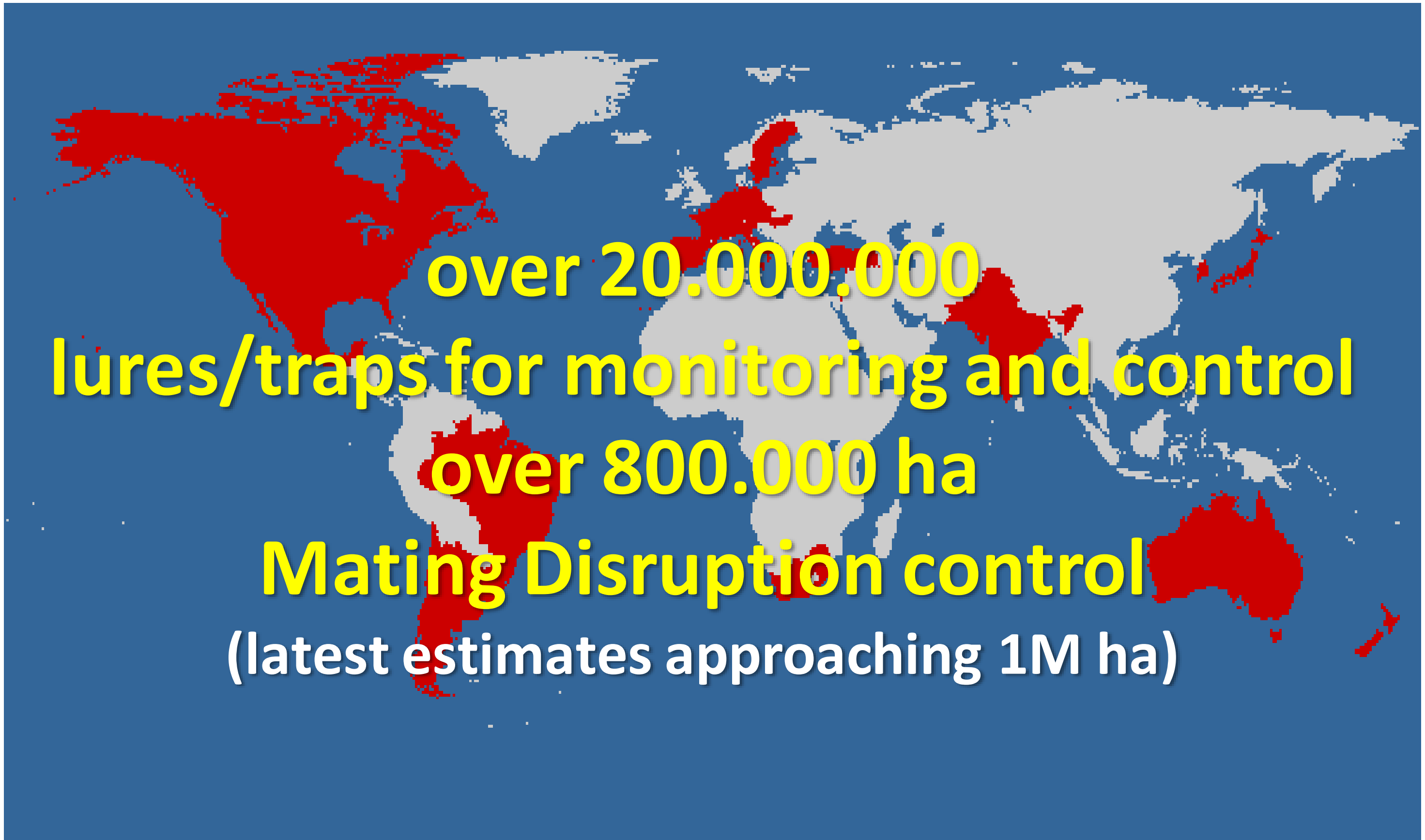
TODAY USE OF PHEROMONES…A BASE IN IPM



over 20.000.000

lures/traps for monitoring and control

over 800.000 ha

Mating Disruption control

(latest estimates approaching 1M ha)

Source: Sex Pheromones and their impact in pest management
Peter Witzgall et al. - Journal of Chem. Ecol. 2010

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IPM, NEVER TAKE IT FOR GRANTED

FAO definition:

Integrated Pest Management (IPM) means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that **discourage the development of pest populations** and **keep pesticides and other interventions to levels that are economically justified** and **reduce or minimize risks to human health and the environment**. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

IOBC IP & IPM definition:

Integrated Production – is a concept of sustainable agriculture developed in 1976 which has gained international recognition and application. The concept **is based on the use of natural resources and regulating mechanisms to replace potentially polluting inputs. The agronomic preventive measures and biological/physical/chemical methods are carefully selected and balanced taking into account the protection of health of both farmers and consumers and of the environment….**

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EU *SUD* & IPM

SUD Directive 128/2009
Art. 12
Reduction of pesticide use or risks in specific areas
…Appropriate risk management measures shall be taken and **the use of low-risk plant protection products** **as defined in Regulation EC No. 1107/2009** **and biological control measures shall be considered in the first place.**

Art. 14
Integrated Pest Management
Member States shall take all necessary measures to promote low pesticide-input pest management, giving wherever possible priority to non-chemical methods , so that professional users of pesticides switch to practices and products with the lowest risk to human health and the environment among those available for the same pest problem. Low pesticides-input pest management includes integrated pest management as well as organic farming…

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BIOCONTROL & IPM

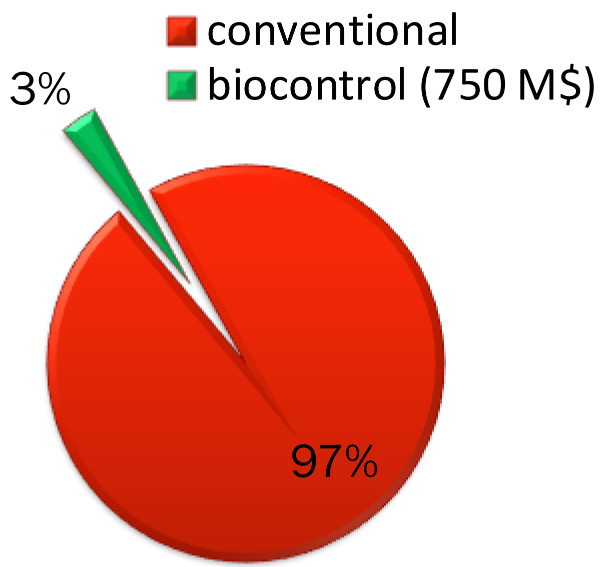
A pivotal role in IPM fully in accordance with the Sustainable Use Directive

- **Prevention**
- **Monitoring**
- **Resistance management**
- **Reduction of pesticides uses**
- **Respect of ecosystem**
- **Reduction of consumers and workers health risks**

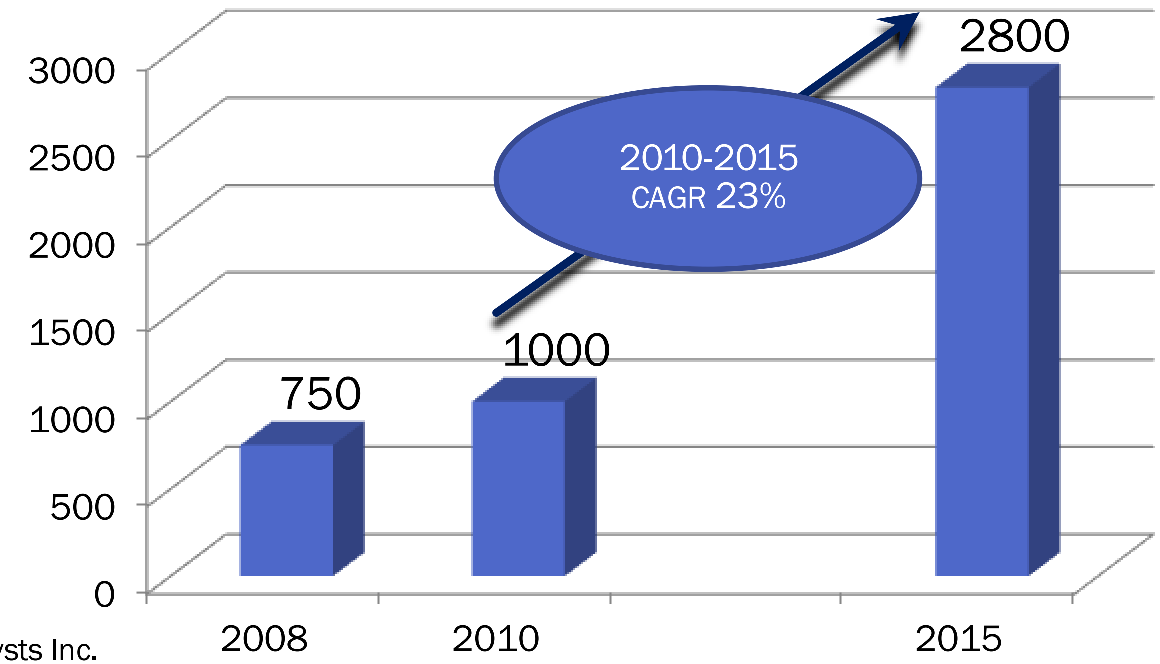
ONLY BIOCONTROL CAN CONTRIBUTE TO EACH STEP !

GROWTH OF BIOCONTROL MARKET

World Crop Pesticide Market
25 bl US$ (2008)

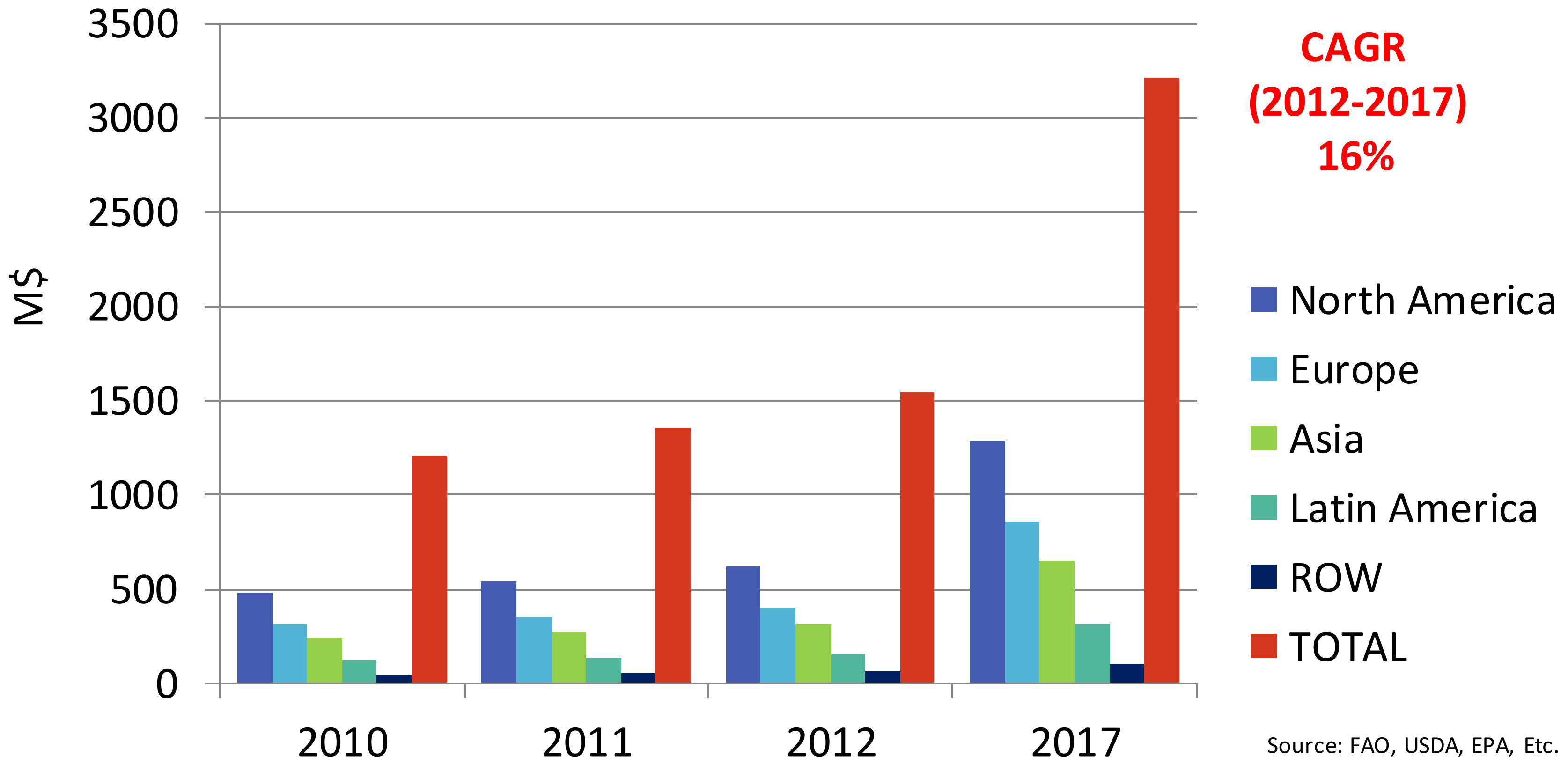


World Crop Biocontrol Market
expected growth 2010-2015 (M$)



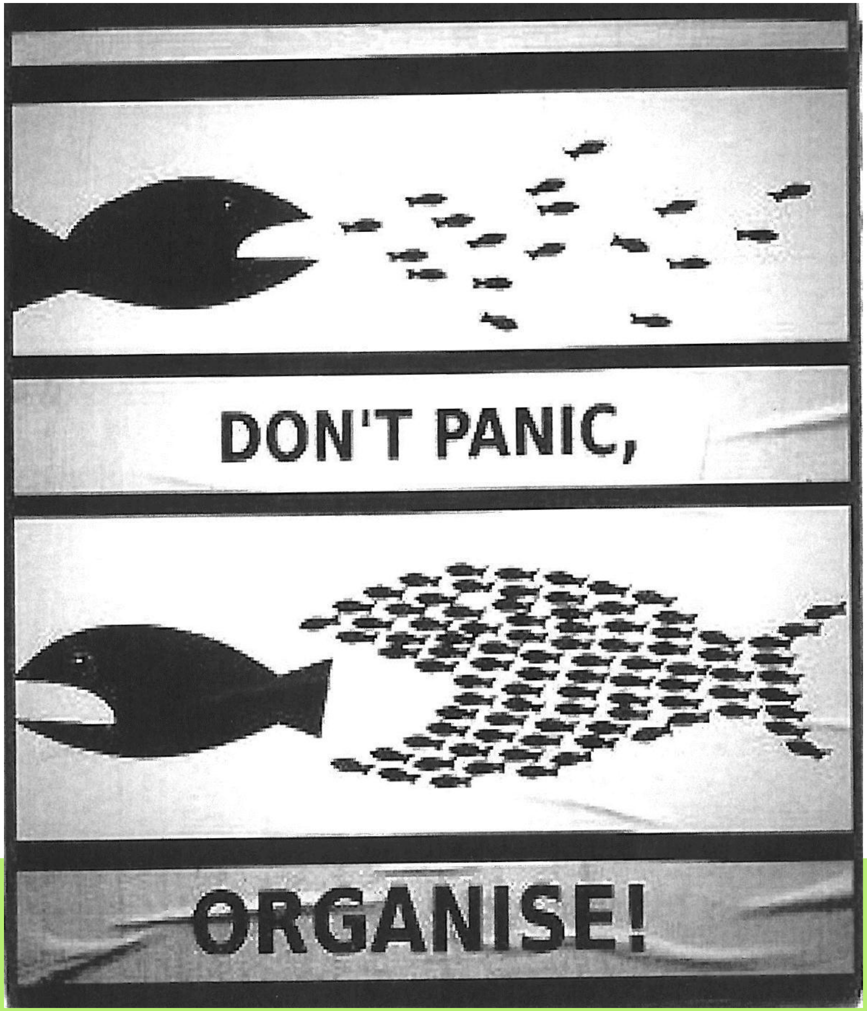
Source: Global Industry Analysts Inc.

BIOCONTROL MARKET GROWTH BY WORLD AREA

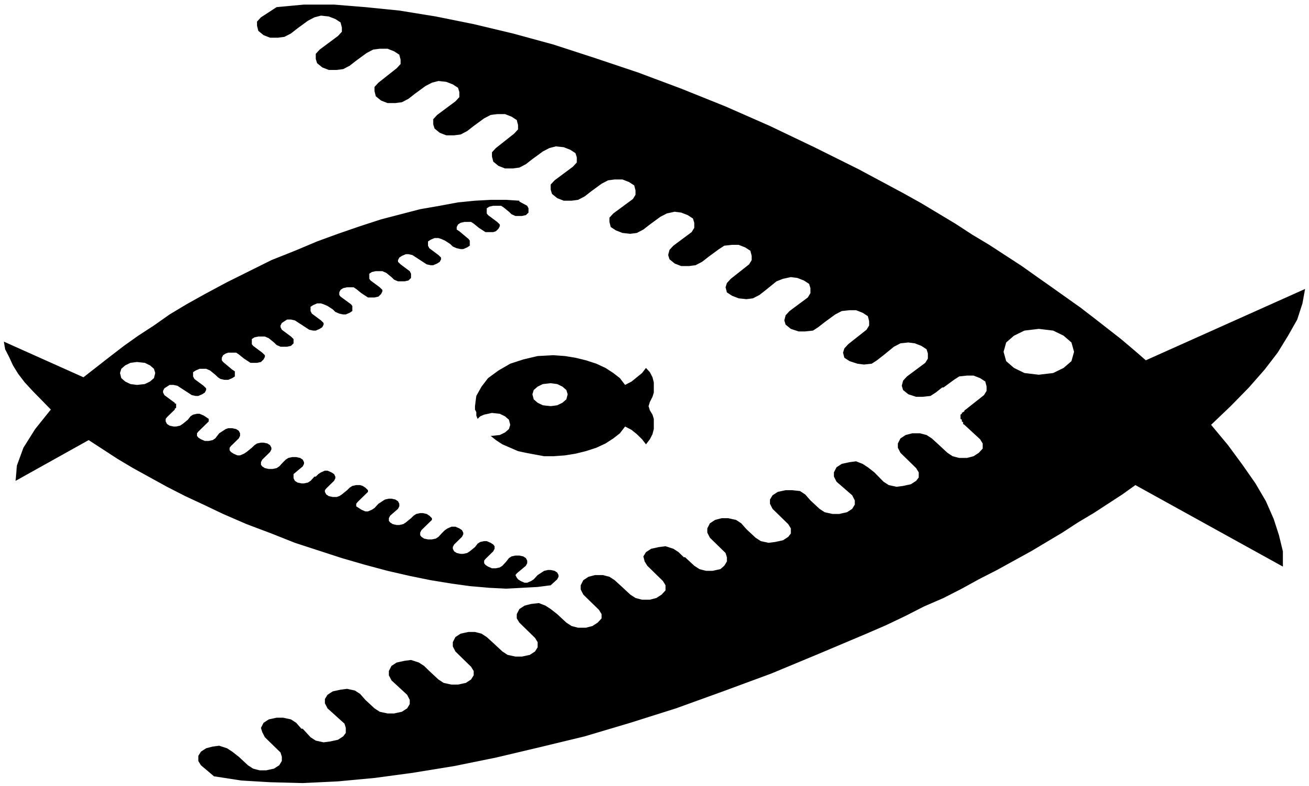


Source: FAO, USDA, EPA, Etc.

OLD VIEW ?



NEW TREND ?



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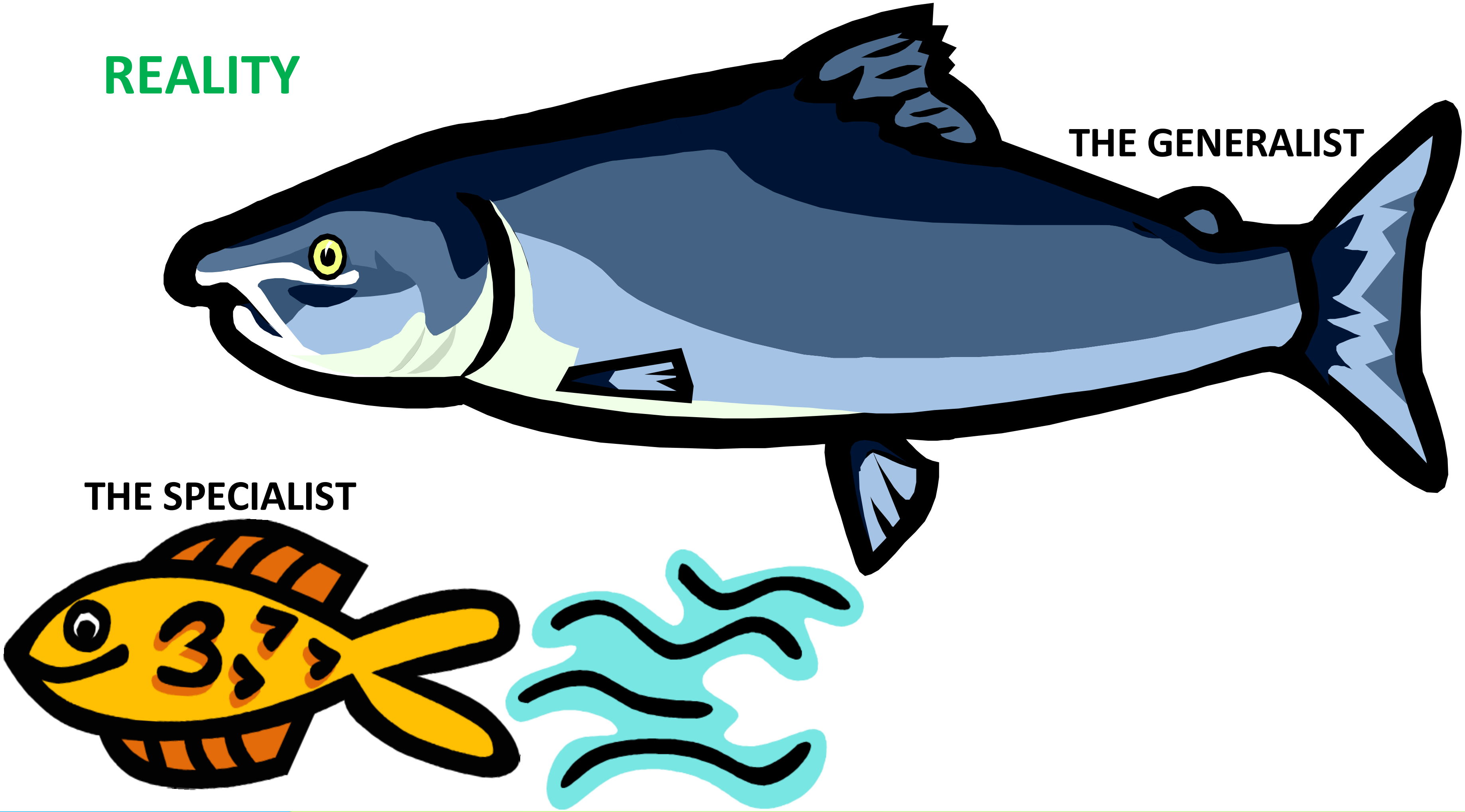
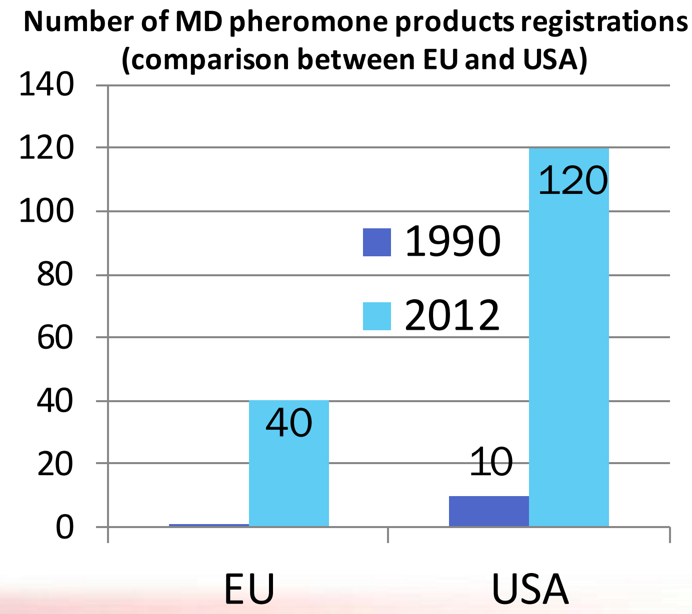
REALITY



BIOCONTROL NEEDS

- A more specific Regulatory framework (today Regulation 1107 still has no provision for the specificity of Biocontrol products)
- An Expert group (IOBC) to support Member State evaluation of Biocontrol products
- A much shorter “time to market” for products
- A more direct contribution to research
- A better supporting program for tech transfer to growers



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THANK YOU FOR THE ATTENTION